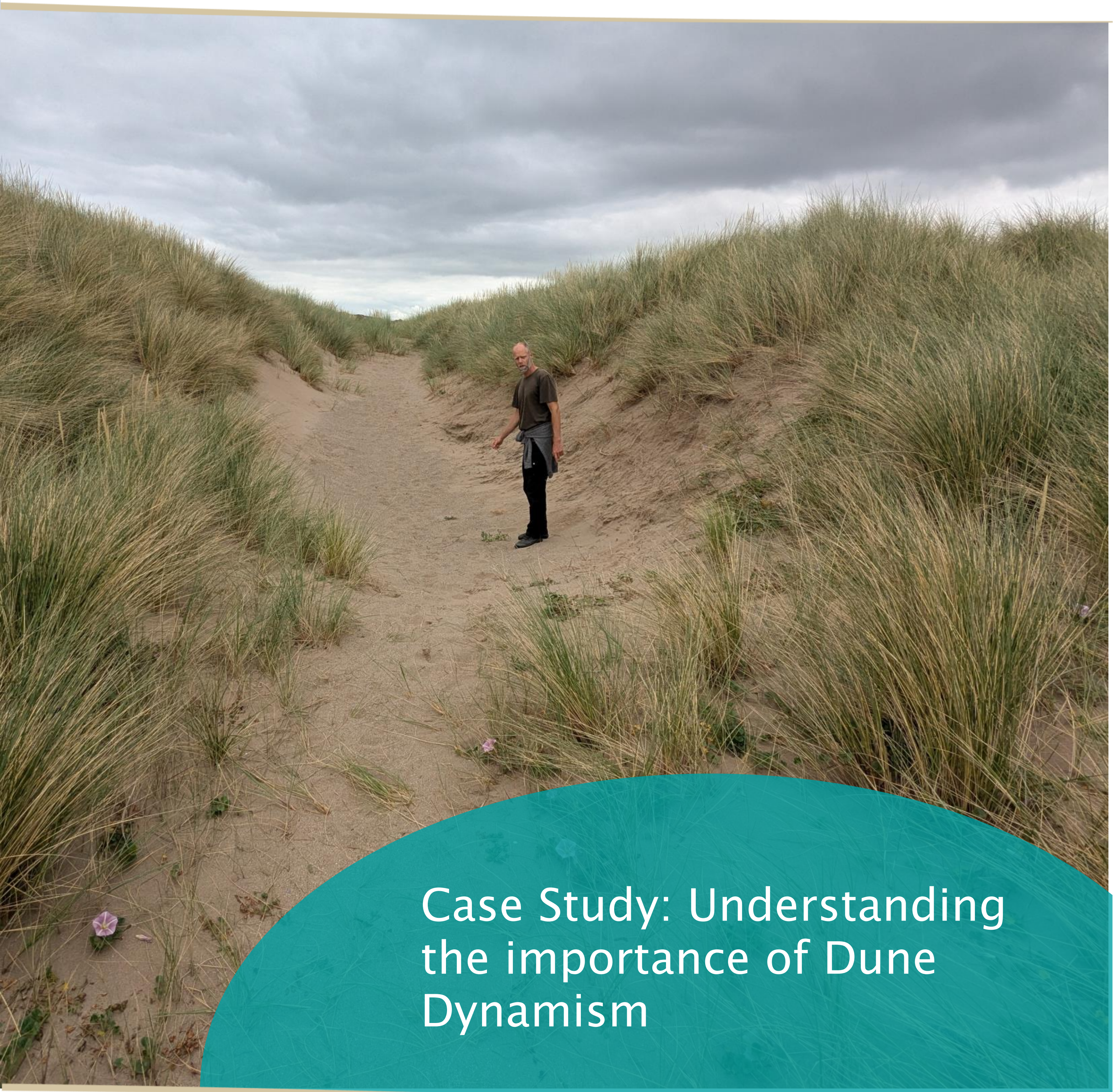

Case Study: Understanding the importance of Dune Dynamism

Contents

1 NON-TECHNICAL SUMMARY

Sand dunes are living landscapes. They shift, grow, erode, and rebuild in response to wind, waves, and weather. This natural movement — known as *dune dynamism* — is essential for healthy dune ecosystems. When dunes stop moving, they lose the open, sandy habitats that many rare plants and animals depend on.

Why dune movement matters
Healthy dunes contain a mix of vegetation and bare sand. Bare sand is especially important because it creates warm, open conditions that support many specialised species. Historically, some English dunes had large areas of bare sand (in places up to 60–70%) but today most sites have only a few percent. This loss of mobility is a major reason why nearly all English dune habitats are currently classed as being in *unfavourable* condition.

What's causing dunes to become over-stabilised?
Over the last century, dunes have become increasingly covered by tall grasses, scrub, and invasive plants. Several pressures contribute to this:

- Reduced natural disturbance (e.g., fewer storms or grazing animals)
- Human activities such as coastal development, sea defences, and trampling
- Climate change, which encourages faster vegetation growth
- Interruptions to natural sand movement from the beach inland

When vegetation becomes too dense, dunes lose their ability to shift and regenerate.

How dune mobility is assessed
Scientists compare how mobile dunes *should* be (based on climate) with how mobile they *actually* are (based on vegetation cover and bare sand). This helps identify whether a dune system is behaving naturally or has become unnaturally stabilised. Tools include:

- Percentage of bare ground
- Historic and current aerial photography
- Climate based mobility indices
- On the ground surveys of vegetation and landform condition

This approach helps pinpoint what's driving change and where management is needed.

Restoring dynamism: what the Dynamic Dunescapes project has done
The project has worked across England and Wales to bring movement back into dune systems. Actions included:

- Clearing scrub and invasive species
- Creating notches and blowouts to let wind move sand again
- Scraping back vegetation to expose bare sand
- Reintroducing grazing
- Monitoring change using high resolution aerial and LIDAR mapping

Over 325 hectares of dunes have been rejuvenated, with significant increases in bare sand at several sites and reductions in invasive species and scrub. This provides improved conditions for natural sand movement. Further surveys will be undertaken between 2026 and 2029, which will give a fuller picture of long-term recovery.

What "favourable condition" looks like
For dunes to be considered healthy, they need:

- Active sand movement

- A natural, varied dune topography
- Good connectivity with the beach and wider sediment system
- A mosaic of vegetation and bare sand (up to 50% bare in the most mobile zones)
- The ability to adapt to storms, sea level rise, and climate change

These principles guide how SSSIs and SACs are assessed and managed.

