DYNAMIC DUNESCAPES

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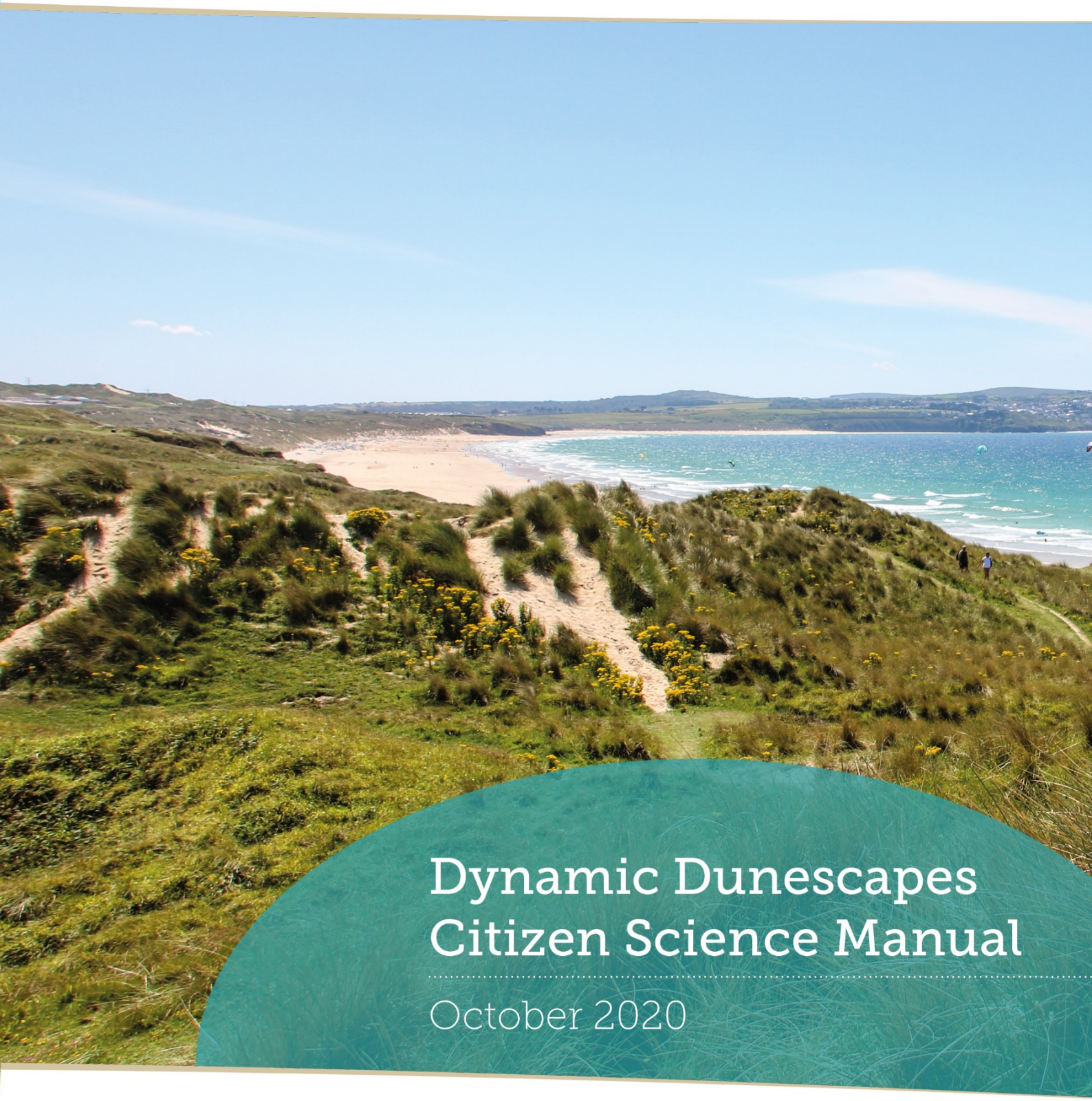

Dynamic Dunescapes Citizen Science Manual

October 2020

NATURAL ENGLAND

Plantlife

National Trust

Cyfoeth Naturiol Cymru
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Citizen Science Manual

for monitoring sand dunes

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1 Introduction

1.1 Monitoring aims

Sand dune systems have become increasingly stable in recent decades, and as a result have lost the bare sand that keeps them active and supports many rare species. This is due to a range of factors, which include a reduction in rabbit and other grazing, a reduction in other forms of disturbance and deliberate management activities to stabilise dunes. Sand dunes are naturally low in nutrients and so would typically support species adapted to these conditions. When sites become enriched with nutrients, for example through nitrogen deposition from air pollution, these species are outcompeted by those that thrive under more fertile conditions and there is an overall increase in plant growth, leading to taller plants, shading of rare species, soil accumulation and loss of bare sand. Invasive species can also increase the vegetation cover and hence stability of sites and outcompete many other species. All of these factors have contributed to a loss of species associated with open sandy areas.

The citizen science activities described in this manual are designed to monitor the health of sand dune systems, with a focus on stability and the impacts of nitrogen deposition. As part of the Dynamic Dunescapes project, management of sites is designed to reverse over-stabilisation and to increase the openness of sites. These citizen science activities will help to monitor the effect of this management on the health of sand dune systems. In particular, the citizen science activities will help to answer the following research questions:

A) Where are the transitions between different sand dune zones? How are these changing over time and is it different in managed and unmanaged areas? A narrowing of the mobile dune zones and widening of fixed grassland, for example, could indicate a loss of dynamism in the system.
B) What does the height profile of the sand dune system look like? How is this changing over time and is it different in managed and unmanaged areas? A very stable height profile over time, for example, could indicate that the system is not very dynamic.
C) What is the percentage cover of bare sand and broad vegetation types in different zones of the sand dune system? How is this changing over time and is it different in managed and unmanaged areas? A loss of bare sand in mobile dune areas, for example, could be indicative of the system becoming increasingly vegetated and so less dynamic.
D) What is the percentage cover of short vegetation in fixed dune grassland zones? A loss of short vegetation in these areas could suggest a loss of dynamism, an increase in nutrient enrichment or a change in grazing regime.
E) What is the distribution and percentage cover of plant species that are positive and negative indicators of dune health? How is this changing over time and is it different in managed and unmanaged areas? An increase in negative indicators could be a sign of a decline in the health of the sand dune system.
F) What is the distribution and percentage cover of plant species that are indicators of nutrient enrichment? How is this changing over time and is it different in managed and unmanaged areas? This will give an indication of how the site is being affected by nutrient enrichment.
G) What is the water table depth in dune slacks and how is this changing over time? This will give an indication of nutrient, climate change and other impacts on vegetation communities in dune slacks.
H) How does disturbance from grazers, people and other causes (bare sand, litter, other factors) change across the site and over time ? This will give an indication of spatial patterns in disturbance (which can be good and bad) and more negative aspects like litter, to guide site management.

1.2 Volunteer engagement

A key aim of these citizen science activities is to help people re-think what is natural in dune systems. This means a shift away from the idea that dunes should be stabilised, to understanding that many plant and animal species benefit from mobile sand in a naturally dynamic habitat. The activities have been designed to appeal to a range of audiences, from casual visitors, to people wishing to monitor the same transect year-after-year, to those who prefer volunteering indoors. The activities differ in the time they take and the level of knowledge or training they require. This is described in more detail in the overview of the survey structure described in section 1.3.

1.3 Overview of the survey structure

The six different activities that form the citizen science monitoring programme are outlined in Table 1 below. The typical locations in a dune system where these activities take place are illustrated in Figure 1. Activities 1 (zonation) and 2 (sand dune profile) take place on a series of fixed transects that run through the sand dune system; activities 3 (fixed point photography) and 4 (vegetation recording) takes place at pre-determined locations around the dune system focusing on particular areas or habitats of interest; activity 5 takes place at dipwells in dune slacks and activity 6 can be done anywhere in the dune system. The table also details which of the research questions outlined in section 1.1 are addressed by each of the activities and the depth of engagement possible with volunteers.

Table 1. Overview of the citizen science activities

Activity	**Location and timing**	**Research questions**	**Volunteer engagement**
1. Zonation: mapping and photographing the boundaries between different sand dune zones.	Annually in April or May. Fixed transect routes focused on key transitions between zones, particularly linked to management activity. e.g. from the strandline to the fixed dunes, across blowouts or newly restored areas, monitoring scrub encroachment.	A	Training on methodology required or surveys could be led by a member of staff or experienced volunteer; surveying in small groups recommended; smaller numbers of people involved.
2. Sand dune profile: mapping the height profile of sand dune features.	Annually in April or May. Fixed transect routes focused on mobile dunes, and areas of recent management activity (notches, blowouts, scrapes and turf removal from dunes and slacks).	B	Training on methodology required or surveys could be led by a member of staff or experienced volunteer; surveying in small groups recommended; smaller numbers of people involved.
3. Fixed point photography: tracking change in sand dune features through developing a photographic record.	Annually in April or May at fixed points. These may focus on transition zones, intervention areas, dune slacks.	A,B,C,D, (E,F,G)	Simple but standardised methodology needs to be followed; can be done alone or in groups; more people could be involved.
4. Vegetation: monitoring the cover and height of different vegetation types, and indicator species of dune health and nitrogen deposition.	Annually in June to August at permanently marked quadrat locations across a range of habitats (quadrats in mobile dune areas may not be permanently marked).	C,D,E,F	Relatively simple but standardised methodology needs to be followed; surveying in small groups recommended; more people could be involved.
5. Water table depth: tracking water table depth in dune slacks.	At dipwells in dune slacks at least once per month.	G	Simple but standardised methodology needs to be followed; can be done alone or in groups; more people could be involved.
6. Disturbance/Other: recording information on animal and human disturbance or other points of interest	Across the site as a whole at any time.	H	Very straightforward methodology; ad-hoc recording around the site; can be done by anyone, alone or in groups; lots of people can be involved.
7. Key species survey: tracking the distribution of key positive and	Across the site as a whole at any time.	E	Very straightforward methodology; ad-hoc recording around the site; can be done by

negative plant indicator species			anyone, alone or in groups; lots of people can be involved.

