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Dynamic Dunescapes

Education Enquiry: Sand dune rejuvenation and natural dune dynamics

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Dynamic Dunescapes

Education Enquiry: Sand dune rejuvenation and natural dune dynamics

This resource should support and be suitable for the following stages of the National Curriculum:

Geography KS3
Science KS3 and KS4 (Biology)
Elements of Mathematics KS3 and KS4

Background

Many of us know and love sand dunes as beautiful coastal landscapes, but they are also important biodiversity hotspots. These dunes are a sanctuary for rare species which are perfectly adapted to live in sand. At a healthy dune, you could find a wide variety of life thriving, including plants, insects, amphibians, birds and reptiles.

But these specialist plants, animals and habitats are at risk. Indeed, sand dunes have been identified as the habitat most at risk in Europe from biodiversity loss.

Over time, many dunes have become covered by grass and scrub which have over-stabilised the sand. On many sites, invasive species have overtaken native ones. We now know that a healthy dune environment needs areas of freely moving sand and a range of diverse habitats including sheltered dune slacks, and areas with short vegetation to support its varied, pioneer and specialist wildlife. The Dynamic Dunescapes Project is using pioneering conservation techniques to rejuvenate the dunes and make their shifting sands the perfect home for threatened wildlife again.

Introduction

Coastal sand dunes are found on coastlines around the world and support a high level of biodiversity, including many threatened plant and animal species. These dynamic ecosystems are shaped by four key elements: sand, wind, water and vegetation. Sand is the basic material dunes are made of; wind speeds need to be fast enough to pick up the sand grains and move them; groundwater near the soil surface is necessary for dune wetlands to form; plants themselves are the fourth agent, which helps create different types of dune. Together, these forces shape dune landforms and the plants and animals that live in the dune system.

Unfortunately, dynamic dune systems with naturally blowing sand no longer occur across most of the UK and north-west Europe. Most dune systems now consist of stabilised dune landforms covered in vegetation. This has resulted in loss of habitat and a decline in many rare and specialist species.

Fortunately, there are a wide range of dune management options available to address these issues.

Examples of wildlife found in sand dunes in the UK; silver-studded blue butterfly and sand lizard. Images: Emma Brisdion and Natalie Hunt

Management techniques past, present and future

Sand dune managers increasingly recognise that there is a need to work with natural processes and to manage these processes alongside directly managing habitats or species.

Past

Up until the 1970s, the focus was on stabilising any blowing sand. Moving sand was seen as a threat and to be controlled at all costs – a sign of the system being out of control. Measures such as installing sand-fences, marram planting and afforestation were acceptable management techniques within the UK and widely encouraged. In fairness, many areas were suffering from high visitor pressure caused by an increase in seaside holidays and increasing mobility of families who could now own their own car. However, all conservation efforts had a similar focus on preventing mobility. At the same time, the conventional thinking on preventing coastal erosion in the UK was to use 'hard engineering' approaches such as rock armour, gabions and concrete sea walls. These often led to increased sand loss from beaches or transferred erosion problems further down the coast due to interruption of the natural chain of sediment supply.

Present

We learned from this that it is possible to stabilise dunes at a large scale, but this may have unintended consequences on the features of dunes that we value and want to protect. Since the 1990s, perceptions of sand dune conservation have changed. In some locations, Marram planting and fencing is still ongoing but perhaps on a small-scale to meet site objectives. However, the importance of sand dune remobilisation has now come to the forefront of sand dune management, but this is still mostly done on a small scale. Even in the late 2010s, management practices mainly revolved around grazing to keep biomass low, and turf stripping in small areas to create patches of bare sand. These practices have improved biodiversity and are relatively low cost but don't tend to address the key underlying issues of a lack of natural dune dynamics and natural dune processes. These small-scale management actions are usually not self-sustaining. In the early 2020s, larger scale interventions are now happening, primarily through restoration projects funded by the LIFE programme and Heritage Lottery Funds, such as the Dynamic Dunescapes project.