2 PURPOSE OF THE DOCUMENT

This document provides background to dune dynamism and explains why mobility is essential for the ecological health of English sand dunes. It summarises the current condition of dune habitats, outlines lessons from the Dynamic Dunescapes project, and proposes methodologies for assessing dune mobility. It sets out key attributes that can be used to measure dune dynamism with an example from Braunton Burrows. This information can be used to inform condition assessment at a site level and Favourable Conservation Status of the habitat more widely, with the ultimate aim of providing information to inform updates to the UK national site network Standard Data Forms when the opportunity arises. The aim is that the document will support site managers, decision makers, and others involved in dune conservation.

Introduction

Dune dynamism — the natural movement of sand within dune systems — is a core indicator of dune health and a key criterion for assessing the condition of sand dunes in England. Bare sand and early successional habitats are particularly important, supporting many species such as Sand Lizards, Natterjack Toads, and many rare or scarce plants and invertebrate's species.

One of the key aims of the Dynamic Dunescapes project has been to increase the ability of dunes to be dynamic and increase recognition that dune dynamism is crucial to dune health. This document explains how using bare sand as a proxy to assess dune dynamism can lead to a better understanding of the overall condition of a site.

The Sand Dune Managers Handbook (Denning and others, 2024) provides detailed guidance on coastal geomorphology (coastal processes) that drive the formation of sand dunes and maintain their ecological structure and function. It also provides many case studies and management techniques, that can increase the extent of bare sand and create a 'sustainable' dynamism/ movement back into our dune systems. Relevant sections include dune dynamics, notching, bare sand creation, blowout reactivation, turf stripping, and slack restoration.

3 BACKGROUND: DRIVERS OF DUNE DYNAMISM

Dune morphology and vegetation of dune systems vary spatially, with regional climate (wind, temperature, precipitation) exerting strong control over vegetation cover and mobility. Superimposed on these climatic drivers are natural disturbances and human activities (Table 1).

Table 1: Types of disturbance which can cause direct changes to relative proportions of vegetation cover and bare ground (adapted from Delgado-Fernandez and others 2019).

		Increased %	
Disturbance type	**Driver**	**Bare sand**	**Vegetation cover**
Geomorphology	Littoral sediment budget	Negative	Positive
	Foredune sediment budget	Negative (extreme positive)	Positive
	Sea level	Rising	Stable – falling?
	Storm surges	Frequent	Infrequent
Vegetation	Pioneer grasses	No burial/salt tolerant	Burial/salt tolerant
	Shrubs	Few to no salt tolerant	Burial/salt tolerant
	Animals	Grazers & burrowers	Few to none
Direct human interventions	Grazing	High	Low to absent
	Farming	Active	Low to absent
	Recreation	Unauthorised trails, vegetation trampling	Limited to none
	ATV and 4-wheel drive activity	High	Low to absent
	Other land uses (e.g. sand mining, military uses)	High	Low to absent
	Management activities leading to artificial mobility (e.g. notching)	Present	Absent
	Management activities leading to artificial stabilisation	Absent	Present

Over the last century, many dunes have become over stabilised due to:

- Increased tall grass and scrub cover
- Reduced natural disturbance
- Coastal development and sea defences
- Climate driven vegetation growth
- Changes in atmospheric composition
- Restricted sediment supply

Anthropogenic interventions can alter geomorphological processes, for example:

- Sea defences fossilising dunes behind walls
- Coastal squeeze of seaward dunes
- Restricted landward migration
- Increased vegetation growth due to climate change (see section 4).

Although succession from bare sand to vegetated dunes is natural, its rate can be altered by human activity. Understanding the relative influence of natural and anthropogenic drivers is essential for diagnosing site condition and targeting management.

Climate change affects coastal sand dunes through both direct and indirect pathways. Direct impacts include habitat loss from coastal erosion and rising sea levels, along with shifts in suitable climate conditions affecting dune biodiversity. Indirect effects occur through changes to key ecosystem processes such as soil mineralisation, plant productivity, soil moisture, evapotranspiration, and groundwater recharge which alter dune hydrology. These changes can raise or lower the water table sustaining dune slack habitats and influence how sand moves, with wind-driven sand transport being particularly sensitive to changing climatic conditions.

One of the key climate driven threats to sand dune biodiversity in England and Wales is the loss of structural diversity through stabilisation. This has been attributed to the combined effects of atmospheric deposition of nitrogen, increases in temperature, changes in precipitation patterns and wind speeds, promoting vigorous vegetation growth that favours species which thrive in nutrient rich conditions at the expense of slower growing dune specialists. The net result is an overall loss of diversity and the stabilisation of successional communities. The most recent assessment of the conservation status of the UK's dunes indicated 'bad, declining' or 'bad, no change' condition, mainly due to overstabilisation and scrub cover (JNCC, 2026).

The current IPCC climate change scenario SSP2-4.5 (increase in temperature of 2.9 ◦C), predicts that by the year 2080 - 2100 the total amounts of precipitation during the growing season in northern, western and central Europe will increase while consecutive dry days will also increase (with respect to 1981 – 2010) (Gutiérrez and others, 2021).

Coastal dune development has been linked to growing season precipitation through promoting the growth of dune building grasses e.g. *Ammophila arenaria* (Marram) and *Elymus junceiformis* (Sand couch). Wet conditions promote rapid vegetation growth, increasing embryo dune formation and dune crest heights. High rainfall can also reduce sediment transport by increasing surface moisture levels. The interaction between vegetation growth and rainfall can substantially alter dune development, reducing variability and increasing dune stability as conditions become wetter.

More extreme changes to the duration and seasonality of rainfall which lead to increased frequency and duration of periods of drought might also influence a shift in species composition. Observations in the Mediterranean (Sorce and others, 2019) for example suggest some susceptibility of *Ammophila* to extended dry periods. Longer lasting droughts might become increasingly important as they may cause a decline in vegetation cover with the potential to change fixed dunes into active dunes.

With increasing frequency of climate extremes, the resilience of dune-building vegetation will become an important indicator for determining the levels of dynamism within a system and the intervention measures needed to maintain it.