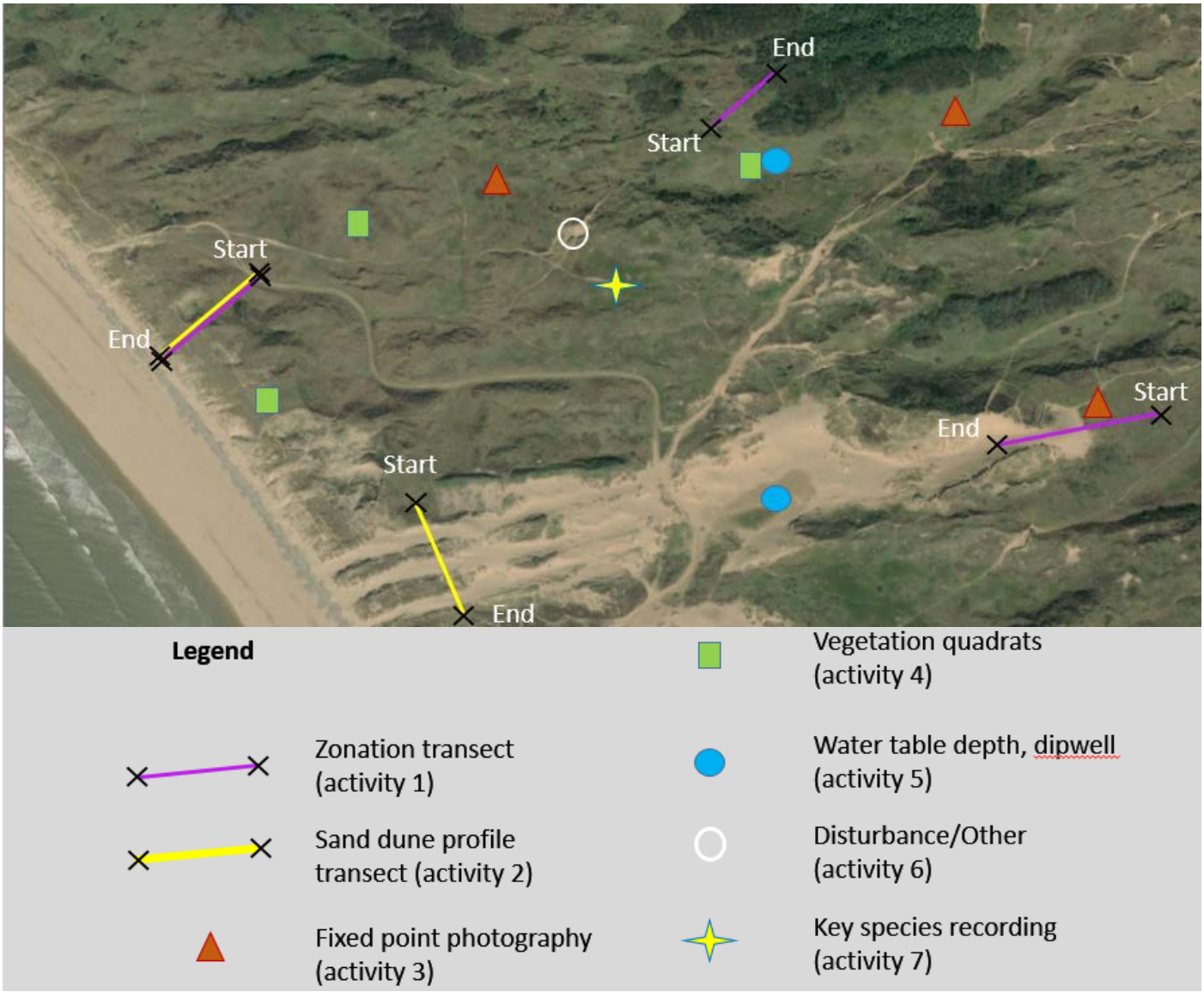


Figure 1. Types of locations at which different activities take place within the sand dune system, see Section 2 for details on each activity. Note transects usually start at an easily locatable, fixed marker point. The same transect can be used for two activities. Imagery source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS user community

1.4 Aim of this document

This document describes how each of the activities should be undertaken. Section 2 provides guidance and materials required for carrying out the different activities. Section 3 outlines health and safety guidance for all of the citizen science activities. In Section 4 there are guidelines for selecting the locations of monitoring transects and quadrats, if this has not been done already. In Section 5 are some suggestions for volunteer coordination as well as data entry and management and Section 6 summarises the equipment requirements for the different activities. Section 7 provides suggestions for data analysis and visualisation to help answer the research questions. The Appendix in Section 8 provides lists of indicator species.

2 Activities

2.1 Zonation

2.1.1 Background

The aim of this activity is to record and photograph the locations of transitions between different zones of the sand dune system to monitor how these boundaries are changing over time. Transitions are the abrupt or gradual change of habitat from one type to another. Monitoring is likely to focus on some of the following: mobile dune transitions to semi-fixed or to fixed dunes, the extent of bare sand around newly restored/scraped areas or blowouts, scrub encroachment or the transition from dune slack vegetation to drier habitats.

2.1.2 Method

When and where to survey

Zonation surveys are carried out once a year, in April or May, along the fixed transect routes that have been selected at your site. It will take roughly take between 1 to 3 hours per transect.

Equipment

Take with you:

- Handheld GPS unit
- Mobile phone app - transect locations downloaded beforehand
- Compass
- Long tape measure (ideally 50 m or more)
- Marker canes with high visibility tape/ribbon (suggested minimum 3)
- Transect description for the transect you intend to walk
- Zonation recording form
- Sand dune zone guide
- Camera

Navigating to and along the transect

a) Using your handheld GPS (and mobile phone app), navigate to the first point of the transect, which will be marked by a post. For transects to the sea, this will usually be the inland end. The grid reference can be found on the transect description form, or the start point described in the notes box on the app.
b) Use the grid reference for the end of the transect and your compass (and your mobile phone app) to navigate along the transect. The 3 marker canes can help you keep to the transect. Place the first marker cane at the start point. Following the bearing provided for the transect, navigate along the transect roughly 50 metres & place the second marker cane. A person sited at the first marker cane, holding the compass can then direct the location of the third marker cane to be placed 50m further down the transect. When all 3 canes are aligned, walk back to the first cane and start recording the transitions. The first cane can then be re-located further along, aligning with the other two canes to maintain your bearing and the process repeated to move down the transect. Some transects may be shorter than 100m. Adjust the method if required to maintain line of sight between marker canes. For transects ending at the beach, the last point will be on the beach itself.
c) Use the tape measure to measure the distance between locations, and record the distance between zonation transition points.

What to record along the transect

a) As you walk along the transect, use the sand dune zone guide to assess which zone you are in (Figure 2, Figure 3). When you move from one zone to another, record the grid reference from your GPS (if using the manual recording form), along with the names of the zones you are moving between. The app will guide you through this when you enter a new transition point.
b) Record the distance from the last transition point, in metres and to the nearest 10 cm.

c) At each transition point, take two photographs perpendicular to the direction of the transect (one to the left, and one to the right). On the manual recording form, note down the time that these photographs were taken so that they can be identified and stored correctly. On the app, the time of photos will be recorded automatically.

d) Notes:

- The transition between different zones may not be clear cut but you should record the point at which you feel the dominance of characteristics has shifted from one zone type to another.

-You may also transition from one zone to another and then back again – each transition should be recorded on the form. Anything larger than 2 metres can be considered a new zone.

-On very loose sand on a steep dune, it may be necessary to walk a few metres away from the direct line to avoid disturbing the dune, but track back to the direct line to take the next measurement.

-The end point for some transects may be a scrub or woodland boundary – in this case, measure to where the scrub/woodland forms a fairly unbroken line (not individual bushes or trees)

-The end point of the transect for transects leading onto the shore should be approximately 5 m seawards from the last vegetation you see (but be aware of steep eroded dune edges – if access is difficult just record this edge)

