Natural England Commissioned Report NECR153

Survey and analysis of vegetation and hydrological change in English dune slack habitats

Annex 6 - Site report for Holme

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Executive Summary

- Dune wetlands at Holme Dunes were surveyed and mapped in the summer of 2012, repeating the wetland component of the earlier Sand Dune Survey of Great Britain (SDGB) at this site in 1989. Some vegetation quadrats from the 1989 survey were relocated and re-surveyed. Some hydrological interpretation is also provided for this site.

- Little hydrological information exists for Holme Dunes. The water table is influenced by various surface water features and the role of these in determining hydro-ecological conditions is as yet unknown.

- There has been a net change in area of wetland habitats from wetter to drier habitats between 1989 and 2012, with an apparent loss of 84% in wetland area. There is poor fit of the vegetation assemblages to NVC classifications, therefore some of these changes may be due to different surveyor interpretation.

- Six quadrats were resurveyed. There was a significant decline in Ellenberg salinity scores, but no significant change in other indicator values for environmental or climate indicators. There was a significant increase in species richness, but the conservation implications of this have not been evaluated.

- Soils were not sampled at this site.

- Vegetation assemblages at Holme show a poor fit to the NVC, and areas of wetland are relatively small at the site. This makes specific management recommendations for these areas difficult. Interpretation of results from this survey does not suggest any obvious management recommendations.

Contents

1 Introduction

This work was conducted under a Memorandum of Agreement between Natural England and the Centre for Ecology and Hydrology (CEH). It comprised two elements: hydrological studies at key sites and a re-survey of the dune wetland resource, repeating where possible mapping and survey work conducted as part of the Sand Dune Survey of Great Britain (SDGB) (Radley 1994). Work conducted at Holme Dunes under these two components is reported here.

2 Site Description

The site description is separated into hydrological and ecological components, both focusing primarily on the wetland features of the site.

2.1 Geological and hydrological setting

Holme Dunes NNR is located on the North Norfolk coast, four miles north east of Hunstanton (Figure 1). This is a hindshore dune about 1.5 km long by up to 300 m wide. The dunes front reclaimed tidal marsh land, and both rest on Holkham Till which is a red/brown gravelly clay. Bedrock beneath comprises the White Chalk Supergoup.

The western half of the site has been extensively manicured with two parallel dune ridges some containing gravel scooped up from the head and beach face material. The eastern half of the site is partly wooded and remains ion its natural configuration. The central section of the dunes is wooded and overlooks a large fresh water lake, Broad Water, within the reclaimed tidal marsh. Regulated drainage from the lake goes to the east, protected from the sea behind a single dune ridge which trails towards the south east (Figure 2).

The dunes at Holme essentially consist of a single frontal ridge, which in places reaches an elevation of 10 m AOD, and to the south of this, lower lying slack areas with an elevation of ~ 3 m AOD (Figure 3). The dune slacks are essentially dry apart from some man-made scoops on the inland part of the engineered western section of the site. Unlike Winterton to the south, the sand is rich in shell debris and supports an alkaline-rich ecology.

The hydrology of the dunes will be influenced by rainfall, evaporation and seepage, however the numerous surface water features (ditches, ponds and lakes) will also play a very important part in determining the direction and magnitude of groundwater flow, and hence the water level across the site.

Figure 1. The location of Holme Dunes NNR in the UK.

Figure 2. Aerial photo of Holme Dunes NNR. © Next Perspectives.