Increasing severity of winter storms linked to higher rainfall and rising sea levels will enhance mobility of some dunes, by exposing fresh sand and reactivating areas that have become overly vegetated. High wave energies and storm surges can result in erosion of frontal dunes and accelerate their landward retreat. Repeated storm driven erosion can lower the dune crest enough to increase the risk of coastal flooding, especially where sediment supply is limited or where hard defences restrict natural rebuilding. Naturally dynamic dunes able to migrate inland or change position on the shoreline are more resilient to the impacts of sea level rise and increasing storminess.

Coastal management strategies seek to restore dynamics to stabilised dune systems on a landscape scale by allowing natural, geomorphological processes that produce a habitat mosaic with a wide range of ecological conditions. The reinstatement of natural mobility and early successional biodiversity is typically achieved through measures designed to increase sediment dynamics such as vegetation removal and notch cutting. The success of these management approaches could become more challenging to deliver and sustain without repeated interventions in the future, as faster grass encroachment and dune recovery can be expected along temperate coastlines under a changing climate.

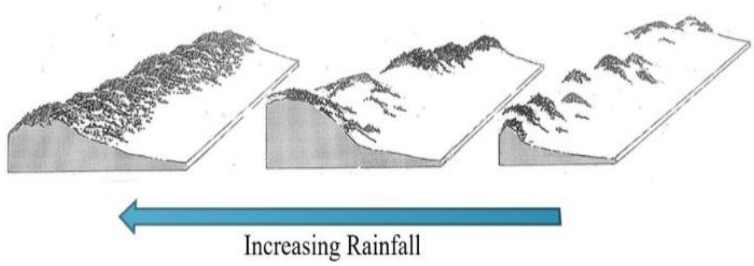

Figure 1 - A conceptual model of foredunes as they relate to rainfall (Hesp 2025).

Rising variability and extremes of rainfall are expected to accelerate dune fixation, reducing habitat diversity and limiting the natural dynamism required for long-term resilience. Conversely, prolonged droughts and more severe storm events may increase dune mobility, creating conditions that enhance climate resilience and support a broader range of biodiversity. By anticipating these outcomes coastal managers can prioritise adaptive management strategies such as restoring natural sediment dynamics and supporting early successional habitats that maintain the ecological functions and protective value of coastal dune systems under future climate scenarios.

Impacts of climate change on dunes are also described in the Climate Change Adaptation Manual for Coastal Sand Dunes (Natural England and RSPB, 2019).

UK National Site Network

The Habitats Regulations General Implementation Report for England (Defra, 2026) provides an overview of the current condition of English Sand Dunes that form part of the UK National Site Network (particularly Special Areas of Conservation). It provides an evaluation of how conservation measures (*i.e.* as undertaken through the Dynamic Dunescapes project) have supported the over-arching objectives to conserve and restore biodiversity by preserving, maintaining, or restoring natural habitats and species, including wild birds.

The report shows that almost all Annex I dune habitats are in Unfavourable bad (U2) condition. Only H2160 (Dunes with *Hippophae rhamnoides*) is assessed as Favourable (see Table 2). One of the key indicators of Conservation Status is structure and function which is strongly influenced by vegetation cover, bare sand, and nitrogen exceedance. This is a major driver of poor status.

Table 2 – Summary of the Conservation Status of Annex I Sand Dune Habitats in England

Annex I habitat	Overall Conservation Status[1]	Range	Area covered by habitat	Structure and functions	Future prospects
H2110 - Embryonic shifting dunes	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-bad (U2)	Unfavourable-bad (U2)
H2120 - Shifting dunes along the shoreline with *Ammophila arenaria* (‘white dunes’)	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-bad (U2)	Unfavourable-bad (U2)
H2130 - Fixed dunes with herbaceous vegetation (‘grey dunes’)	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-bad (U2)	Unfavourable-bad (U2)
H2150 - Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-inadequate (U1)	Unfavourable-bad (U2)
H2160 - Dunes with *Hippophae rhamnoides*	Favourable (FV)	Favourable (FV)	Favourable (FV)	Unfavourable-inadequate (U1)	Favourable (FV)
H2170 - Dunes with Salix repens ssp. argentea (*Salicion arenariae*)	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-bad (U2)	Unfavourable-bad (U2)
H2190 - Humid dune slacks	Unfavourable-bad (U2)	Favourable (FV)	Unfavourable-bad (U2)	Unfavourable-bad (U2)	Unfavourable-bad (U2)

SSSI Condition Data

Sites of Special Scientific Interest (SSSI) monitoring data can also be used to provide an

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[1] Favourable (FV): The habitat or species is thriving throughout its natural range and is expected to continue to do so.
Unfavourable-inadequate (U1) (Poor): The status is below the favourable reference values, but not critically so. This is often referred to as "Poor" in general EU reporting.
Unfavourable-bad (U2) (Bad): The status is significantly below the favourable reference values, indicating a high risk of decline or severe degradation. This is often referred to as "Bad" in general EU reporting.

indication of the overall condition of sand dune habitat. Three SSSI features are relevant - Sand dune; strandline, embryo and mobile dunes (SD1-6), Fixed dune grassland, Humid dune slacks. The SSSI data shows similarly poor condition, with high proportions of “Unfavourable Declining” across dune features and very low levels of favourable condition, particularly in humid dune slacks (see Table 3).

Table 3 - Proportion of SSSI sand dune features in favourable, unfavourable and unrecorded condition across England.

SSSI Feature	Proportion of total area
Sand dune; strandline, embryo and mobile dunes (SD1-6)	**100.00%**
Favourable	23.53%
Unfavourable - Recovering	13.51%
Unfavourable - No change	8.55%
Unfavourable - Declining	36.84%
Not Recorded	17.58%
Fixed dune grassland	**100.00%**
Favourable	23.22%
Unfavourable - Recovering	2.69%
Unfavourable - No change	8.43%
Unfavourable - Declining	60.69%
Not Recorded	4.61%
Partially destroyed	0.36%
Humid dune slacks	**100.00%**
Favourable	0.15%
Unfavourable - Recovering	7.19%
Unfavourable - No change	24.09%
Unfavourable - Declining	13.86%
Not Recorded	54.72%

Taken downloaded from Natural England’s Designated Sites View (Site Search) on 28th January 2026.

Bare sand is a critical indicator of dune dynamism. This is recognised in the Definition of Favourable Conservation Status (FCS) for Coastal Sand Dunes (Rees, 2021) which emphasis that dune mobility is essential part of an active dune system, and critical for heat tolerant species, with over 60% of Section 41 dune species dependent on early successional habitats (Webb and others, 2010).