2.1.3 Sand dune zone guide

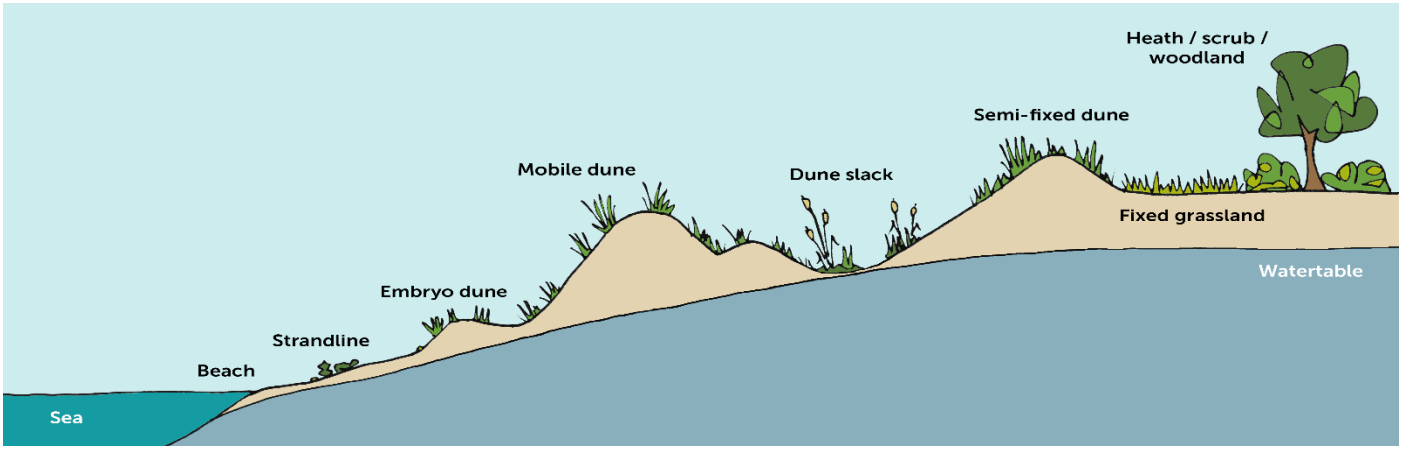


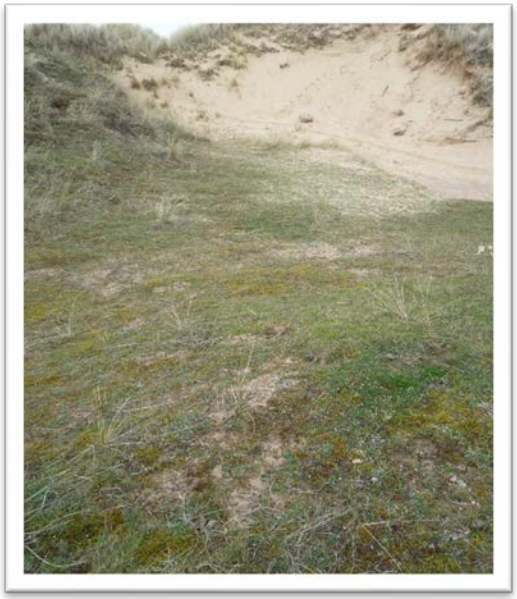
Figure 2. Diagram of zones in a sand dune system. ***(N.B. Fixed grassland = Fixed dune grassland).***

Figure 3. Description of sand dune zones.

Zone		Key features	Photographs
Beach		• Bare sand and no vegetation	
Mobile dune	**Vegetated Strandline**	• Lots of bare sand • Annual plants present; may include sea rocket and prickly saltwort • Miniature sand dunes can form around plants, and other debris on the high tide line	

	Embryo dune	• Above the usual high tide line • Lots of bare sand • First perennial plants present; may include sand couch and lyme grass • Low, hummocky dunes form around these plants	

	Mobile dune	• Lots of bare sand (20-50%) • Marram grass dominates • Sand builds up around marram to form high, mobile dunes • A small number of other plants may be present; may include sea holly and sea spurge	

Fixed dune	**Semi-fixed dune**	• Often some bare sand cover (0-30%) • Red fescue and mosses cover patches between marram • Species diversity increasing; may include restharrow, sand sedge, birds foot trefoil • No real soil layer	

	Fixed dune (Fixed dune grassland)	• Bare sand only where turf is broken (<10%) • Soil beginning to form • Many plants now coexisting; may include red fescue, lady's bedstraw, harebell • Surface lichens and mosses may be present • Little if any scrub or tree cover	

Dune slack	• Flat, low-lying area between dunes • Usually floods in winter • Can be very large • Species may include sedges, water mint, mosses and liverworts, creeping willow	

Heath	• Soil is dry, acidic and nutrient-poor • Plants present are those associated with acid grassland and heaths; may include heather	
Scrub and woodland	• Dominance of tall, woody perennials and understorey species. • Very little if any bare sand	
Other	• There may be non-dune habitats on the transect. For example, permanent water bodies, improved grassland, etc.	*[No photos provided, as this category can be used to represent any non-dune habitat]*

2.1.4 Recording form

Example recording form

ZONATION RECORDING FORM					
Site name:			**Date:**		
Transect name:			**Surveyors:**		
Survey point	**Grid reference**	**Distance between points (m)**	**From (zone)**	**To (zone)**	**Time photographs taken (Left, Right)**
1. Start					
	Notes				

2.2 Sand dune profile

2.2.1 Background

The aim of this activity is to create a height profile of key areas of interest in the sand dune system. These are likely to focus on naturally mobile dunes, blow-outs and managed or rejuvenated areas which have created bare sand. This can then be used to examine how the height profile of the sand dunes is changing over time and how much dynamism there is in the system.

2.2.2 Method

When and where to survey

Sand profile surveys are carried out once a year, in April or May, along the preselected transect routes. It will take roughly two to four hours depending on the length of the transect.

Equipment

Make sure you take with you:

- Handheld GPS unit
- Mobile phone app - transect locations downloaded beforehand
- Compass
- Long tape measure (ideally 50 m or more)
- Ranging poles (exactly the same height)
- Clinometer
- Transect description for the transect you intend to walk
- Sand profile recording form

Navigating to and along the transect

a) Using your handheld GPS (and mobile phone app), navigate to the first point of the transect, which will be marked by a post. For transects to the sea, this will usually be the inland end. The grid reference can be found on the transect description form, or the start point described in the notes box on the app.
b) Use the grid reference for the end of the transect and your compass (and your mobile phone app) to navigate along the transect. For transects ending at the beach, the end point will be on the beach itself.
c) Use the tape measure to measure the distance between survey locations.
d) When using the app, use the same phone to record all the data for one transect.

What to record along the transect

a) At point 1 of the transect, person A should stand holding ranging pole 1 and the clinometer. Make sure you hold the pole vertical and it does not sink into the sand. Enter the grid reference of the start point on the manual recording form. The app will do this automatically when you register the Start point. Note that the grid references for each location can be manually edited to add a 10 figure grid reference if required.
b) Following the bearing of the transect (i.e. heading towards the end point), person B should take ranging pole 2 to the point at which there is a marked change in the angle of the slope of the dune, or at approximately 50 m distance if no clear change in slope (see Figure 4) - there may be long uniform areas which are beyond convenient sighting distance. At this point, place ranging pole 2 on the ground, again making sure you hold it vertical and that it does not sink into the sand. Enter the grid reference of this point on the recording form. The app will automatically record the grid reference when you click to register the next survey point.
c) Person A should then use the clinometer to measure the angle of the slope from pole 1 to pole 2. The reading should be taken in the direction of the transect, from the top of pole 1 to the top of pole 2 (see diagram below). If the poles are too tall to sight from the top, then read from the marking on pole 1 that is closest to person A's eye level and the corresponding marking on pole 2 (mark these with bright coloured tape before starting the transect for easy reference). Note down this angle on the recording form, or in the app.
d) If you find yourself going downhill as you walk along the transect, it should be noted in the recording form or on the app that this was a downhill reading. Enter the angle as a negative number.

e) Use the tape measure to measure the distance along the ground from pole 1 to pole 2. Note this distance down on the recording form, or in the app.
f) Person B with pole 2 should then stay where they are and person A should continue walking along the bearing of the transect, handing the clinometer to person A as they pass them.
g) When they reach another distinct change in the angle of the slope of the dune, they should stop and place ranging pole 1 vertically on the sand and the process of measuring the angle of the slope and the distance between the poles should be repeated, this time with person B taking the clinometer measurements from pole 2 to pole 1, in the direction of the transect.
h) Repeat this process until you reach the end of the transect.
i) Notes:
-On very loose sand on a steep dune, it may be necessary to walk a few metres away from the direct line to avoid disturbing the dune, but track back to the direct line to take the next measurement.

-The end point of the transect for transects leading to the shore should be approximately 5 m seawards from the edge of the mobile dune or embryo dune zone.

-It may be useful to establish longer 'sight-lines', e.g. also take bearings from points on a distant horizon, to help maintain the correct bearing along the transect.

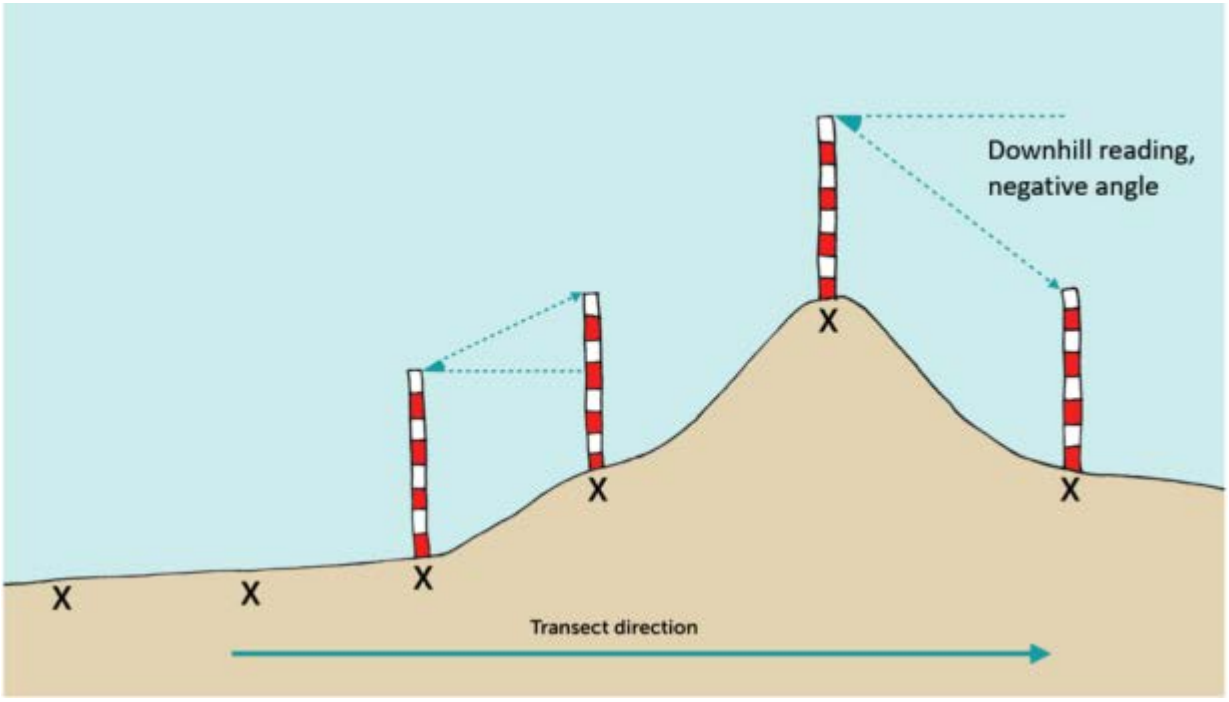


Figure 4. Illustration of how to measure the profile along a sand dune. X marks points at which measurements might be taken.