Images of the same location at Studland Bay, Dorset, from 1936 and 2014, showing the dramatic increase in vegetation cover and loss of bare sand habitat

Future

The objective of restoration projects is that we learn to unpick the problems created in the past and have clear examples to follow that can provide benefits across the whole dune system and will allow better adaptation to climate change, and other challenges. More holistic approaches to sand dune management need to be embraced, where sand, wind and water are all considered with the aim of encouraging a self-regulating system that requires relatively little intervention. This doesn't come cheaply nor quickly. It requires long-term thinking and a willingness to consider adaptive management and planning approaches. The tools available include a range of established methods along with larger scale and more ambitious rejuvenation techniques that are increasingly being adopted by site managers in the UK. Future Flood Risk Management will make more use of coastal processes, accepting some natural variation in the dune toe position and in beach-dune sand exchange.

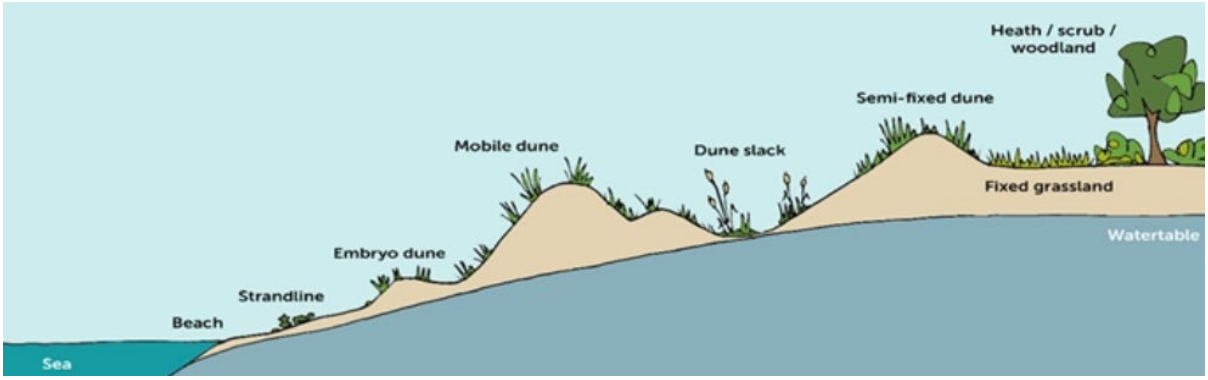
1. Introduction to dunes

Learning objectives
Learners can describe what a coastal sand dune is.
Learners can explain where coastal sand dunes are found and why.
Learners can identify the components / ingredients of sand dunes and how sand, wind, water and plants act together.

Context and scene setting

Nature's process of building a sand dune, their formation and how the associated communities of plants and animals evolve over time is an example of **ecological succession.** In dune systems, this process includes:

- Waves pushing sand onto the beach.
- Onshore winds blow dry sand landwards - the stronger the wind, the higher the dune.
- Obstacles at the top of the beach like driftwood, shells & stones, slow and trap sand so that it builds up.
- Where the sand builds up, pioneer plant species become established. These species are highly specialised enabling them to grow where other plants could not survive. These dunes are known as embryo dunes.



Resources for more information

Online learning modules, Unit 1: Introduction to Dunes: Dynamic Dunescapes: General Public - Unit 1: Introduction to Dunes

A series of videos teaching you to identify different sand dune habitats: https://dynamicdunescapes.co.uk/identifying-different-dune-habitats

2. Current threats to sand dunes

Learning objectives
Learners can outline why dunes have become stabilised.
Learners understand the current threats to sand dunes.

Context and scene setting

Over-stabilisation
Naturally, sand dunes are mobile systems. However, a variety of factors have contributed to the stabilisation of dunes - such as nitrogen deposition - causing a loss of mobile, early-successional habitats, with large parts of the sand dune system progressing towards stabilised, later-successional habitats.