Despite this we know that the amount of bare sand across England's dunes is significantly less than desired (although currently we do not have a national figure), and that there have been significant losses of bare sand overtime. The 1980-1990s national sand dune survey of England recorded only 253 ha of bare sand (roughly 2% of the total 12,000ha surveyed[2]).

As an example, at Braunton Burrows we know historically, the dunes had significantly higher levels of bare sand, and experienced natural and human caused sand mobility, with up to 60-70% of the site remaining unvegetated. This is supported by photographic evidence from the site from 1940 (i.e. before the military activity). Radley (1994) estimated bare sand across the surveyed site[3] as roughly 6.5% (37.9ha). By 2016 (see Table 2), it was estimated that around 2% (~12.7ha) of the site remained open (largely due to the continued military vehicle use and conservation management). Follow interventions as part of the Dynamic Dunescapes project, the 2023 CASI/ Lidar survey identified that bare sand had increased to 3.45% (20.62ha) with the project increasing bare sand by 7.9 ha. While we are not suggesting we want to return the extent of bare sand 1940's level, favourable condition typically requires around 20% bare sand, rising to 50% in the mobile dune zones (Denning and others, 2024). In addition, it should be noted that many English SSSI's were already degraded when designated, meaning that the area of bare sand etc at time of designation may not reflect the true Favourable condition at the site.

6.1 Assessing dune mobility – a holistic approach

Dune mobility depends on vegetation cover, which is controlled by climate. Mobility indices (e.g., Lancaster 1988) estimate expected vegetation cover based on climate variables.

For example, in arid to semi-arid regions, coastal vegetation cover is scarcer, which causes greater mobility in dune systems. In temperate and tropical regions, wetter climates are ideal for vegetation growth; therefore, in locations such as the UK, dune systems can be expected to have greater vegetation cover and be relatively inactive in comparison with their arid/ semi-arid counterparts. Dune mobility indices exist which are based on regional climate variables (e.g. precipitation, wind strength) as illustrated in Figure 1. Although many of these indices have been devised and applied on continental dunes, there is great potential to use them in the context of coastal dunes, as their broader bio-geomorphological state is also driven by climatic factors.

Various types and levels of disturbance (listed in Table 1) can cause or prevent the establishment of vegetation, potentially causing significant deviations from the expected system state. The observed vegetation cover is therefore a useful proxy when assessing dune mobility and comparing this either qualitatively or semi-quantitatively with the expected vegetation cover based on climatic factors, can indicate whether the dune field is in a favourable or degraded state. This process can target removal of stressors to the system, which may have caused or be causing deviations from the expected system state, either by causing unnatural expansions or contractions in vegetation cover.

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[2] The area of sand dunes in England is estimated at approximately 12,000 ha based on the 1987-1990 Sand dune survey of Great Britain (Radley, 1994). This survey identified 121 individual locations and mapped all habitats over sand deposits at the coast to National Vegetation Classification level, together with other semi-natural and modified habitats within the dunes surveyed. Included within the 12,000 ha are 1345 ha of plantations, scrub, improved grassland and other cultivated land plus 375 ha of golf fairways.

[3] Which does not necessarily correspond to the designated site boundary

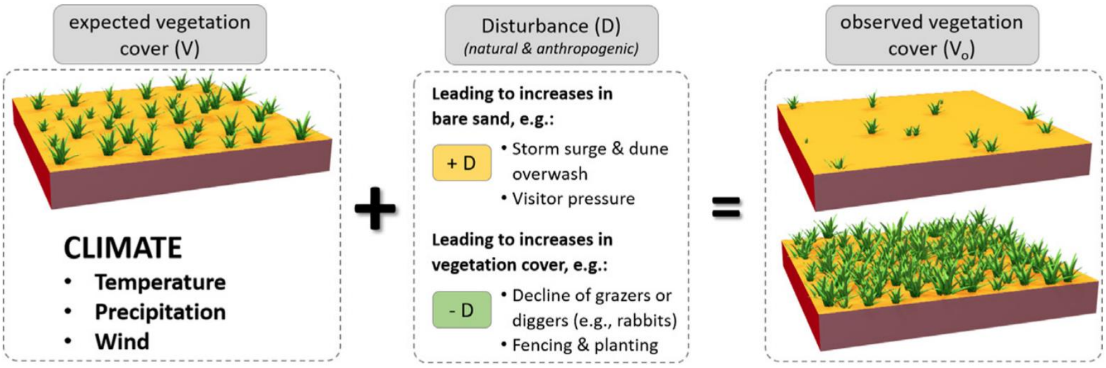

Figure 2 – Graphical abstract taken from Delgado-Fernandez and others, 2019.

The following approach is recommended to assess dune system condition, by comparing the actual mobility of the system with the expected mobility based on the regional climate. The greater the difference between the expected and actual state, the greater significance of impact that external drivers (either natural or anthropogenic) have had on the system. The approach also attempts to investigative the relative influence of likely drivers for any changes to dune system and whether these are natural or anthropogenic forcers. This approach can not only be used to assess dune condition and 'naturalness', but also to assess the potential impact of management interventions. A comprehensive overview of this approach is detailed in Delgado Fernandez and others (2019), but the below points provide a summary guide: -

a. **Use a dune mobility index** to determine expected mobility. In the above study, the mobility index by Lancaster (1988) was used, but other indices can be considered.
b. **Measure % bare ground** across the site and within sub areas within the dune field to provide an indication of actual dune mobility. By considering both the whole site and smaller subdivisions it allows assessment of spatial variability in dune mobility across the site. It is also recommended to use historic aerial photography to assess temporal variations in dune mobility.
c. **Use historical aerial photograph** and other available data to assess temporal change.
d. **Analyse drivers of change** (natural vs anthropogenic). Using available data conduct an historic trend analysis to assess the relative influence of the various drivers listed in Table 1.

The above approach provides a semi-quantitative way of assessing dune dynamism, its climatic, historic and contemporary drivers, and identifies the ideal ballpark amount of vegetated area/bare ground to consider as a near-natural target. There are limitations to the approach and opportunities for its improvement, as detailed within Delgado Fernandez and others (2019) but is likely to be the current best practice for assessing dune condition based on mobility.