2.2.3 Recording form

Example recording form

SAND PROFILE RECORDING FORM	
Site name:	**Date:**
Transect name:	**Surveyors:**

Survey point	Grid reference	Slope angle (degrees, negative if downhill)	Distance between poles (m, to nearest 10 cm)	Uphill (Up) or downhill (Down)
1. Start				
	Notes			

2.3 Fixed point photography

2.3.1 Background

The aim of this survey is to develop a visual record of the sand dune system using fixed point photographs. This will allow assessments to be made of how the morphology (form, shape and structure) and vegetation composition of sites are changing over time.

2.3.2 Method

When and where to survey

Fixed point photographs should be taken at least once a year, in April or May, at preselected locations.

Equipment

Make sure you take with you:

- Handheld GPS unit

- Mobile phone app – fixed point photography locations downloaded beforehand
- Compass
- Fixed point photography recording form
- Camera

Navigating to the photography points

a) Using your handheld GPS (and mobile phone app), navigate to each photography point, which will be marked by a post. The grid reference can be found on the description form for photography points, or described on the app. Some photography points may be along transects, others may be in dune slacks or other points of interest on the site.
b) For points that are along transects, from the starting point of the transect marked by a post, use the grid reference of the end of the transect and your compass (and your mobile phone app) to navigate along the transect.

What to record

a) Take a photograph at each photography point. It is important to take your photograph so it matches the position of the original photo (see the list of locations, or the app) so that direct comparisons can be made. To help you do this:
   - Each photograph should be taken in the direction indicated (as aligned with the guide photo)
   - Take the photograph at eye level
   - Refer back to the photographs shown in the transect description form, or on the app. If there are any useful reference points (e.g. trees, buildings), make sure these are in the same place in your new photograph.
b) For each photograph, record the time it was taken on the recording form so that it can be identified and stored correctly. This will be recorded automatically on the app.

2.3.3 Recording form

Example recording form

FIXED POINT PHOTOGRAPHY RECORDING FORM		
Site name:		**Date:**
Transect/group (if relevant):		**Surveyors:**
Fixed point number	**Time photograph taken**	**Notes, at location**
1		
2		
3		
4		
5		
6		
7		
8		
General notes		

2.4 Vegetation

2.4.1 Background

The aims of this survey cover three aspects:

i) to record the percentage cover of bare sand and the cover and height of broad vegetation types. This will allow us to examine whether the composition and structure of the vegetation at the site is changing over time.

ii) to record the percentage cover of plant species that are positive and negative indicators of dune health (including rare species and invasive species) so we can track how the health of the sand dune system is changing over time.

iii) to record the percentage cover of species which indicate higher nutrient levels.

2.4.2 Method

When and where to survey

Vegetation surveys should take place once a year, in June, July or August, at pre-set quadrat locations. It will take roughly 30 -45 minutes to complete a survey in a single quadrat.

Equipment

Make sure you take with you:

- Handheld GPS unit
- Mobile phone app – quadrat locations downloaded beforehand
- Compass
- Long tape measure (> 10 metre)
- Ruler (1 metre, or short tape measure)
- 4 marking canes
- Grid references for the quadrats you intend to survey
- Quadrat recording form
- Plant indicator species list and identification guide

Finding and marking out the quadrat

a) Using your handheld GPS (and mobile phone app), navigate to the grid reference of the quadrat you intend to survey. This will be marked by a post in all habitats except for mobile dunes. The grid reference and the habitat it is located in can be found on the description form for quadrats, or described on the app.
b) Where the quadrat has a marker post, use your tape measure and compass to measure 2 m due north and then place one of your marking canes in the ground at this point; this will be the south west corner of the quadrat.
c) If it is a mobile dune quadrat, place one of your marking canes at the point of the grid reference you were provided with; this will be south west corner of the quadrat.
d) Then, using your compass, find due north and, using the tape measure, measure 2 m in this direction. Mark this point using a second marking cane.
e) Repeat this process moving east, south then west until you have marked out a 2 m by 2 m square.

f) You can keep the tape measure wrapped around the outside of the canes to help you define what is inside and what is outside of the quadrat.
Notes:
-The marker post is positioned 2 m away from the quadrat itself to avoid disturbance in the quadrat e.g. from livestock using it as a scratching post or birds perching on it.

What to record in the quadrat

i) Vegetation cover

Note the total percentage cover within the quadrat of:

- Bare ground & sand
- Moss & lichen (see species guide)
- Grass (includes grasses, sedges and rushes) - These are all plants that are grass-like in appearance. The stems of sedges generally have three edges whereas rushes have very rounded stems that are filled with pith
- Herbs - These are all other plants which are not trees or shrubs (but includes things like bramble, bracken and other ferns)
- Shrubs - only heathland shrubs (i.e. heather, gorse, bilberry)
- Scrub - Includes trees and scrub, and young plants of these species

Estimates should be made by looking from above at the vegetation cover. It may help to try to imagine all of the different patches of a single vegetation type clustered together and how much of the 2 × 2 m square this would take up. Keep in mind that:

- 20 × 20 cm is 1 % cover
- 50 × 50 cm is 6.25 % cover
- 1 × 1 m is 25 % cover

Looking at the tape measure surrounding the quadrat may help here.

If there are multiple people in your surveying team, each person should come up with an estimated percentage cover for each vegetation type separately and then the average of these estimates should be recorded on the quadrat recording form.

If the cover of a single vegetation type is less than 1 % then record this as 0.5 %.

The total vegetation cover may exceed 100 % because different layers of vegetation may be overlapping but combined cover of vegetation and bare ground/sand should reach at least 100 % otherwise an error has been made. The app will automatically calculate the total cover.

ii) Vegetation height

Considering all areas with vegetation in the quadrat, take five measurements of the height of the vegetation (ideally one in each quarter of the quadrat and one in the middle). Measure the height with a ruler or tape measure, recording the height that most of the vegetation reaches within roughly 20 cm of your ruler – ignore occasional tall flowering stems if they rise above this height. If there are multiple people in your surveying team, it is useful for two or three to agree the height that should be recorded in each location. Record all five height measurements on your form, or on the app. The app will automatically calculate the average.

2.4.3 Recording form for vegetation cover and height

VEGETATION COVER AND HEIGHT RECORDING FORM

Site name:						**Date:**
Quadrat number:						**Surveyors:**
Dune zone:						
PERCENTAGE VEGETATION COVER						
Vegetation type	**Percentage cover (please include zeros if the vegetation type is absent)**					
Bare ground & sand						
Moss & lichen						
Grasses (including sedges and rushes)						
Herbs						
Shrubs (Heathland shrubs)						
Scrub/woodland						
VEGETATION HEIGHT						
Vegetation height (cm) (5 measurements)	1.	2.	3.	4.	5.	Average
QUADRAT NOTES						

iii) Health indicator species and nitrogen indicator species

Using the species list of positive and negative plant indicators for the site, for each species that you see in the quadrat, record its name on the quadrat recording form, or select it in the app. Note that there are separate lists for each habitat so make sure you use the appropriate one for the quadrat you are surveying. Estimate the percentage cover of each species.

Repeat this process for the nitrogen indicator species (for fixed dune grassland and dune slack habitats)
Estimates should be made by looking from above at the vegetation cover. It may help to imagine all of the different patches of a single vegetation type clustered together and how much of the 2 × 2 m square this would take up. Keep in mind that:

- 20 × 20 cm is 1 % cover
- 50 × 50 cm is 6.25 % cover

- 1 × 1 m is 25 % cover

Looking at the tape measure surrounding the quadrat may help here.

If there are multiple people in your surveying team, each person should come up with an estimated percentage cover for each vegetation type separately and then the average of these estimates should be recorded on the quadrat recording form, or in the app.

If the cover of a single vegetation type is less than 1 % then record this as 0.5 % on the quadrat recording form.

2.4.4 Recording form for plant indicator species

PLANT INDICATOR SPECIES RECORDING FORM	
Site name:	**Date:**
Transect/quadrat group (if relevant):	**Habitat:**
Quadrat number:	**Surveyors:**
DUNE HEALTH INDICATOR SPECIES	
Species	**Percentage cover**
NUTRIENT INDICATOR SPECIES	
Species	**Percentage cover**
QUADRAT NOTES	

2.5 Water table depth

2.5.1 Background

The aim of this survey is to monitor water table depth in dune slacks (seasonal wetlands) within the sand dune system. Water table depth influences the type and health of dune slack vegetation and on species like natterjack toads and many insects that also use dune slacks or damp sand.