Invasive species
Invasive species can be both native and non-native and may have colonised sites by intentional or unintentional introductions. They often become dominant and may change conditions on a site.

Visitor pressure
The coastline is one of the most popular places for people to visit, with over 270 million visits a year in England alone. Visitors are usually welcome on sand dunes, but if rubbish and dog faeces are not appropriately disposed of they can have negative impacts on our sand dunes.

Falling ground water
Ground water levels in sand dunes fluctuate naturally over time, both between years and within years (eg typically higher in winter months). Where high ground water levels reach the surface of the lower areas of dunes, you may get dune slacks or other types of wetland and sometimes seasonal streams.

Resources for more information

Online learning module, Unit 2: Current Threats to Sand Dunes: Dynamic Dunescapes: General Public - Unit 2: Current Threats to Sand Dunes

3. Natural dune dynamics

Learning objectives
Learners can explain why it is important to introduce natural dune dynamics.
Learners can identify benefits of introducing natural dune dynamics.
Learners can outline some of the considerations in terms of introducing natural dune dynamics.

Context and scene setting

Natural dune dynamics refers to mobilised dunes which slowly travel inland. In doing so, they bury later-successional habitats whilst creating bare and open conditions, ideal for early-successional species

The aim of encouraging natural dune dynamics is to achieve a healthier balance between early-successional habitats (including bare sand) and later-successional habitats.

Both habitats are valuable and support their own groups of species, but currently most dune systems have lost their mobile, younger habitats, with large parts of the site slowly progressing towards stabilised, older habitats.

Resources for more information

Online learning module Unit 3: Natural Dune Dynamics: Dynamic Dunescapes: General Public - Unit 3: Natural Dune Dynamics

4. Management techniques over time

Learning objectives

Learners can describe how dune management has changed over time.
Learners can compare different stages over time.

Context and scene setting

Past
Up until the 1970s, mobile sand was seen as a threat that should be controlled at all costs. Therefore, conservation efforts focused on preventing the mobility of sand by installing sand-fences, tree planting and afforestation

Present
Since the 1990s, perceptions of sand dune conservation have changed. The importance of sand dune remobilisation has come to the forefront of sand dune management, although this is still only practiced on a small scale. Management practices still revolve around techniques such as grazing, turf stripping, clearing invasive species and managing scrub. These practices have improved biodiversity and are relatively low cost but don't tend to address the key underlying issues such as a lack of natural dune dynamics

Future
The objective of restoration projects is that we learn from past issues and use conservation techniques that benefit the whole dune system, allowing better adaptation to climate change. More holistic approaches to sand dune management need to be embraced, where sand, wind, water and vegetation are all considered. The aim should be to encourage a self-regulating system that requires relatively little intervention

Resources for more information

Online learning module, Unit 4: Management Techniques Over Time:

Dynamic Dunescapes: General Public - Unit 4: Management Techniques Over Time

5. Managing dunes for dynamism

Learning objectives

Learners can identify 2 techniques that introduce dynamism in dunes.
Learners can explain when, how and where those techniques can be used.
Learners are aware of any benefits and disbenefits in selecting those techniques.

Context and scene setting

Healthy sand dunes need the ability to move and be dynamic.

The differences in a dune's form, vegetation, habitats and geographical location are important to maintain the diverse species found in dunes, therefore management techniques hope to encourage dune dynamism

There are two main management techniques which aim to encourage dune dynamism, these are notching and turf stripping and reprofiling.

Notching can used where sites are over-stabilised at the frontal dune and there is a need to increase natural dune dynamics. The idea of notching is to create sand pathways through the frontal dunes.

A notch and scrape was created at Oxwich, South Wales, to increase the amount of bare sand movement through the dune system. Image: Natural Resources Wales

This allows wind to blow through and transport sand beyond the foredunes and supports the presence of early-successional stage habitats and species.