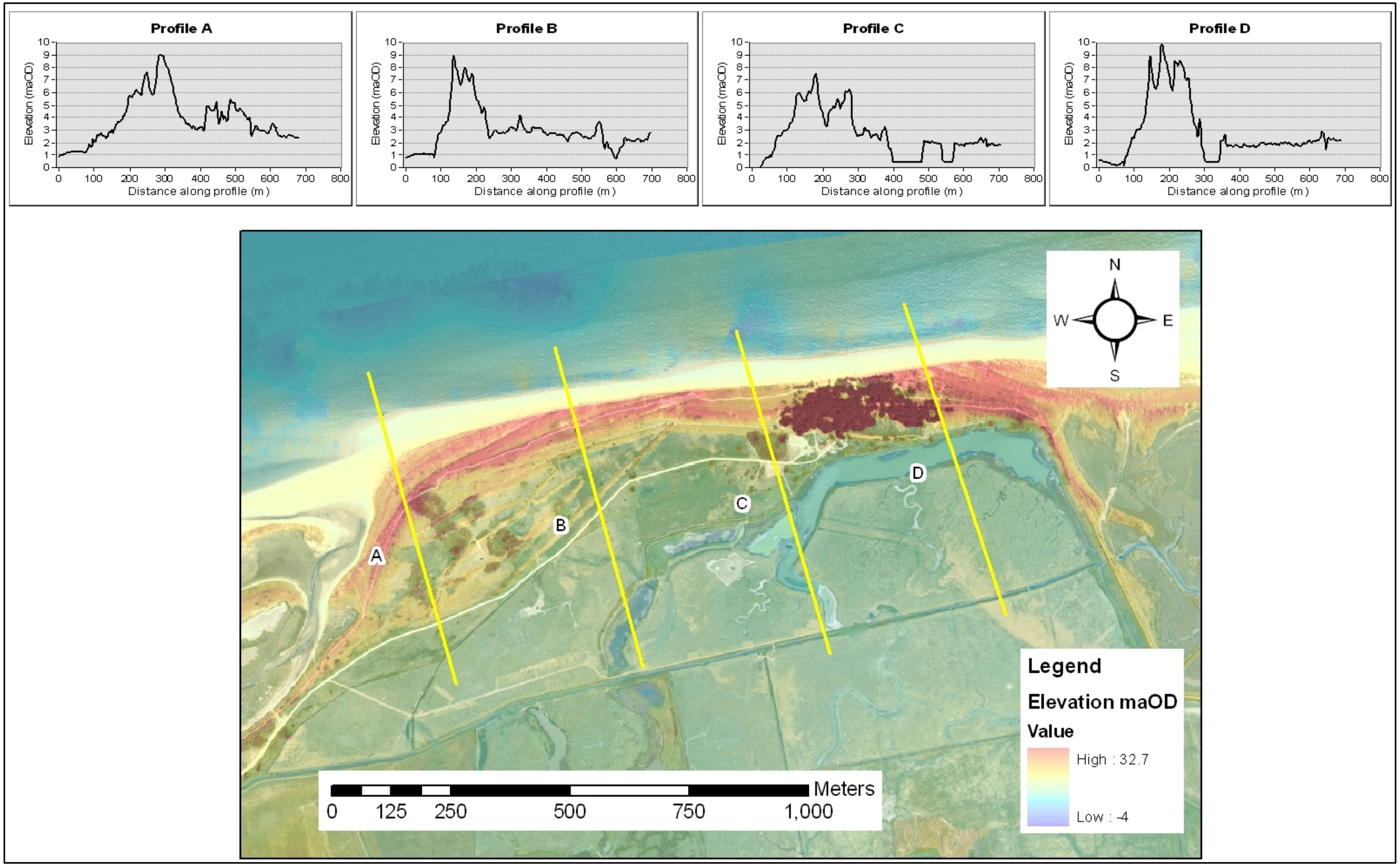

Figure 3. Elevation profiles at several locations along Holme Dunes NNR. Values represent the elevation of the top surface, not of the ground surface, so are affected by vegetation height. © NERC (CEH) 2013. © Next Perspectives.

Long-term data for the basic hydrological drivers (rainfall and evaporation) are shown in Figure 4. Whilst evapotranspiration is broadly similar across many of the UK sites, rainfall varies considerably, and Holme Dunes is one of the sites receiving the lowest average amounts of rainfall. The long term (1961 to 2012) average annual rainfall for this area (area defined as the 40km x 40km grid square calculated using the Meteorological Office Rainfall and Evapotranspiration Calculation System (MORECS)) is 630 mm, and the long term (1961 to 2012) average annual net (rainfall – actual evaporation) is 74 mm. This means that there is very little water available to drive or support a rising water table, and that relatively small changes in the timing and amount of rainfall could bring about a recharge deficit.