2.5.2 Method

When and where to survey

Water levels should be measured at least once per month at preselected dipwell locations.

Equipment

Make sure you take with you:

- Handheld GPS unit
- (Mobile phone app – dipwell locations downloaded beforehand)
- Water-level measuring device (see notes)
- Water level recording form
- Camera

Navigating to the dipwell locations

a) Using your handheld GPS (and mobile phone app), navigate to each dipwell. The grid reference can be found on the description form for dipwell locations, or described on the app.

What to record

a) If there is a cap on the dipwell, unscrew it or prise it off (depending on the type)
b) If there is a datalogger suspended on a wire, carefully pull it out (When you have finished measuring the water level, slowly lower the logger back down the dipwell. DON'T drop it as this can cause the logger to malfunction).
c) Using an appropriate water-level measuring device, measure from the top of the dipwell down to the water level.
d) Record the value to the nearest cm. If the slack is flooded and the water level is above the dipwell, again measure to the top of the dipwell, but record this as a negative number. Note down the water level on the form, or on the app.
e) Take a photograph of the dipwell, aligning it to the photograph on the dipwell information sheet, or on the app.

2.5.3 Recording form

Example recording form

WATER LEVEL RECORDING FORM	
Site name:	**Date:**
Dipwell group (if relevant):	**Surveyors:**

Dipwell name	Time	Water table depth (cm)	Notes
1			
2			
3			
4			
5			
6			
7			
8			
General notes			

2.6 Disturbance

2.6.1 Background

The aim of this survey is to monitor signs of disturbance, damage or other aspects around the site. Disturbance can be considered good or bad depending on what is happening and where. For example, some disturbance can be useful to maintain areas of bare sand. It covers disturbance by animals and from human activities.

2.6.2 Method

When and where to survey

Disturbance can be recorded at any time, anywhere on the site.

Equipment

Make sure you take with you:

- Handheld GPS unit
- (Mobile phone app - site information downloaded beforehand)
- Disturbance recording form
- Camera

Navigating to locations

There are no pre-set locations, but you may want to visit particular areas to follow up previous reports of disturbance or points of interest. These can be obtained by discussing with the site manager.

What to record

If you wish to record some disturbance or other feature on the site, use the recording form, or the app activity. This covers the following aspects:

- The presence and size of patches of bare sand, or where the turf has been broken up by activity of animals or people.
- Presence of animal dung, and if possible an indication of which animal it is from (rabbits, ponies, cattle, sheep, other)
- Rabbit activity (small feeding scrapes, burrows)
- Human activities such as damage from vehicle tracks (including motorbikes), litter or fly-tipping. Recording litter is not aimed at the occasional sweet wrapper, but things like remains of a barbeque, multiple cans/bottles left by visitors, large rubbish items like car tyres, etc. should be recorded.
- Any other aspects can be recorded using the 'Other' section on the form or on the app.

Please also take a photo if you can.

2.6.3 Recording form

Example recording form

DISTURBANCE RECORDING FORM			
Site name:			**Date:**
Surveyors:			
Disturbance type	**Detail**	**Tick if present**	**Notes**
Bare ground / poached area	Less than 1m across		
	More than 1m across		
Animal dung	Rabbit		
	Cattle		
	Pony		
	Sheep		
	Unknown		
Rabbit activity	Small feeding scrape		
	Burrow		
Other	Vehicle tracks		
	Litter/fly-tipping		
	Fires/BBQ remnants		
	Other		
Other information			

2.7 Key species surveys

2.7.1 Background

The postcard survey provides a less intensive way for visitors to sand dunes to get involved with monitoring dune health. The postcard template contains information about drivers of dune health and key species to look out for; those that are characteristic of dunes in good condition as well as unwanted and invasive species. The target positive (wanted) and negative (unwanted) species may differ from site-to-site, they should be selected with the involvement of site managers and other key stakeholders. People are asked to record the date and location of the species they have seen and then return information of their sightings.

Data from this survey will allow us to map the distribution of the positive and negative target species across the site and examine the impacts of management interventions on positive and negative indicator species as well as act as an early warning system for the appearance or spread of invasive species

2.7.2 Recording form

Dynamic Dunescapes Key Species Survey
Site name

In recent decades, our sand dune systems have become increasingly stable and vegetated due to a number of factors including active management to reduce the movement of sand, air pollution in the form of nitrogen deposition, a reduction in rabbit grazing and the introduction of invasive species. As a result, many of the plant and animal species that favour dunes with areas of bare sand have been lost or become less common on important sand dune sites.

The Dynamic Dunescapes project seeks to improve the health and dynamism of sand dunes across the UK.

To take part in this survey, tell us where and when you have seen any of the species below. The *Wanted Species* are some of those we expect to see in a healthy sand dune system whereas the presence of *Unwanted Species* can be a sign that the dune system is not in good health.

By providing us with this information you will be helping us to understand the health of this site and how that is changing in response to the management we are carrying out.

Wanted	**Unwanted**
Lady's Bedstraw • Usually shorter than 30 cm • Long thin leaves with pointed ends in whorls of 8 to 12 along the stem • Clusters of small (2-3 mm across) yellow flowers in July to August Photo/sketch *Lady's bedstraw is an indicator of healthy sand dunes and of low levels of nitrogen deposition.* ☐ Tick here if you saw Lady's Bedstraw Date of sighting _____ Where was it? (Give details of up to three locations. Try to be as accurate as you can, a grid reference would be great) _____	

Submitting your results…	

3 Health and Safety

Health and Safety considerations should not be a barrier to undertaking Citizen Science activities. Indeed, outdoor learning and connecting to nature has positive physical and mental health benefits as well as enhanced learning outcomes and attainment.

It is anticipated that any organisation undertaking field work will operate within its own health and safety policies, procedures and risk management protocols.

If no risk assessment exists, following the Health and Safety Executive's guidance will be a good starting point https://www.hse.gov.uk/services/education/school-trips.pdf

A generic risk assessment for a visit or activity may prove helpful in the first instance and should include:

- the activity to be undertaken
- what are the main risks?
- who might be harmed and how?
- what is the likelihood of harm?
- what would be the severity of harm?
- what are you already doing to control the risks?
- what further action do you need to take to control/mitigate the risks?
- who needs to carry out the action?
- when the action is needed by?
- when will the Risk Assessment be reviewed?

Some simple top tips.

You and your team

In the unlikely event of an accident or incident, don't panic. Call your emergency contact, let them know the situation, what happened and where you are. Stay put and follow instructions carefully.

It is important to not lose anybody. Stay as a group and form a buddy system. Follow any instruction carefully. Have a safe meeting point if you do find yourself separated from your team.

People and your surroundings

Sand dunes can be quite disorientating. Be aware of the tides when in a coastal area. Check and double check before you go. Know your site or contact the site manager/landowner for advice and guidance. Be aware of and pay heed to warning signs. For example, there may be areas of sinking sand, strong currents and open ponds or military training; or conservation activities, ground nesting birds or sensitive habitats that need to be avoided at particular times.

You may want to wear long trousers in the dunes as marram grass can be quite prickly. Wear sensible footwear and clothes. Be careful of sand blowing in your eyes and be aware of stinging plants and animals.

On sunny days, don't forget your sun cream, hat and stay covered up in the heat of the day. Take some water with you. There might not be a lot of shade in the dunes.

4 Setting up

If fixed locations for transects, quadrats, photography points and dipwells have not yet been selected, this will need to be done before the majority of the activities can be carried out. The following sections provide instructions for how to do this, and how to set them up on the website before volunteers or staff use the app for recording.

4.1 Principles behind setting up monitoring

A key aim is to understand changes happening as a result of management interventions on the site. However, part of this is knowing what change would happen anyway without any intervention (e.g. as a result of a particularly dry and windy year, or a particularly wet year).

Therefore, wherever an intervention is set up, it is strongly recommended to set up similar monitoring in a 'control' area that is otherwise very similar, but has not had an intervention. This allows you to say whether the intervention has had an effect, or not. In an ideal world, you would have a control area associated with every intervention. This may not be possible, but a minimum of two control areas are recommended, and ideally more than that.

This applies to any intervention (introducing or changing grazing pressure or type of grazers, actions to improve sand mobility or alter hydrology, etc.).

It is also useful to get baseline data before an intervention takes place, so consider setting up monitoring points in the summer before a planned activity if possible.

The principle of 'control' monitoring locations applies to all the activities (transects, fixed photography points, quadrats etc.). As an example, where a dune notch is created to increase windspeeds and sand blow into the site, consider setting up transects and photography monitoring points over a partially mobile dune that is directly downwind of the notch, and a similar dune a few hundred metres away that is not directly downwind of the notch, and which is unlikely to be affected by the intervention – this will be your control area.