It's important to note that notching is a highly technical form of management and it cannot be done everywhere.

Turf stripping and reprofiling mechanically removes a surface layer of vegetation and soil. The goals of this technique include:

- To increase the amount of bare sand.
- To remove organic matter and associated soil nutrients, or acidified surface soil layers.
- To return to earlier stages of succession, or to bring the ground surface closer to the water table.

Resources for more information

Online learning module, Unit 5: Managing Dunes for Dynamism Dynamic Dunescapes: General Public - Unit 5: Managing Dunes for Dynamism

6. Managing dunes for diverse plant communities

Learning objectives
Learners show an understanding of why diverse plant communities are important and understand how mowing, scrub clearance and removing invasive species helps create diverse communities.
Learners can identify why you use grazing, mowing and cutting, scrub clearance.
Learners show a detailed understanding of each technique and what it achieves and show an understanding of when to use it and considerations.
Learners can identify common invasive species on dunes and are aware of the impacts of invasive species.
Learners know how to manage invasive species.

Context and scene setting

The four main management techniques which encourage diverse plant communities are mowing, grazing, scrub clearance and invasive species control.

Mowing has similar effects to **grazing** the main objective is to keep vegetation short and control scrub growth. The benefits of these techniques include:

- The shorter vegetation allows more light to reach the ground which helps rarer, less competitive species to persist.
- Disturbance by grazers creates small patches of bare soil which encourage germination from the seedbank to help to maintain plant diversity.
- Domestic stock can keep vegetation short which encourages natural grazers like rabbits and deer.
- Mowing and cutting can also be used to control problem species and to remove nutrients from a site if material is collected and removed. The machinery can also create areas of bare sand where seeds can germinate


Mowing and grazing are effective methods for controlling scrub and vegetation growth.

Scrub clearance helps to prevent adverse effects of too much scrub. If scrub becomes dominant, it can:

- Shade and shelter the ground, making conditions less suitable for dune-specialist plants and insects.
- Dominant woody shrubs take over the habitat needed by dune specialist species.

- By anchoring the soil and providing a windbreak, scrub can reduce the power of the wind to blow sand around and keep dunes mobile.

Both use of large machinery and working with volunteers working by hand are effective methods of removing scrub or controlling invasive species.

The goal of **invasive species control** is to eliminate or reduce the spread of problem species to protect species of greater conservation interest.

Invasive species control can increase the availability of open dune habitats, allowing other, specialist species to flourish and create diverse plant communities

Resources for more information

Online learning module, Unit 6: Managing Dunes for Diverse Plant Communities: Dynamic Dunescapes: General Public - Unit 6: Managing Dunes for Diverse Plant Communities

7. Dune Hydrology

Learning objectives
Learners understand the basics of dune hydrology including the factors that impact dune hydrology and how hydrology affects dynamism and plant communities
Learners know how hydrology can be managed

Context and scene setting

Water table depth in dune slacks influences the type and health of dune slack vegetation, as well as the abundance and breeding success of species that use dune slacks or damp sand.

Installing dipwells into the dune slacks monitors water table depths and fluctuations. The water table depth can then be measured by site staff or volunteers with monthly or bi-weekly readings. Manual measurements can use a variety of equipment ranging from cheap but fiddly to expensive but simple. Alternatively, you can install automated data-loggers which can store hourly readings for as long as a year. Occasional, manual measurements are still necessary to supplement automated systems in case they develop faults

Water table measurements are useful for three purposes:

- To record change over time and better understand the hydrological regime at a site.
- Having several dipwells allows you to model the shape of the water table across the site and how it changes over time. For this purpose, the absolute water level height (expressed as height above sea level, or height above Ordnance Datum) is needed. Dipwells may be arranged in transects perpendicular to the sea and parallel to the sea to represent the whole site.
- Water tables can help understand the condition of the dune system, especially for vegetation and for species like Natterjack toads. This is a powerful way to guide management and restoration efforts. For this last purpose, water levels are calculated as depth above or below ground surface.