6.2 Attributes for measuring dune dynamism

Extent of bare sand is a measurable proxy for dune health and an indicator of dune dynamism. The 2004a JNCC Common Standards Monitoring Guidance for Coastal Sand Dunes, provides targets for bare sand for the different sand dune habitat, although these are now considered to low given widespread over-stabilisation today.

The following figure (Figure 3) taken from the Sand Dune Managers Handbook gives typical figures for the extent of bare sand across different dune features.

Key criteria for favourable condition of coastal sand dune features

For a whole site:

- less than 10% of any dune site should retain dune scrublwoodland into the long term
- an 'active dune zone' should be present along 95% of the dune frontage, subject to local natural coastal processes and sediment supply

For strandline/embryo/mobile dunes, 'favourable' condition includes:

- native scrub should be rare or absent from any dune site's mobile dune grassland
- non-native scrub should be rare or absent. with invasive non-native species such as sea buckthorn and Rosa rugosa absent
- up to 50% of any dune site's mobile dunes should constitute bare sand

For fixed dune grassland, 'favourable' condition includes:

- between 5% and 10% of any dune site's fixed dune grassland should have native scrub either scattered or in small clumps
- non-native scrub should be rare or absent. with invasive non-native species such as sea buckthorn and Rosa rugosa absent
- native scrub should be rare or absent from any dune site's semi-fixed dune grassland
- between 5% and 20% of any dune site's fixed dune grassland should constitute bare sand
- any dune site's fixed dune grassland should have 30-70% of its sward comprising short turf. 2-10cm tall

For dune heath, 'favourable' condition includes:

- between 5% and 20% of any dune site's dune heathland should have native scrub either scattered or in small clumps
- non-native scrub should be rare or absent
- between 5% and 20% of any dune site's dune heath should constitute bare sand
- all growth phases of heathers should be present (pioneer/building/degenerate/dead phases)
- some acid grassland present as mosaics providing a contrasting structure

For humid dune slacks/dunes with *Salix repens*, 'favourable' condition includes:

- early vegetation succession stages should make up not less than 20% of the overall extent of any dune site's humid slacks
- between 5% and 10% of any dune site's dune wetlands should have native scrub either scattered or in small clumps
- non-native scrub should be rare or absent. with invasive non-native species such as sea buckthorn; poplars and *Rosa rugosa* absent
- between 5% and 20% of any dune site's wetlands should constitute bare sand
- between 20-40% of the dune slack sward to comprise short turf. 2-15cm tall

Figure 14 - Example criteria for favourable condition of coastal sand dune features based on the Common Standards Monitoring Guidance and internal Natural England targets for tailoring the Favourable Conservation Tables for SSSIs (source Graham Weaver). Note each protected site may have its own conservation objectives which should be referred to in the first instance.

Figure 3 - Key Criteria for favourable condition of coastal sand dune features

Other key attributes include:

- Dune topography
- Integrity of geomorphological processes
- Functional connectivity with the wider sediment system
- Presence of unvegetated surfaces
- Adaptation and resilience to environmental change

Further information on this is detailed below.

Conservation objectives for SSSIs designated for active geomorphology features focus on allowing the processes and features that they create to evolve naturally, unimpeded by human intervention, whilst accepting that some degree of land management will have taken place on many sites. The principal target for these sites will be that there are no artificial developments or modifications of any kind that affect the evolution of the natural geomorphological systems (JNCC, 2004b). The JNCCs Common Standards Monitoring Guidance for Earth Science Sites provides key attributes and targets for sites designated for active coastal geomorphology, which outline critical factors to consider when assessing the condition of sand dunes. This qualitative process includes considering the landform, quality and physical integrity, freedom of geomorphological processes to evolve naturally, and extent of the geomorphological features. An adapted table of these attributes is provided in Appendix 2.

During site assessment, it is worth considering that the impact of the same type and level of disturbance could be spatially dependent, based on potential for recovery. For example, pedestrian trampling on the foredune is likely to impact (bio)geomorphological processes more significantly than in locations further landward due to the exacerbation of marine as well as aeolian erosion processes. Appendix 3 contains an assessment of one of the attributes for Braunton Burrows SSSI active coastal geomorphology feature, which covers the potential impacts of visitor pressure on an area of the site. JNCC (2004b) highlight the difficulties in assessing the naturalness of coastal geomorphology features and particularly in setting acceptable limits on variability of the system, but the focus of the exercise should be on the known historic variability and likely capacity to recover from disturbance. The approach detailed in Sections 5 and 6 could inform this assessment.

For SSSIs and SACs, the sites monitoring specification should provide details of the conservation objectives[4] and definitions of favourable condition for designated features of interest. This includes both ecological and geomorphological features where appropriate. For example, the monitoring specification for Braunton Burrows includes both Supralittoral sediment (*e.g.* sand dunes) and Active process geomorphological (IA) and sets out how the condition of the site should be assessed using key attributes and site-specific targets.

For SAC's there is a greater emphasis on coastal processes on which the sand dune feature relies. For example, for Embryonic shifting dunes H2110, supporting processes includes attributes that consider aeolian (wind-blow) processes, functional connectivity with wider coastal sedimentary system and adaptation and resilience that allow the dunes to adapt or evolve to wider environmental change, either within or external to the site. In addition, dune topography and presence of unvegetated surfaces are key attributes. An example of this is set out in Appendix 1.

[4] Available through Natural England's Designated Site View Site Search

7 DYNAMIC DUNESCAPES PROJECT RESTORING DUNE DYNAMISM

The Dynamic Dunescapes project has delivered extensive interventions to restore mobility and increase bare sand including:

- 325 ha of rejuvenation (scrub clearance, scraping, notching)
- 122 ha of invasive species removal
- 605 ha of grazing introduced

Capturing the extent of bare sand is possible both using remote sensing techniques along with ground surveys. For example, the Environment Agency/ Natural England CASI/ Lidar Habitat Map derives habitat data using CASI (Compact Airborne Spectrographic Imager) and LIDAR (Light Detection and Ranging) data. This is freely available for a number of English sand dunes[5]. Surveys are repeated approximately every 6-years so enable sand dune change over time to be document.