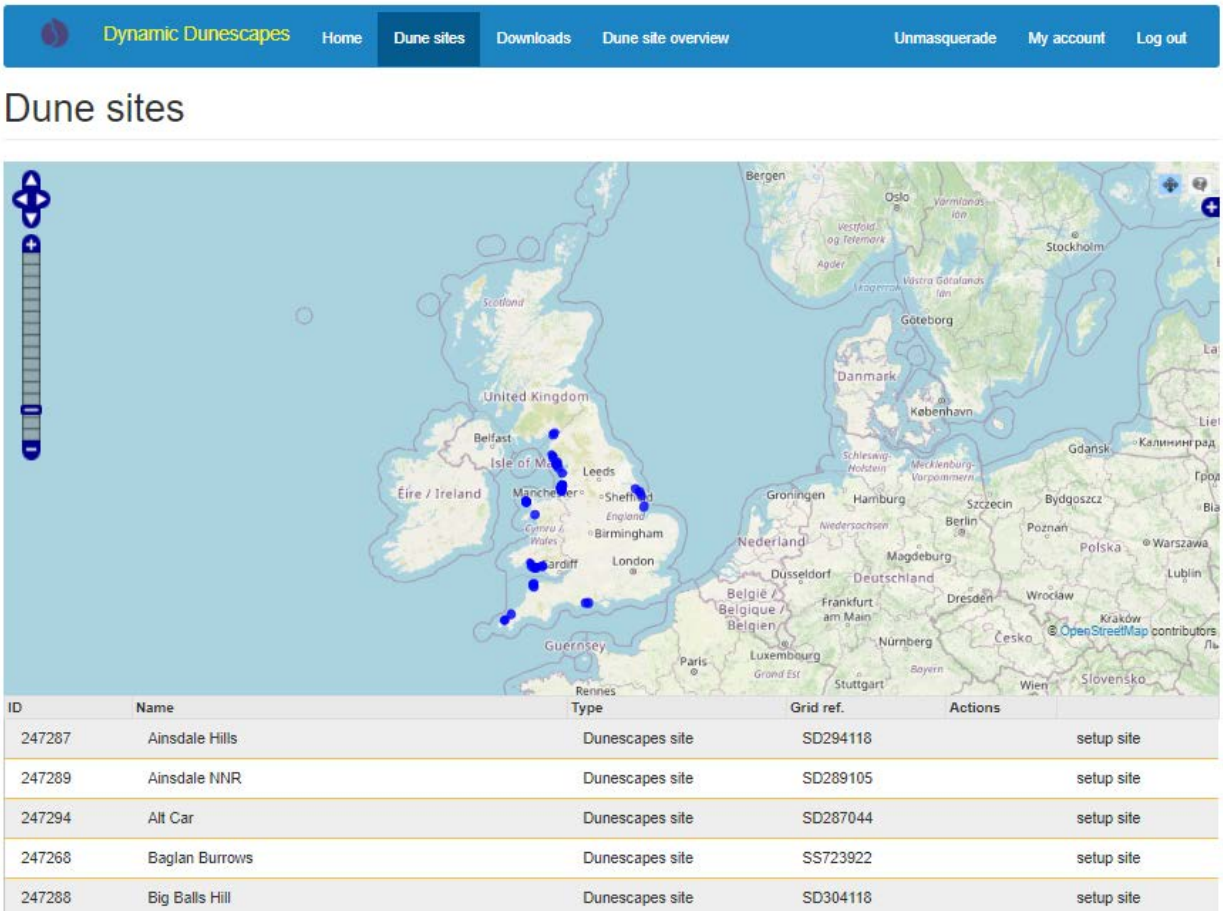
4.2 Setting up locations on the website (for use in the app)

Fixed monitoring locations (e.g. transects or fixed point) need to be setup prior to being available within the mobile application for entering data. Site managers setup their monitoring locations on a dedicated website - https://dunescapes.brc.ac.uk after being setup with an account with an 'editor role'. Site managers should contact BRC (brc@ceh.ac.uk) to request to be setup as site editors.

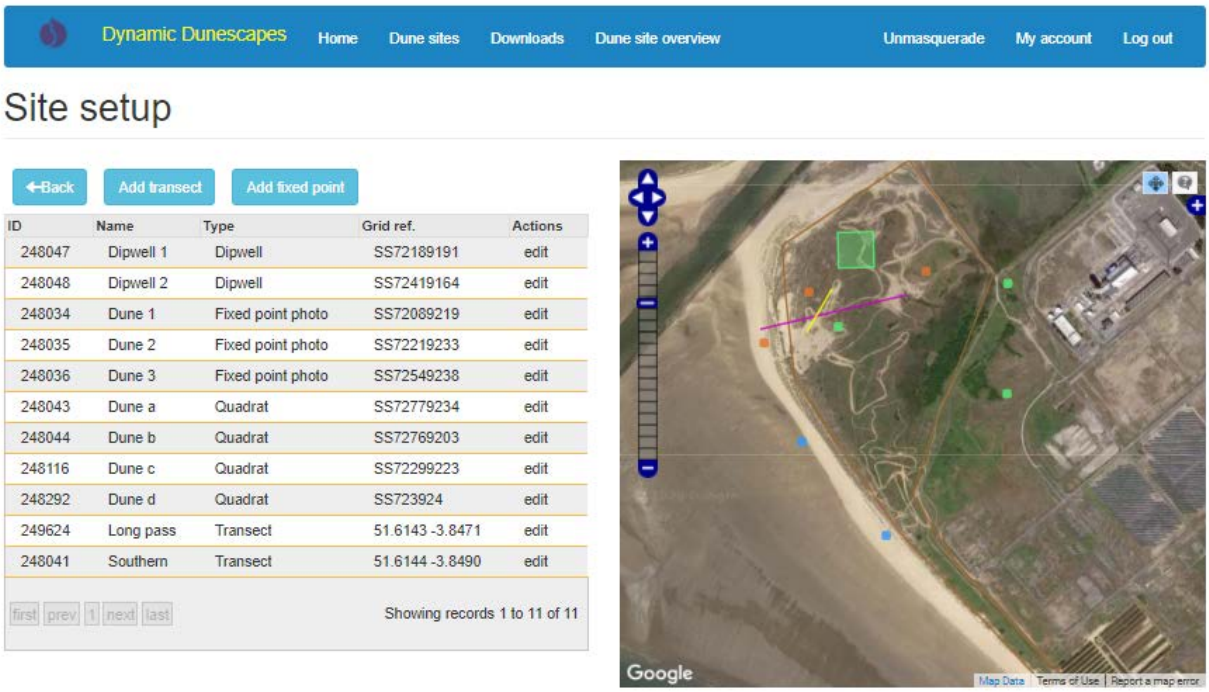
Once logged into the site manager's website (https://dunescapes.brc.ac.uk), site managers are provided with dedicated functionality to setup locations and download data.

4.2.1 Setup of transects and fixed points

Site managers should first select the menu item 'Dune Sites' and are then presented with a map of dune sites (site centroid or boundary) and a table listing all sites; the table can be ordered by site names by clicking on the column name. New sites can be added by contacting BRC, as above.



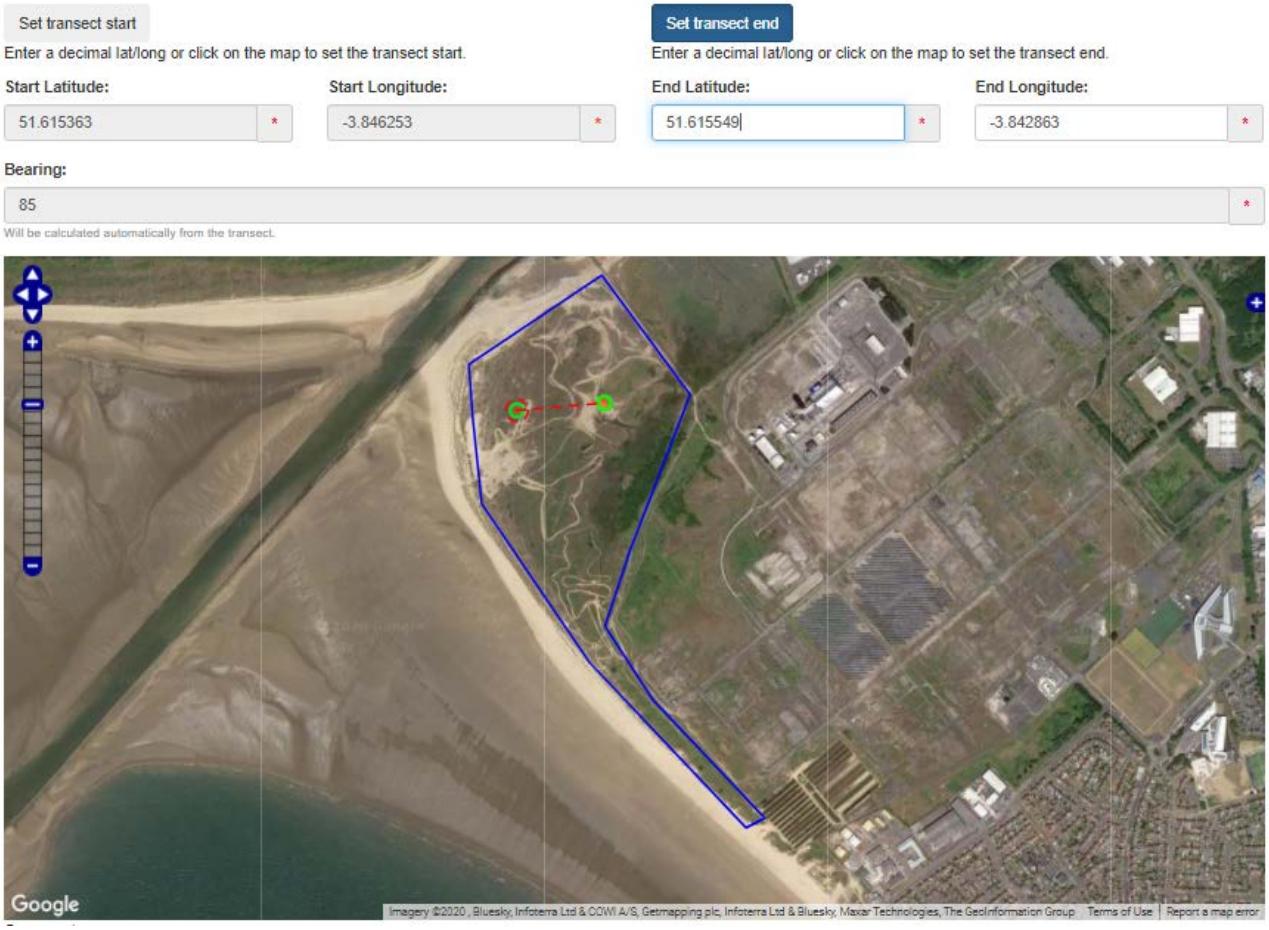
Clicking on the 'setup site' link in the right-hand column for the site required brings a page for setting up transects and fixed points. The screenshot below shows the site setup page for Baglan Burrows for example. The site setup pages shows a table of existing transects and points already setup, together with a map of these locations. Existing transects/points can be modified by clicking on the 'edit' link. Further transects or fixed points can be added by clicking on the respective button. Click on the back button returns to the page listing all sites.