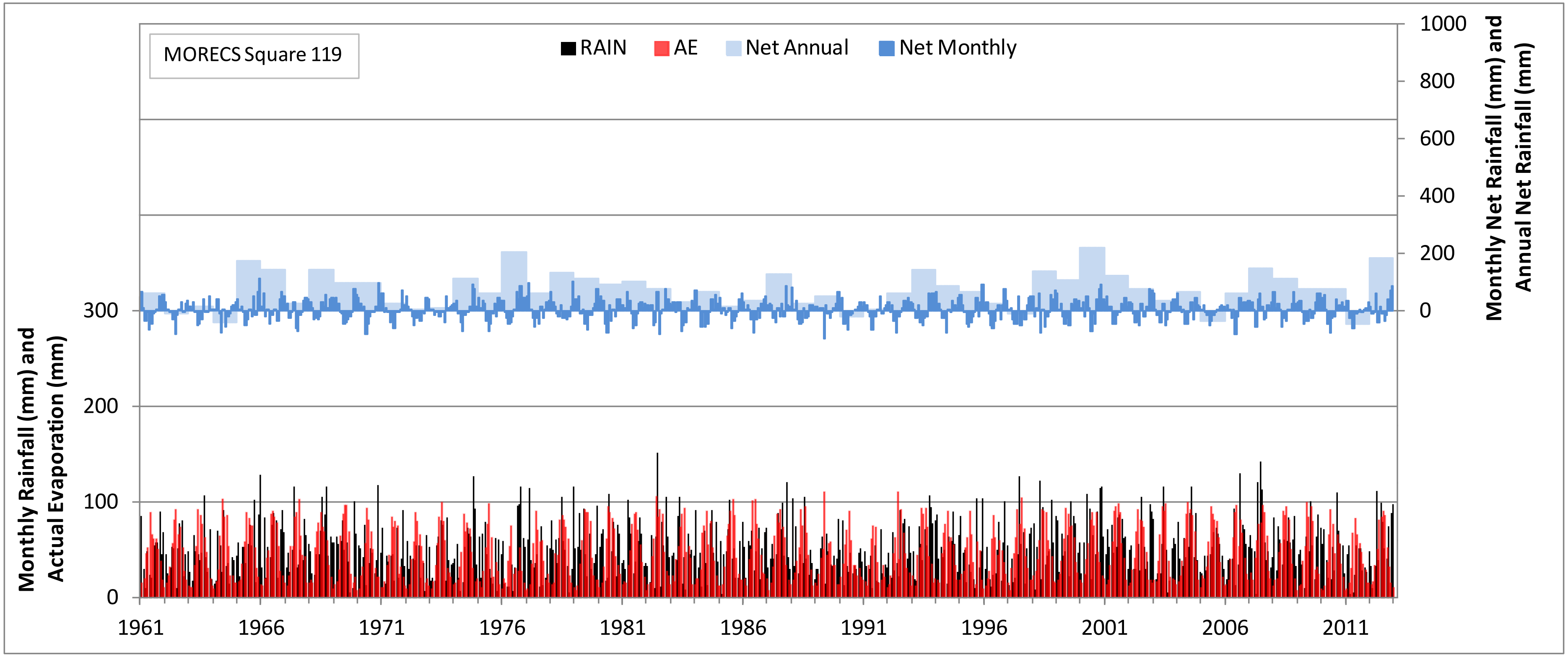

Figure 4. Monthly Rainfall and Evaporation data for MORECS square 119. Net (Rainfall - actual evaporation) monthly and annual totals also shown. MORECS data © Crown copyright 2013, the Met Office.

Interpretation of MORECS data must remember that the data reflect the average conditions for the whole grid square. It is quite possible the conditions at a single coastal dune system will not be accurately represented by MORECS data and the results should therefore only be used as very broad indicator. Nevertheless, MORECS does provide a very useful long term average view of conditions and its inclusion here is therefore justified.

2.2 Ecological setting

The site was previously surveyed in 1989 by Radley et al. (1989). The following ecological setting is based on survey work in this study conducted in 2012. The most dominant community found within the area previously mapped as dune-slack habitat is MG1 Arrhenatherum elatius grassland. The Easternmost area, found between Sea Buckthorn scrub and open sallow, comprises *Arrhenatherum* and *Holcus lanatus*, with *Senecio jacobaea, Agrimonia*, occasional Sea Buckthorn seedlings, *Phragmites australis, Juncus maritimus*, and a few plants of *Hieracium umbellatum*. Moving further West and South, additions to the herbaceous flora include *Lotus corniculatus* and *Potentilla anserina*, and less frequent *Plantago lanceolata, Agrimonia eupatoria, Trifolium pratense, Anthoxanthum, Torilis japonica* and *Cirsium arvense*. Patches of *P. australis* and *Calamagrostis epigejos* of varying densities are scattered throughout the area of MG1. *Festuca rubra* accompanies the dominant *A. elatius* in places, with *Pastinaca sativa, Lathyrus pratensis* and *Lotus corniculatus*. Hummocks, often with scrub on top (including in one place, *Euonymus europaeus*) and scattered patches of *C. epigejos* are found throughout. There is a proposal to introduce winter grazing with Dartmoor ponies moving around the site in rotation, specifically to restore the coarsening MG1 and especially *C. epigejos* back to more dune slack turf. *Agrostis stolonifera* and *F. rubra* become prominent in the sward in some places, particularly where grazing/mowing has taken place, and here the vegetation can be better classified as MG11 *Festuca rubra-Agrostis stolonifera-Potentilla anserina* grassland. Accompanying species here include *Brachythecium rutabulum* and occasional *Cerastium fontanum, Trifolium repens* and *Senecio jacobaea*.