Monitoring Results

Only sites with both pre- and post- intervention mapping are included (*i.e.* Penhale, Gwithian to Mexico Towans, Braunton Burrows). See Table 4 for details but in summary the results show:

- Increases in bare sand
- Reductions in invasive species
- Mixed changes in dune scrub depending on site

The other Dynamic Dunescapes sites including Studland Dunes (Dorset), Lincolnshire sand dunes sites Gibraltar Point NNR and Saltfleetby-Theddlethorpe Dunes NNR, and Sefton Coast sand dune sites currently only have pre-intervention CASI & LIDAR habitat maps, with the post-intervention surveys planned between 2026 and 2028. In addition, the Cumbrian sites (Grune, Silloth Dunes, Sandscale Haws, North Walney, South Walney were resurveyed in 2025, with the results available in 2026).

Table 4 - lists the English Dynamic Dunescapes project sand dune sites monitoring results, showing only the sites where both the project start and completion dates coincided with the mapping of the dune sites as part of the CASI & LIDAR habitat mapping project (Environment Agency, 2024, 2025a, 2025b). (see comments for further information about the data used).

Site	Penhale (Cornwall)			Gwithian to Mexico Towans (Cornwall)			Braunton Burrows (North Devon)		
	Radley	Year 1 (pre)	Year 2 (post)[6]	Radley	Year 1 (pre)	Year 2 (post)	Radley	Year 1 (pre)	Year 2 (post)
Year of survey	**1994**[7]	**2016**	**2024**	**1994**	**2017**	**2024**	**1994**	**2016**	**2023**
Feature									
Bare Sand	25.9ha	1.4% 9.1ha	3.06% 13.8ha	15.3ha	2.74% 10.3ha	2.97% 11.2ha	~6% 37.9ha	~2% 12.7ha	~3.45% 20.62ha
Dune scrub	7.6ha	5.9% 33.6ha	10.8% 67.1ha	35.4ha	12.6% 47.7ha	11.4% 42.8ha	~ 9.4ha	~26% 155ha	-10.3% 61.7ha
Invasive species	-	0.79% 4.9ha	0.25% 1.6ha	-	0.78% 2.9ha	2.63% 9.9ha	-	~0.5% 3ha[8]	~0.35% 2.1ha

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[5] CASI and LIDAR Habitat Map - data.gov.uk

[6] All habitat features figures, taken from the unpublished change analysis report produced for Natural England by the Environment Agency unless otherwise stated, are given in hectares (ha) and percentage (%) as an average for the whole sand dune site. Braunton Burrows Dune 2016 – 2023: Change Detection (EA, 2024); Penhale Dunes 2016 – 2024: Change Detection (EA, 2025); Gwithian to Mexico Towans 2016 – 2024: Change Detection (EA 2025).

[7] Radley (1994) note the surveys were undertaken in the 1980-1990s and the extent data given for bare sand and dune scrub will relate to the whole survey area which does not necessary equate to the protected site boundary. These values can therefore only be considered as indicative.

[8] *Hippophae rhamnoides* (Sea-buckthorn) which is non-native at Braunton Burrows

8 IMPLICATIONS FOR FAVOURABLE CONDITION AND FUTURE MANAGEMENT

Healthy dunes require:

- Active sand movement
- Natural topography
- Functional connectivity with the beach
- A mosaic of vegetation and bare sand
- Capacity to adapt to storms and climate change

The methodologies outlined here can support:

- Site-level condition assessments
- National Favourable Conservation Status evaluations
- Future updates to the Standard Data Forms for sand dunes that form part of the UK national site network
- Targeted management to restore mobility

Long-term monitoring (2026–2029) will provide further evidence of recovery and inform adaptive management.

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Front Cover: Rupert Hawley, Dynamic Dunescapes Manager of Braunton Burrows SAC, in frontal dune notch created with grant funding from the project. (Glen Cooper).

10 APPENDIX 1: EXAMPLE OF ATTRIBUTES, SUB-ATTRIBUTES AND TARGETS RELATING TO COASTAL PROCESSES THAT DRIVE FAVOURABLE CONDITION OF SAND DUNES (IN THIS CASE FOR EMBRYONIC SHIFTING DUNES H2110).

Attribute	Sub-attribute	Target	Summarized explanatory notes
Structure and function (including its typical species)	Dune topography	[Maintain OR Restore] a natural dune topography, and allow natural change that is wind driven (some change may be necessary to maintain the continuity of slacks	Dune topography in this zone can change seasonally and through the years due to wind and tidal events. Accumulations of driftline organic material are important for trapping sand and initiating dune formation.
Structure and function (including its typical species)	Presence of unvegetated surfaces	[Maintain OR Restore] an extent of bare sand of varying sizes in a mosaic with the vegetation (up to 50% of the feature extent)	In these developing, dynamic zones, bare sand should be expected. Lack of bare sand would suggest an artificially stabilised system. Blow-throughs are a natural element of this zone. If extent of sand is towards the upper end of the range, it will become important to assess whether recreational pressures are over-riding natural dynamics.
Structure and function (including its typical species)	Adaptation and resilience	[Maintain OR Restore] the feature's ability, and that of its supporting processes, to adapt or evolve to wider environmental change, either within or external to the site	This recognises the increasing likelihood of natural habitat features to absorb or adapt to wider environmental changes. Resilience may be described as the ability of an ecological system to cope with and adapt to environmental stress and change whilst retaining the same basic structure and ways of functioning. Such environmental changes may include changes in sea levels, precipitation and temperature for example, which are likely to affect the extent, distribution, composition and functioning of a feature within a site.
Supporting processes (on which the feature relies)	Functional connectivity with wider coastal sedimentary system	[Maintain OR Restore] adequate movement of sediment from all key sediment sources (directly from the beach, indirectly from offshore, eroding cliffs etc).	This recognises the potential need to maintain or restore the connectivity of the site to its wider landscape to meet the conservation objectives. These connections may take the form of landscape features outside of the designated site boundary which are important for the continuous supply of sediment (such as soft eroding cliffs, dunes, offshore sand banks). This Annex 1 habitat is an integral element of the 'coastal foredune' (the beach-dune sand-sharing system). However, it is also important that sediment transport that feeds the beach from offshore is also not interrupted. In some cases, sand may come from marram-dominated dunes

			landward (Shifting dunes along the shore with *Ammophila arenaria*).
Supporting processes (on which the feature relies)	Aeolian (wind-blow) processes	[Maintain OR Restore] the natural movement of sand within the site, resulting from wind blow-outs and blow-throughs.	Allowing natural wind-blow (or 'aeolian') processes to operate and to allow active movement of dry sand is important. Blow-throughs are a natural element of the dynamics of this zone. However, excessive recreational pressure can inhibit vegetation growth in sand building phases.