The “add a transect page” (see below) requires the following information to be provided:

- *Transect name*
- *Transect activity type* (e.g. Zonation or profile from the drop-down list)
- An optional *photo* of the transect location. By dragging the image file onto the page or using the upload link.
- *Transect line*. To create the transect line, the start and end points need to be set. To set the start point, click on the ‘Set transect start’ button and then click on the start location on the map. Clicking on the map automatically sets the spatial reference. Alternatively, an exact reference for the start point can be entered by typing a value into the relevant part of the page. To set the end point and complete the transect line, click on ‘Set transect end’ and again click on the map at the required location. The transect bearing is calculated automatically. The map displays the transect line (as show below).
- *Comment* (optional)

  Once all information is provided, click on the ‘Submit’ button at the bottom of the page.



A similar process is required to setup a fixed point. The fixed point page requires the following information to be provided.

- *Fixed point label*
- *Group* (a text label which allows the user to allocate fixed points to a group, e.g. North, Group 1, etc.). Even if you don’t want to set up different groups on a site, it is worth setting up a single group for e.g. all quadrats on a site, otherwise the app treats each individual quadrat as a unique group.
- *Location type* (e.g. Dipwell, Fixed point photo, Quadrat from the drop-down list)
- An optional *photo* of the fixed point. By dragging the image file onto the page or using the upload link.
- *Fixed point location*. Clicking on the map sets a grid reference for the location. The resolution of the grid reference depends on the zoom level of the map. Zooming further into the map provides a higher precision grid reference when clicking on the map. If a precise location is required, this can be entered in the relevant

boxes on the form for X, Y and Z co-ordinates. Z co-ordinates (vertical elevation) may be necessary/useful for dipwells.

- *Comment* (optional, but recommended. Use this to record important information about the location, which will also appear on the app)

Once all information is provided, click on the 'Submit' button at the bottom of the page.

4.3 Using marker posts for fixed locations

Ideally each fixed monitoring location should be marked with a post to allow easy re-location by volunteers and site staff. The type of marker and its height will be governed by a range of considerations. Since these are designed to be long-term markers, plastic or metal may be preferable, but wooden posts are less intrusive. The thicker the post, the longer it will survive. A 5x5 cm thick treated wooden stake is unlikely to last much longer than 5 years, and can easily be snapped by livestock, so ideally aim for thicker posts.

Post height will be governed by site considerations, such as the following:

- If the post is higher than about 30 cm above ground surface it may be used as a scratching post by livestock. This may damage the post, but will also cause localised disturbance as animals congregate around the post.
- Post height needs to balance visibility based on the vegetation it is located in (short grass, vs tall grass vs scrub), and aspects like trip-hazards or damage by vehicles or stock. 5-10 cm above ground surface (or above typical vegetation height) may be an acceptable compromise.

Depending on the purpose of the marker, the survey location may be at, or a set distance from the marker, primarily due to disturbance issues discussed above. As a start or end point for a transect, or a fixed photography point, the marker can show the exact location. For quadrats or dipwells, the survey location should be 2 m due North of the marker post to minimise disturbance to the monitoring location (e.g. the south-west corner of a quadrat should be exactly 2 m due North of the marker post).

4.4 Transects for zonation and sand dune profiles

4.4.1 Select transect routes on maps

a) The focus for both these transects is areas of the site which are likely to change over time, or where restoration or management work has been undertaken, which may trigger changes in the dune system.
b) Transect routes can be designed to include one or more focal areas of interest (mobile dunes, management interventions, boundaries between habitats), starting and ending either side.
c) Remember to set up 'control' transects in areas which are not receiving an intervention, to allow you to compare managed and un-managed areas.
d) Where transects include mobile or embryo dunes at the shoreline, the starting point should be inland so that it can be marked by a fixed post. The transect should run perpendicular to the coast, and aim to end at the shoreline.
e) Note down and record the grid references of the start and the end points of the transect.
f) Calculate and record on the transect description form the compass bearing of the transect line you have drawn from the start point to the end (this is shown on the ruler function in Google Earth).

4.4.2 Ground truth the transect routes

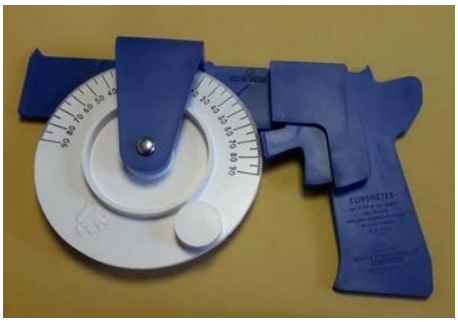
a) If using the app, download the transect locations, or take the recording sheet which lists the grid reference locations.
b) Navigate to the starting point of the first transect using a handheld GPS (or equivalent smartphone app). Then use the grid reference for the end point and the compass bearing of the transect to navigate along the length of the transect, checking that it is possible to walk the whole length of the transect route.
c) Take photographs of the start and end-points of the transect – these will help reassure volunteers they have found the right location.

d) You may need to adjust the start and end points of the transect
e) If the transect needs to cross an inaccessible area e.g. a large patch of scrub, or a stream, then add notes to the transect indicating how users should navigate around this. Or, consider setting up two separate transects.
f) When you are happy with the start and end-points, record the grid references, and mark the start point with a marker post.
g) Re-calculate the transect bearing if required, and update the locations and transect bearing on the website and recording forms.

4.4.3 Equipment for measuring slope angles

There are a range of approaches for measuring slope angle. The equipment most likely to be used by site staff and volunteers is a clinometer. See examples below.

The Abney hand level



Simple hand-held clinometer

Suunto Opti clinometer

4.4.4 Transect description form

A transect description form template is provided below. Create one of these for each of your transects. It may only be necessary to record start and end points.

TRANSECT DESCRIPTION FORM		
Site name:	**Transect name/number:**	
Transect bearing:		
Locations:	**Grid reference**	**Photograph**
1. Start		
2		
3		
…		
End		

Guidance notes for accessing or navigating the transect:		

4.5 Quadrats

Quadrats should be selected in separate habitat zones, focusing on those of most interest at the site: mobile dune, semi-fixed dune, fixed dune, dune slack and heath areas. Ground-truthing for the zonation surveys may help with the selection of some quadrat locations. Ideally there should be at least 30 quadrats in each dune zone, although more could be selected if there are volunteers available to survey them. The following steps can be followed to select and record quadrat locations. All quadrats will be 2 x 2 m.

4.5.1 Select quadrat locations on maps

a) Start with site habitat maps, or rough mapping generated while ground-truthing the zonation surveys. Aerial imagery e.g. from Google Earth may help here.
b) For each habitat separately, generate random coordinates for quadrat locations. Random coordinates within defined boundaries (polygons) can be generated using GIS software. If this is not available, you can use Google Earth to define the coordinates of the northern-, southern-, eastern- and western-most points of the different dune zones areas separately. These can then be entered into a website such as http://www.zonums.com/gmaps/kml_rand.html, along with the number of points you want to generate in each area (e.g. 30). The random points that are generated can then be downloaded and viewed in Google Earth. Depending on the shape of your site you may need to repeat this process until you generate enough points that fall within the area of interest. It is also a good idea to generate some 'reserve' points which can be used if the ground truthing exercise shows some of the initial points are unsuitable.
c) For quadrat monitoring in dune slacks, see the next section 4.5.1 which gives guidance on selecting a range of different dune slack habitat types for monitoring purposes.
d) Remember to set up quadrats at locations which are not receiving management, or not affected by interventions (see section 4.4.3).
e) Store the grid references of the random points you have generated in a spreadsheet.

4.5.2 Ground truth and mark quadrat locations

Use the grid references derived from the mapping exercise to navigate to each of the quadrats using a handheld GPS or equivalent smartphone app. Make sure that you are happy that the quadrat falls within the sand dune zone that was identified in the mapping exercise. In the mobile dune zone, where quadrats are not marked by a fixed post the quadrat will be a 2 × 2 m square with the grid reference in the south west corner; in all other habitat zones, the grid reference corresponds to the point 2 m south of the south west corner of the quadrat. If the quadrat will not fall within the intended zone, exclude it from your list and replace it with one of the reserve points, which will also need checking.

For all quadrats apart from mobile dunes, permanent marker posts should be installed to mark the location of the quadrat. See section 4.2 for guidance on marking locations.

4.5.3 Monitoring the impact of management interventions

If a management intervention is taking place that you are interested in monitoring the effect of, additional 'control' quadrats should be selected to monitor the impact of the management and make comparisons with unmanaged areas. One option for this would be to select an additional set of quadrat locations within the area where management is due to take place (the exact number will depend on the size of the managed area). Then identify an area of similar size where no management is due to take place but has similar properties e.g. habitat, topography. In this 'control' area,

select the same number of quadrat locations as in the managed area. Evaluation of the effect of management interventions could then be done by comparing data from quadrats in the managed and control areas.