Some small but well-demarcated depressions towards the centre of the site were re-excavated approximately seven years prior to this survey and in parts recently mown, and here SD17 Potentilla anserina-Carex nigra dune-slack communities are present. Species here include A. stolonifera, with Carex flacca, sallow, Hydrocotyle vulgare, Potentilla anserina, Equisetum palustre, Pulicaria dysenterica, Lycopus europaeus, and scattered C. epigejos and P. australis. *Linum catharticum, Cirsium palustre,* Cynosurus cristatus, Prunella vulgaris, Juncus maritimus, Odontites vernus, L. corniculatus, Calliergonella cuspidata, Epipactis palustris and Dactylorhiza ssp., are also found occasionally in these depressions. There is some evidence of recent scrub cutting (and removal or stump grinding), but *Hippophaë rhamnoides*, *Rubus fruticosus* agg. and *Ligustrum vulgare* are invading in places with scattered dune-slack species such as *E. palustris* and *Dactylorhiza* spp., *H. vulgare*, and *J. maritimus*. Occasionally standing water is found in the bottom of depressions, with one or two small areas dominated by *P. australis* which can be loosely classified as S4 or S26 *Phragmites australis-Urtica dioica* tall-herb fen. The edges of these pools, where grazed, support *A. stolonifera, J. maritimus, Samolus valerandi, Centaurium erythraea, H. vulgare, Salix* spp. and *E. palustris*.

3 Hydrological work

At the time of this report, there were no previous hydrological monitoring points (dip wells) on Holme Dunes. BGS have recently installed a monitoring well and have also investigated a possible surface water monitoring point, however there is currently too little information from this point to be of use in developing the hydrological understanding. In the absence of monitoring data within the dune system, the conceptual model is based upon site observations made both during the desk study and field visit.

As with all the sites in this study, the water table in the dunes is influenced by rainfall and evaporation, with an outflow seepage along the beach. It is quite likely that at Holme Dunes, there is a significant exchange of surface water and/or groundwater between the surface water features (ditches, ponds and lakes) and the sand aquifer of the dunes. Confirmation of this will only be possible through further site investigation. The important implication of this is that the quantity and quality of water in the dunes could be affected by activities taking place in those surface water features, which in turn may be affected by activities off site.

Figure 5. Holme Dunes NNR conceptual groundwater flow diagram. The yellow arrows indicate the likely direction of groundwater flow. © NERC (CEH) 2013. © Next Perspectives.

The conceptual groundwater model indicates that in the west of the site, flow from the middle of the dunes north towards the sea, and also flow south towards one of the ditches (Figure 5). This will depend on the water level in the ditch, and may therefore change direction under certain conditions. To the east of this, where the distance between the ditch and the beach decreases, it is likely that the majority of flow will be towards the beach as the effect of the ditch is greater relative to the width of the sand aquifer.

The impact of the forested area to the north of the lake and the lake itself is poorly understood at present and further investigation would be required in order to determine this.

4 Vegetation Survey

4.1 Methodology

4.1.1 Field Mapping

The use of GPS-linked portable electronic tablet PCs in the field equipped with Arcpad GIS software enabled a variety of layers to be loaded simultaneously and selected or made semi-transparent as required. GIS layers included aerial photos covering the extent of the dunes, scanned and geo-referenced copies of the original survey maps, the editable layers for mapping and, where available, additional survey information for dune slacks recorded since the SDGB survey.