11 APPENDIX 2 ATTRIBUTES AND TARGETS FOR ASSESSING THE CONDITION OF ACTIVE COASTAL GEOMORPHOLOGY SSSIS DESIGNATED FOR SAND DUNE FEATURES (ADAPTED FROM JNCC 2004B).

<table>
<tr><th>Attribute</th><th>Targets</th><th>Practical considerations</th></tr>
<tr><td>Visibility</td><td>Key landform entities not unnaturally concealed or obscured.</td><td rowspan="3">In general, very low levels of disruption that are reversible or temporary may be acceptable and permitted with consent. Changes that may be acceptable are:
- Small superficial modifications, such as fencing or tree planting in non-critically important parts of the site; or which do not significantly affect the functionality of the active process system;
- Small alterations if they are reversible and short term and do not contaminate the site and do not affect critically important parts of the site. The wider system should not be damaged in the long term.
- Small excavations or removal of samples for research that does not significantly impact site morphology (i.e. acceptable if the sampled area can be naturally reworked); the quantity of sampling permitted will depend on its temporal and spatial magnitude, the sensitivity of the site and likely gain in scientific knowledge.
A certain degree of scrub/other vegetation invasion can be tolerated if it is assessed to be a natural successional change and does not completely obscure (or cause damage by morphodynamically constraining) key parts of the site.</td></tr>
<tr><td rowspan="2">Physical integrity</td><td>Physical composition, morphology and internal structure of the landforms and sediments remain undisturbed by anthropogenic interventions.</td></tr>
<tr><td>Factors to assess:
- Natural woodland development and scrub invasion
- Concealment through erection of artificial structures
- Tipping/dumping/infilling
- Tree planting, introduction of vegetation
- Sediment profiling
- Development/engineering works (buildings, artificial structures, etc)
- Track/road building
- Coastal reclamation/sea defence developments
- Dune stabilisation
- Dredging in an active coastal cell
- Damagine recreational pursuits causing accelerated erosion
- Artificially induced changes to water levels
- Contamination/pollution
- Deterioration caused by agricultural use
- Irresponsible research excavation</td></tr>
</table>

		Continuing agricultural use in its present form may be an important factor to maintain the site in favourable condition, e.g. grazing, which improves the visibility of the elements within the site by removing invasive vegetation, which might otherwise stabilise features such as active dunes. Conversely, vegetative development may be judged acceptable, as part of the natural successional stabilisation of a coastal site, or as protection against exacerbated rates of erosion in an area impacted by pedestrian trampling.
Freedom of geomorphological processes to evolve naturally	Natural geomorphological processes are unimpeded: the levels of activity of the geomorphological processes and their spatial domain retain the capacity to operate across their full range of natural variability, the site maintains the capacity to recreate the geomorphological features where these have been lost or damaged or altered through natural processes. Factors to be assessed: - Hydrodynamic changes induced by developments within the site - Artificially induced stabilisation of processes	Small-scale changes may be tolerated, for example, 'soft engineering' solutions to coastal erosion which has been accelerated by activities outside of the site. However, if interventions have begun to cause significant changes to the site's process regime and its landforms, or the geomorphological processes have been permanently altered and the system is no longer evolving in a natural way, the site will be in unfavourable condition.
Extent of geomorphological features	Extent of key geomorphological features has not diminished: the volume, vertical and lateral extent of features must be within their normal natural range. Factors to be assessed: - Sand/gravel extraction; - Unnatural addition of sediment to the geomorphological system; - Unnatural redistribution of sediment within the site.	Limited extraction and addition and movement of sediment may be tolerated if the system is not likely to be irrevocably affected. However, if interventions have caused geomorphological processes to be permanently altered and the system is no longer evolving in a natural way, the site will be in unfavourable condition.

12 APPENDIX 3 BRAUNTON BURROWS SSSI – EXCERPT FROM FEATURE MONITORING FORM FOR ACTIVE COASTAL GEOMORPHOLOGY (2022)

Attribute: Condition of features of interest

Target: The features of interest remain intact and are evolving naturally

The majority of the site is intact and evolving relatively naturally. There are two locations where anthropogenic disturbance was noted to have a potential impact on site condition.
Significant dune erosion has occurred immediately south of Saunton Sands carpark, at the northern extremity of the SSSI (unit 102). Human disturbance, notably trampling, has been an ongoing impact for at least the last 100 years. This section of the dune front is naturally erosional as the orientation of the beach has been changing over the past 100+ years from drift aligned to swash aligned. However, visitor pressure appears to have significantly increased dune retreat at this localised pressure point – retreated ~45m between 1961 and 2021 as opposed to ~20m on the less visited section to the south. Where visitor pressure is highest, the foredune has been almost completely destroyed and new incipient foredunes are unlikely to develop due to the swash aligned orientation of the beach – sediment supply and therefore accretion rates in this location are limited.

Changes in this location are likely due to a combination of limited sediment supply (further reducing as the beach changes orientation to swash aligned), aeolian erosion, wave erosion and increased vulnerability to all of the former due to reduction in vegetation cover as a result of trampling. Visitor pressure does not allow the natural relaxation period to occur following larger scale erosion events – i.e. some degree of revegetation and stabilisation, before the next major forcing event (see State 5 in Figure 4). The dunes have been forced into Stage 5 of Hesp's conceptual model of dune type, whereas the natural morphology with no anthropogenic forcing would likely be more representative of Stage 3 or 4 (as to the south) (Figure 5). With reduced trampling, some revegetation and dune re-building may occur in between wave erosion events, which might prevent complete disintegration of the foredune and slightly reduce localised retreat rates so that they are proportional with the dune front immediately to the south which is less trampled. To the south, the foredune is in good condition and shows good potential ability to recover from storm events, with a gentle gradient stoss slope and some occasional blowout features (Figure 6). As the disturbance to the morphology of the dunes around the carpark is localised and has been subject to continuous human disturbance for a very long time, with no significant changes since the previous assessment, it is recommended that this unit remains favourable. However, it is recommended this section is monitored regularly and it may be potentially useful to introduce some visitor control measures around the carpark to prevent the expansion of new pathways on areas of new bare sand (if not already in situ).