Resources for more information

Online learning module, Sand Dune Site Managers Unit 6: Managing Dune Hydrology

Dynamic Dunescapes: Site Managers - Unit 6: Managing Dune Hydrology

8. Monitoring Sand Dunes

Learning objectives
Learners are aware that it is important to monitor impact of work
Learners are aware of what should be monitored for different interventions

Context and scene setting

There is no "one size fits all" approach when it comes to sand dune management. Each site needs to have a plan and tailor conservation management activities appropriately and use a range of underpinning knowledge and expertise from different fields of study such as geomorphology, hydrology, ecology and botany. Therefore, the ongoing and reflective practice of monitoring sand dunes is essential.

Species ID and monitoring in Cornwall as part of Dynamic Dunescapes

Vegetation
Although the abundance of plants growing in a dune system changes from year to year depending on the weather, they can reflect what is happening in the soil and longer-term influences such as climate or nitrogen deposition. For example, key indicators include: an increase in nitrogen-loving species over time; a decrease in wetland species in dune slacks and increasing numbers / spread of invasive species.

Sand Movement
Sand movement can indicate how mobile a dune system is which can inform management techniques that help combat over-stabilisation, including turf stripping and reprofiling.

Hydrology
Water table depth in dune slacks influences the type and health of dune slack vegetation, as well as the abundance and breeding success of species that use dune slacks or damp sand.

Soil
Understanding your soil pH will help determine management techniques or restoration actions. Moreover, measuring the thickness of the soil's organic layer gives a rough indication of how fertile the site is.

Resources for more information

Online learning module Sand Dune Site Managers Unit 3: Monitoring Sand Dunes:

Dynamic Dunescapes: Site Managers - Unit 3: Monitoring Sand Dunes

Citizen Science activities – resources for monitoring, data recording & analysis:

Citizen Science - Dynamic Dunescapes

Video series explaining 'how to' survey dunes and exploring different techniques:

How to survey dunes - Dynamic Dunescapes

9. Further resources for teachers and students

Dynamic Dunescapes website: Home - Dynamic Dunescapes

An online e-learning **introduction** course, covering the following topics: Dynamic Dunescapes: General Public - Overview

- Introduction to dunes
- Current threats to sand dunes
- Natural dune dynamics
- Management techniques over time
- Managing dunes for dynamism
- Managing dunes for diverse plant communities
- What can you do?

A more **advanced** e-learning course designed for site managers, covering the following topics: Dynamic Dunescapes: Site Managers - Overview

- Overview
- Current threats to sand dunes
- Natural dune dynamics
- Monitoring sand dunes
- Managing dunes for dynamism
- Managing dunes for diverse plant communities
- Dune hydrology
- Public engagement

Video series exploring how to identify key dune habitats: Identifying different dune habitats - Dynamic Dunescapes

A range of **case studies** from sand dune sites in England and Wales: Site managers - Dynamic Dunescapes

Citizen Science activities – monitoring, data recording & analysis: Citizen Science - Dynamic Dunescapes

Video series exploring 'how to' survey dunes and use different techniques: How to survey dunes - Dynamic Dunescapes

The Dynamic Dunescapes Sand Dune Managers Handbook - a detailed look at **management techniques** and considerations to reintroduce natural dune dynamics to over-stabilised sand dune systems: http://dynamicdunescapes.co.uk/wp-content/uploads/2021/07/Dynamic-Dunescapes-Sand-Dune-Managers-Handbook-June-2021-1.doc

A variety of general and site-specific resources for primary & secondary learners: Schools - Dynamic Dunescapes

Dune Battle: a top trumps-style card game designed for higher education student studying succession and to improve dune ID skills: http://dynamicdunescapes.co.uk/wp-content/uploads/2021/10/Dynamic-Dunescapes-Dune-Battle-Game_updated-Mar-2021.pdf

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