As the project focused very specifically on dune wetlands, there was no scope to map the more widely distributed (dry) dune communities. For each prioritised area surveyed, every slack or wetland mapped in the original survey was revisited as far as possible, aided by printed copies of the SDGB survey maps with wetland habitats highlighted. Additional slacks were then located by covering as much of the intervening ground on foot as possible, and using georeferenced aerial photos as guidance. To aid the surveyors in distinguishing boundaries between dune wetlands and dry dune communities, it was helpful to identify certain indicator species that could be used to help delineate the edge of dune slacks. The basic premise that dune slacks are influenced by the water table meant that in many cases the extent of species strongly associated with damp habitats provided a useful guide. The relative significance of species differed slightly with each site, but usually included *Hydrocotyle vulgaris* (Marsh pennywort), *Carex nigra* (Common sedge), *Agrostis stolonifera* (Creeping bent), *Eleocharis* sp. (Spike-rush) and *Epipactis palustris* (Marsh helleborine) as well as a range of bryophytes. *Calliergonella cuspidata* was particularly useful where it occurred (particularly in NVC communities SD14-15 and SD17) due to its abundance and mat-forming habit. Conversely, certain species strongly associated with dry habitats such as *Ammophila arenaria* (Marram grass) and *Chamerion angustifolium* (Rosebay willowherb) usually helped identify areas outside the extent of the slack.

Once a dune slack was located and delineated, surveyors identified apparently homogenous stands of vegetation, following NVC guidance (Rodwell, 2006). The boundaries of each stand were walked and digitised using the GPS-tracking functionality in Arcpad. Occasionally the GPS accuracy could drop to as low as 20m, at which point the aerial photos were helpful in confirming the location. Associated with each polygon drawn, the information listed in Table 1 was captured.

Table 1. Digital mapping data collection form filled in for each polygon digitised.

Field	*Data entry method*
ID	Unique polygon ID generated by Arcpad
NVC community	Selected from list OR free text
NVC sub-community	Selected from list OR free text
Notes	Free text field for target notes relevant to each polygon; surveyors included dominant species and previous slack ID where relevant
NVC community 2 (mosaic)	Selected from list OR free text
Proportion NVC community 1	Where a mosaic of two habitats occurs the proportion of each was specified
Proportion NVC community 2	

Due to the time constraints of the survey, it was not possible to follow the standard NVC guidance to record at least 5 quadrats in each stand of vegetation (Rodwell, 2006). A variety of resources were used to identify communities, including surveyors' personal experience, NVC habitat keys & descriptions, NVC floristic tables and the use of TABLEFIT software *in situ*. TABLEFIT can perform a useful function with reduced species lists with or without cover data (as well as single or multiple full quadrats), so mappers were able to make use of this for guidance throughout the survey, where the scale of the project otherwise precluded the recording of full quadrats. Close contact throughout the survey of the mappers with those surveyors who were recording quadrats provided an extra level of quality assurance in the mapping exercise.

All wetland communities within the interior of the dune system were mapped at the NVC sub-community level where possible with a minimum mappable unit of 10 x 10m. Although dry dune and other habitats were not mapped, transitions between wet and dry communities were. Former slacks that are now dry and no longer contain slack vegetation were identified by target notes, but their boundaries were not mapped.

4.1.2 Location of vegetation quadrats

Using the GIS resources described above in the mapping methodology, SDGB quadrats for which data were available were re-located. Some expert judgement by the surveyors was required to re-locate the original quadrat position, particularly where error or distortion in the SDGB survey map was evident. Locations of quadrats recorded in 2012 are shown in Figure 6.

4.1.3 Vegetation quadrat recording methodology

Once quadrat positions were located, a 2x2m quadrat oriented north-south was surveyed. The location of the centre of the quadrat was recorded using a Garmin Etrex GPS, to around ±5 m accuracy. Within the quadrats all vascular plants and bryophytes were identified and percentage cover recorded. Where cover of a species was <1%, a value of 0.1% was recorded where a single individual was present, and 0.5% where more than one individual was present, to enable conversion to Domin values (+ and 1 respectively). Cover values between 1 and 10 were recorded to the nearest 1%, and above that to the nearest 5%. Where species identification was not possible in the field (primarily bryophytes), samples were collected and later verified by a specialist.

Additional parameters such as bare ground, aspect, slope, as well as data regarding management in evidence such as grazing, dunging, urine patches, evidence of scrub clearance, etc. were recorded (Table 2). Vegetation height was measured by placing a metre ruler at 5 random locations within the quadrat, and estimating the sward height to which 80 % of the vegetation reached, within a 20 cm radius of the ruler. A unique ID number was assigned to each quadrat within the database, and where relevant the associated quadrat number from the SDGB survey was noted within the recording form. Two photographs were taken at each quadrat facing North; one looking down on the sward, and the other including the surrounding habitat for context. Unique quadrat ID and a four letter site code were included within photographs. Quadrats were allocated to a NVC community following the methodology described for mapping above, though if required TABLEFIT analysis could be delayed until later on with reference to the full species list.