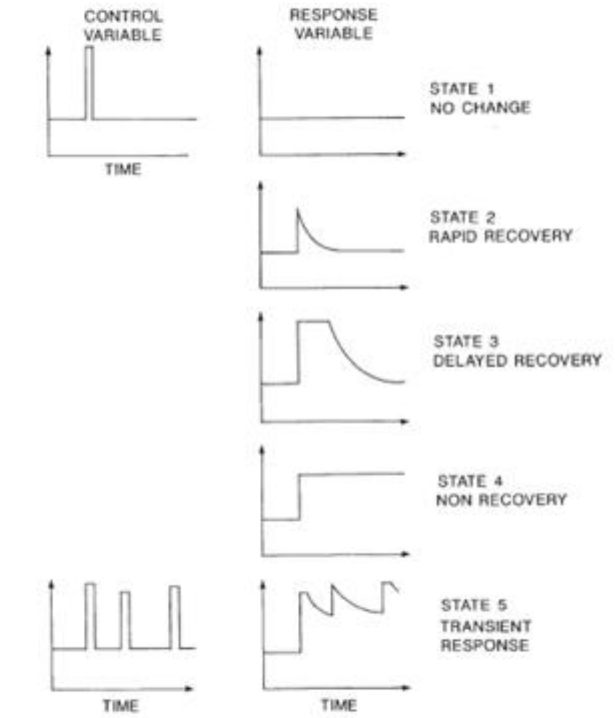

Figure 4: Potential coastal responses to disturbance events (from Pethick & Crooks 2000)

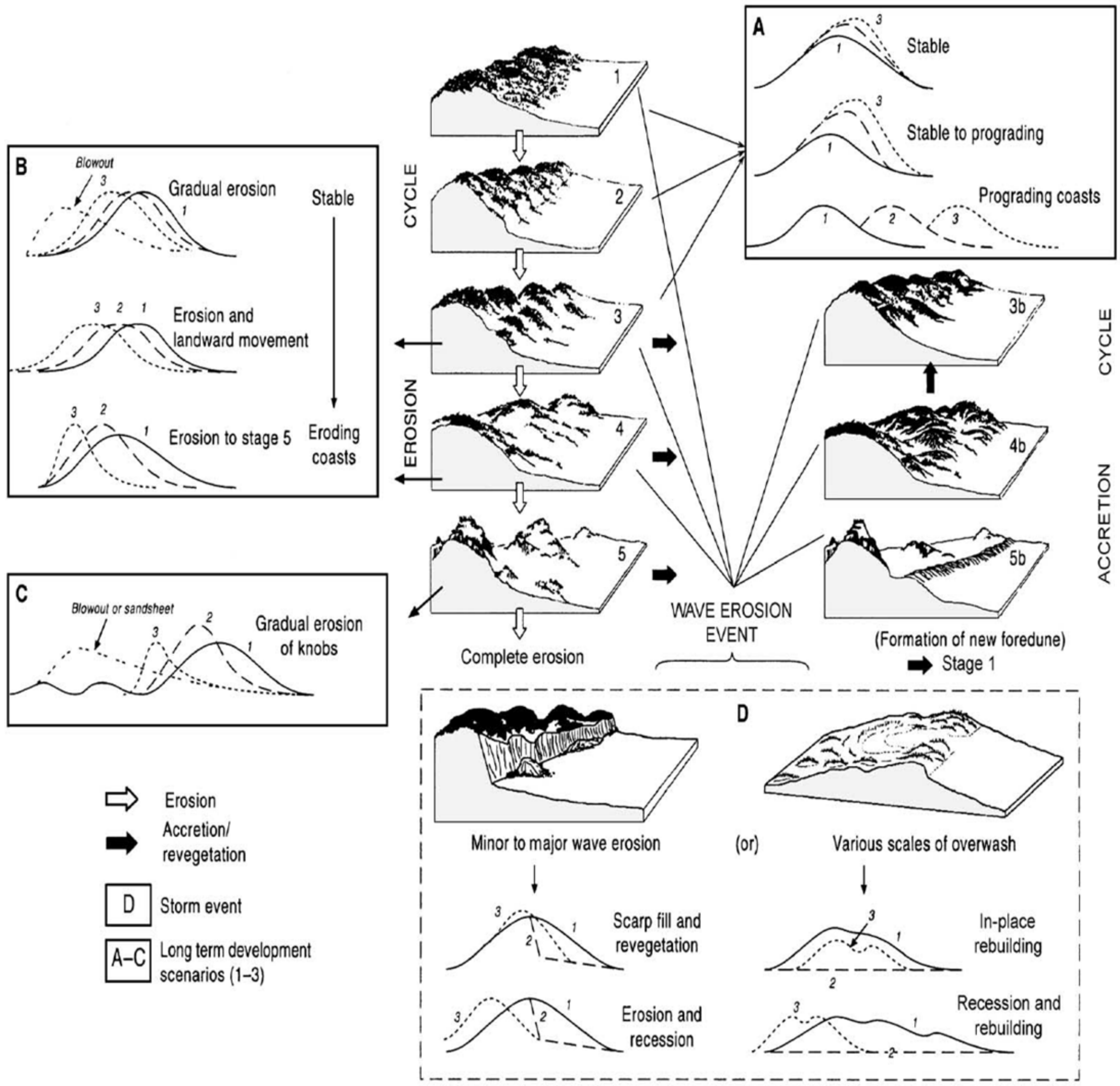

Figure 5: Dune types and evolutionary cycles (from Hesp 2002)

Figure 6: Dune immediately south of main visitor area

At the southern extremity of the site, the rock armour at Crow Point is no longer being maintained and the middle section has now breached. Since the previous Condition Assessment, the middle section of the spit has therefore moved, curving inland and significant sand deposits are present landwards of the spit (Figure 7). The sub-aerial sand dunes at Crow Point are the result of an artificial structure which is no longer present; therefore, it is to be expected that since that structure no longer exists the dunes are experiencing net sediment loss. The rock armour is impacting the condition of the site by inhibiting the natural process of landwards dune migration. Total removal of the rock armouring is recommended to achieve recovering condition, as this would (a) allow the natural process of dune migration to be re-established along the full extent of the spit and (b) remove a relatively recently introduced 'hard point' from the coastline, which would allow natural processes and functioning to ensue.

Figure 7: Crow Point in 2018 (Google Earth, 2022)

For more information, visit www.dynamicdunescapes.co.uk or contact the Dynamic Dunescapes team on dynamicdunescapes@naturalengland.org.uk