Table 2. Data collected associated with each quadrat.

Category	***Sub-category***	***Data entry method***
ID	Unique quadrat ID generated by arcpad	n/a
1990 ID	Quadrat number assigned in SDGB survey	Free text
Characteristics	GPS location	Free text
	Angle of slope (degrees)	
	Aspect (compass degrees)	
	Vegetation height (cm; 5 measurements)	
Management	Grazed?; Rabbit; Sheep; Cattle; Horse; Other animal (specify); Mown; Scrub-cut; Trampled by people; Evidence of fires; Other disturbance (specify)	Choice (yes/no/don't know) & free text to specify 'other'
Additional info.	Flooded at time of survey; Soil sample taken	Choice (yes/no)
	Depth(cm); Photographic record; Soil features	Free text
NVC community	NVC community description	Free text
Vegetation data	Name and % cover for each species	Drop down choice for name and free text for %cover

4.1.4 Species nomenclature

Plant species nomenclature follows that of Stace (2010) for vascular plants and Smith (2004) for bryophytes. Biological Records Centre (BRC) species codes are associated with all vegetation data within the database.

4.1.5 Analysis of change in vegetation

The survey team in 2012 re-visited all areas that were mapped as wetland in 1989, mapping dune wetland vegetation, including any new wetland features e.g. ponds or scrapes noticed while on site, and were guided by the 1989 map.

Change in mapped area was assessed for all mapped dune wetlands. Polygons for wetlands in 1989 which corresponded to areas mapped or revisited in 2012, were digitised from the scanned and georeferenced hard copy vegetation survey map of 1989. The area comparison included the following:

- Locations mapped as wetland in 1989, but deemed no longer to be wetland vegetation in 2012 based on lack of slack vegetation indicator species (see main report Stratford et al. (2013), and methods section above). Note that only wetland vegetation types were mapped in 2012, so where vegetation had changed to a non-wetland type this was noted in a target note, but the extent was not mapped. These therefore represent a contraction in the area of wetland at the site.

- Locations mapped as wetland in both 1989 and 2012.

- New wetland features mapped in 2012.

Each polygon (1989 and 2012) was assigned a code for broad vegetation type (Table 3) for ease of interpretation of multiple vegetation classes and communities. The 1989 survey used the draft version of the NVC for coastal habitats, which meant only a simplified cross-comparison over time was possible. The draft NVC only distinguishes between calcareous-type slacks and acid-type slacks. Mapped polygons are shown in Figure 7.

Table 3. Broad vegetation codes used for reporting of change in mapped area.

Code	Vegetation type
c	Calcareous slack type (Final NVC SD13, SD14, SD15, SD16)
a	Acid slack type (Final NVC SD17)
s/d	Slack to dry transitional
d	Dry habitats
sm	Saltmarsh
wp	Wet pasture (usually frequent Juncus spp) (M23, MG8, MG10, MG11, MG12, OV28)
w	Other wetland type (including swamp, mire, open water, wet woodland, ponds etc.)
t	Trees or scrub (most sites this will be conifer plantations)

Change in vegetation composition was assessed by analysis of a number of quadrats from 1989 in wetland areas which were resurveyed in 2012. Quadrats were relocated based on maps from 1989 and interpretation of likely location on the ground in combination with maps and high resolution orthorectified recent aerial photography. GPS grid-references were taken for quadrat locations in 2012, accuracy + 5m. We estimate that the majority of these quadrats were relocated within 10m of the original quadrat location, but it is likely that some were not so accurately relocated. At each quadrat, vegetation height was recorded. Soil cores were not taken at Holme Dunes.

Where available, species composition of quadrats from 1989 was entered by hand from floristic tables in the Radley et al. (1989) report. Species names were harmonised to Biological Recording Centre (BRC) names, and mean Ellenberg indices for environmental indicators (L=Light; F=Moisture; R=Reaction/pH; N=Nutrients; S=Salinity) and for climate indicators (Tjan=Minimum January temperature; Tjul=Maximum July temperature; Prec=Annual precipitation) were calculated for each quadrat in each time period based on the presence/absence of species in the quadrat. Percentage abundance data for 2012 were converted to 10-point DOMIN as in Rodwell (2006).

4.2 Results

4.2.1 Change in mapped area of dune wetlands

Changes in mapped area of dune wetlands at Holme Dunes between 1989 and 2012 are summarised in Table 4 below. Figure 6 shows the extent of the area mapped in 2012, with polygons colour-coded by broad vegetation code (Table 3), and labelled with the NVC communities assigned.

Table 4. Holme Dunes. Mapped area (ha) of broad vegetation classes in 1989 and 2012, showing net change, and percentage change for classes with area > 1 ha in 1989.

Area summaries	1990	2012	Net change	%change
Slacks+slack/wet transitions	3.6	0.3	-3.3	-92.9
Slack/dry transitions	0.0	0.2	0.2	-
Dry habitats	1.5	3.5	2.1	143.3
Other wetlands	0.1	0.1	0.0	-
Total slacks	3.6	0.5	-3.1	-87.1
Total slacks and other wetlands	3.7	0.6	-3.1	-84.2
(Total Mapped Area)	5.1	4.1	-1.0	-19.7

There was some change in wetland area between the two time points. Detailed change analysis using a change matrix was not possible within the scope of this study. However, based on Table 4 and interpretation of the maps and database (available electronically from Natural England), the following broad changes are apparent from this analysis.

Slacks and slack/wet transitions declined, with a roughly similar increase in area of dry habitats. The total area of slack and wetland declined by 84%. Of the wetland areas identified as slack, these generally had a poor fit to NVC slack communities, most closely resembling SD17 due to the lack of *Salix repens.* This represents a shift in slack community type from the allocations of many of these areas to SD16 in the 1989 survey.

4.2.2 Vegetation change revealed through analysis of repeated quadrats

In 2012, 6 quadrats were surveyed at Holme Dunes. These had previous vegetation data and could be used for analysis of change over time. All quadrats are listed, together with basic descriptive information in Table 6 at the end of this report, with locations shown in Figure 6.

Changes in Ellenberg environmental and climate indicators are summarised in Table 5. There was a significant decrease in Ellenberg Salinity, and a significant increase in species richness, but no significant changes in other environmental indicator scores, or climate indicator scores at this site. The conservation implications of the increase in species richness have not been evaluated.

Table 5. Holme Dunes. Change in environmental and climatic indicators between 1989 and 2012 showing mean, standard deviation (s.d.) for each year, and whether there was a significant difference over time (in bold, * <0.05, ** <0.01, * < 0.001). N = number of quadrats. See methods for description of indicators.**

N=6	Indicator	1989	2012	Significance
Mean	Light	7.42	7.22	
Mean	Moisture	5.49	5.78	
Mean	pH	6.18	6.34	
Mean	Nutrients	4.51	4.78	
Mean	**Salinity**	**0.88**	**0.66**	*
Mean	JanTemp	3.73	3.70	
Mean	JulTemp	14.65	14.72	
Mean	Precipitation	1070	1052	
Mean	**Spp Richness**	**15.00**	**23.00**	**
s.d.	Light	0.19	0.14	
s.d.	Moisture	0.50	0.62	
s.d.	pH	0.20	0.32	
s.d.	Nutrients	0.30	0.52	
s.d.	Salinity	0.39	0.27	
s.d.	JanTemp	0.10	0.07	
s.d.	JulTemp	0.12	0.13	
s.d.	Precipitation	21	22	
s.d.	Spp Richness	5.22	6.00	

4.3 Discussion (in context of hydrological & other key local drivers)

There are no clear signals of change at Holme Dunes. The indications of drying due to changes in habitat area are not supported by change in Ellenberg scores of the six repeat quadrats. There are no changes in indicators of climate or the other environmental factors, except an increase in Ellenberg Salinity scores which is difficult to interpret. Changes between categories in mapped area may therefore be in part due to differences in surveyor interpretation, made more difficult by the poor fit of vegetation assemblages at Holme to the NVC classification.

5 Implications for management

- Vegetation assemblages at Holme show a poor fit to the NVC, and areas of wetland are relatively small at the site. This makes specific management recommendations for these areas difficult. Interpretation of results from this survey does not suggest any obvious management recommendations.

6 References

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7 Quadrat information

Table 6. List of quadrats surveyed at Holme Dunes, with associated environmental data. Note soil cores not collected at this site and quadrat angle and aspect not recorded. OM (organic matter) = organic horizon thickness. LOI% (Loss On Ignition) = % organic matter content.

Quad Code	x	y	ANGLE SLOPE (degrees)	ASPECT (degrees)	Veg Height (cm)	OM thickness (cm)	Soil pH	LOI %	Quad Type
Q32	571150	344920			65				RepeatQuadrat
Q31	571126	344903			40				RepeatQuadrat
Q28	571038	344861			15				RepeatQuadrat
Q27	570965	344748			35				RepeatQuadrat
Q39	570770	344617			25				RepeatQuadrat
Q42	570704	344682			40				RepeatQuadrat

Figure 6. Locations of quadrats surveyed at Holme Dunes NNR. © NERC (CEH) 2013. © Next Perspectives.

8 Survey map

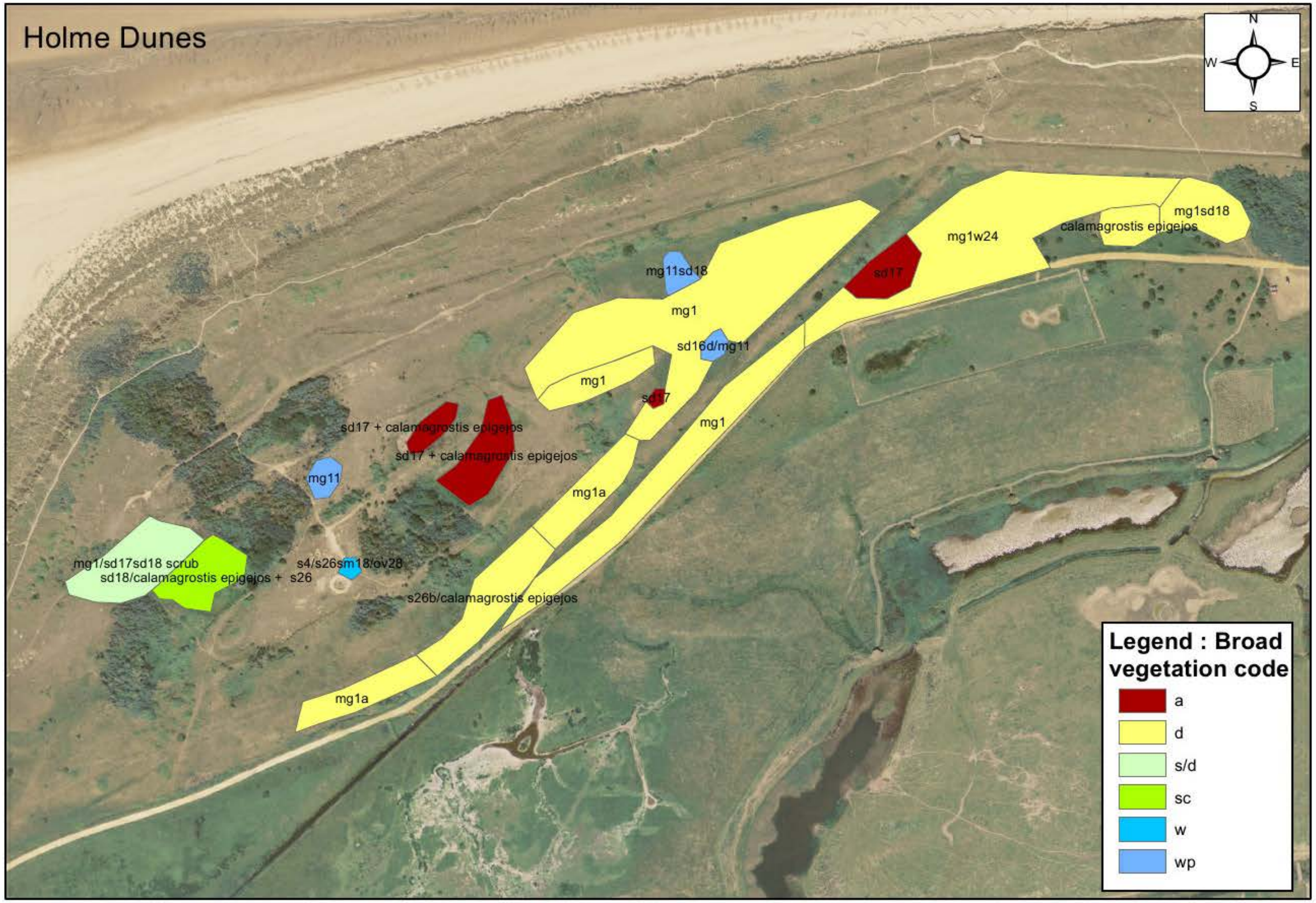

Figure 7. Holme Dunes. NVC communities mapped during 2012 vegetation survey. Broad vegetation codes are described in Table 3.