4.6 Dipwells

4.6.1 Select dipwell locations

Water table depth will be measured in dipwells at fixed locations in dune slacks. The following points can be used to help to select the locations where these dipwells should be installed:

- Try to install dipwells in a range of dune slack communities across the site. This could include, where present, wet dune slacks (typically SD14); wet older dune slacks that are dominated by creeping willow (*Salix repens*) (typically SD15); partially or fully acidic dune slacks often dominated by sedges and where creeping willow tends to be absent (SD17); drier, grassy dune slacks (SD16); and young, early successional dune slacks (SD13, young SD14).
- If the site has not been mapped, try to select a range of drier and wetter slacks, select a range of different vegetation communities, and different ages (where known – historical aerial photographs may help with this).
- Where a slack regularly floods in winter, it is helpful to install dipwells within a few metres from the edge of the slack. This can help with access when it is flooded, allowing measurements to continue. When flooded, measurements should still be taken if possible to record the water level relative to the top of the dipwell (when flooded and higher than the dipwell, these are recorded as negative numbers).
- Note down grid references of likely slack monitoring locations and dipwells.

4.6.2 Marking dipwell locations

If not already marked, install a marker post 2 m due South of each dipwell to aid re-location. Dipwells can be difficult to find, especially if installed at ground level. See section 4.2 for guidance on marking locations.

4.6.3 Methods and equipment for measuring water tables.

A range of methods can be used, depending on the equipment available and the depth of the dipwell. Four approaches are described below, from the quickest but most expensive down to cheaper alternatives which may take a little longer.

a) Dipper

A commercial product which consists of a weighted electronic probe attached to a sturdy measuring tape which is lowered down the dipwell. When the probe touches water it emits an electronic beep, and some models trigger an LED light. You then read off the depth on the measuring tape against the top of the dipwell tube. Typical prices in 2020 ranged from around £250 to £680 including VAT for a 30m range. Examples shown below.

Advantages: quick and easy to use

Disadvantages: expensive; can be heavy to carry around (~2.5 kg)

b) The Pocket Dipper

Is designed to attach to a tape measure or string to lower down a dipwell. It emits a continuous sound until it is submerged when the sound becomes attenuated. You then read off the depth on the measuring tape against the top of the dipwell tube.

Advantages: small and lightweight; likely to be relatively low cost

Disadvantages: not yet widely tested

c) Optic light rod

A home-made device where an optic rod is attached to a ruler or other measuring device. The rod is lowered down the hole and the light at the end stops reflecting off the water when the rod hits the water table. You then take the depth reading against the top of the dipwell tube. In low-light conditions, it may be necessary to shine a torch on top of the rod.

Advantages: relatively cheap to make

Disadvantages: may not be suitable for deeper dipwells (> 1 m depth)

d) Ruler/rod + light

A variant of the optic rod approach above. A ruler or rod is slowly lowered down the dipwell, while shining a torch or phone light down the well at the same time to see the water surface. When the rod hits the water you should be able to see ripples, indicating you have reached the water table. You then take the depth reading against the top of the dipwell tube.

Advantages: very cheap to make

Disadvantages: may not be suitable for deeper dipwells (> 1 m depth)

e) Rod + Ruler

Another variant of the rod approach, but without the torch. Lower the rod or ruler successively down the dipwell at 10 cm intervals, noting the depth each time. When the end comes up wet, dry it off and lower it again to half-way between the previous readings. Continue until you narrow down to the correct water level. Note that a large rod will displace water when submerged below the water level, leading to higher water level readings. To avoid this error, repeat the exercise once you have narrowed down the water table to within a few cm.

Advantages: very cheap to make

Disadvantages: very slow; may need experimentation to find the best rod material (some types of plastic may shed too much water, some types of wood may soak up too much water and not show the new water level (bamboo canes work reasonably well); may not be suitable for deeper dipwells (> 1 m depth), or for use in rainy conditions.

f) Blow tube

A semi-flexible pipe or tube is lowered down the dipwell while the user blows air down it. The bottom length can be attached to a wooden rod to provide stiffness if required. The pipe will 'bubble' when it hits the water. At this point, pinch the tube or pipe, bring it out of the dipwell while maintaining the pinch and measure the depth with a ruler or tape measure.

Advantages: very cheap to make

Disadvantages: may not be suitable for multiple users to share; may be cumbersome to measure deeper dipwells

5 Volunteer coordination and data entry

5.1 Volunteer coordination

Ideally activities 1 to 4 will be carried out annually, activity 5 on at least a monthly basis, and activities 6 and 7 can be carried out at any time. Some coordination of activities will be required to plan when the surveys are completed. Most of the surveys will be carried out under the guidance of staff members e.g. as volunteer days or education sessions. However, where volunteers can be trained to carry out surveys independently, they will need to be familiar with the transect, quadrat, photography or dipwell locations. Lists of grid references for locations should be available as hard copy on-site, but are also available on the app. They must be downloaded beforehand.

Co-ordination of activity to ensure all locations are surveyed could be managed online, for example, on the dunescapes website, or via the site office. This will require a staff member or office volunteer to regularly update the webpage or site records, and will require a system whereby volunteers are allocated a particular set of locations, or state which they intend to survey.

5.2 Data entry & Use of the app

There are several methods of data submission that are available for activities 1-7:

- It is hoped that the majority of data will be entered directly using the app, in the field

- Where data is recorded on paper forms, these could be submitted to the office, and a volunteer or member of staff could enter the data using the app. In this case, photographs will need to be emailed to whoever is managing the data.
- Key species data (activity 7) can be entered using iRecord

Brief notes on using the app

- Download the 'Dynamic dunescapes' app version relevant to your phone (i-Phone or Android)
- To access site information and use the app you need to be a registered user. This process will send you an email verification request for GDPR purposes. Register plenty of time before you intend to use the app (we recommend at least a week) in case there are difficulties receiving the verification email.
- The app is designed to be easy to use, but does cover a lot of activities, each of which is slightly different.
- You may need to enable use of the phone GPS for the app to work.

There are several options for data submission for the postcard survey, of which one or all could be used.

- A freepost address could be included on the postcard for participants to return them directly. The disadvantages of this are that there is a charge associated with the freepost return; someone would have to enter the data; and it is difficult to specify an exact location of a sighting without a map. It does, however, make the survey open to people who don't have smart phones or internet access.
- Other apps (preferably iRecord) could be used to enter species data. The advantages of this are that it is much easier for the location of sightings to be specified accurately; photographs can be included for verification; and data are entered directly onto the system. The disadvantage is that not everyone has a smartphone or will have downloaded the app before they are out on the site.
- A web data entry platform could be developed so people could collect their information on the postcard and then enter their data online. This would allow more accurate specification of the location of the sighting (although perhaps not as accurate as with an app). The disadvantage is that people may lose enthusiasm or forget to submit their data when they are away from the site.

6 Equipment requirements

Below is a summary list of equipment required for the different citizen science activities. Details of specific equipment can be found under the relevant section above.

Equipment	**Activities**
GPS unit	1-7
Mobile phone app	1-6
Compass	1-2, (4-6)
Sand dune zone guide	1,3-4
Tape measure	1-2,4
Ranging poles (x2)	2
Clinometer	2
Permanent marker posts	1-5
Canes	1,4
Indicator species identification guide	4
Dipwell equipment (will vary depending on the option chosen)	6
Key species survey postcards	7
Online data entry and management system	All activities

7 Data analysis and visualisation

The sections below illustrate some mapping techniques which can be used. Section 7.7 gives an overview of how to download the data, how to use the quick on-line visualisation using a separate website tool, and some suggestions for further analysis in Excel if required.

7.1 Zonation

Data from this survey can be used to answer the following questions:

Where are the boundaries between different sand dune zones, and how are they changing over time?

Based on the start and end points of the transects, and the distances data recorded using the app, precise boundaries and transition points between habitats can be mapped. Note the grid references calculated from the phone or app recording device are unlikely to be accurate enough for this purpose, so the measured distances recorded by the volunteers should be used, together with the start and end points, and direction of the transect, which are separately stored by the site manager. Photographs taken at the zone boundaries can be used to help verify the locations of the zones.

Maps showing the locations of transitions between different zones can be produced annually and then overlaid with each other to show how the dune zones are changing over time. Time lapses could also be built using photographs from the transitions zones to show if and how these are changing over time. Information on disturbance could also help with interpretation of results.

7.2 Sand dune profile

Data from this survey can be used to answer the following questions:

What is the height profile of different cross sections the sand dune system, and how is it changing over time?
The raw data from this survey are, for each slope measured along each transect, the grid reference, angle of the slope, distance between poles and whether the slope was uphill or downhill for each measured section. These data can be visualised on-line, or further processed in Excel or other packages using the instructions lower down. Profiles from different transects can be plotted on the same graph to make a visual assessment of whether and how the sand profile differs through the site, or over time.

Profiles from the same transect in different years can be plotted on the same graph to make a visual assessment of whether and how the sand profile is changing over time. Information on the timing and location of management interventions and of any disturbance recorded as well as fixed point photographs can be used to help with the interpretation of these graphs.

7.3 Fixed point photography

Photographs can be used to make qualitative assessments of changes over time in dune profile, the amount or type of vegetation present (including the presence or cover of invasive species) and vegetation height. Information on disturbance and the management of the site can be used to inform the interpretation of photographs. Time lapse sequences of photographs from the same location can also be built up.

7.4 Vegetation

7.4.1 Vegetation cover and height

Data from this survey can be used to answer the following questions:

How is the percentage cover of bare sand and different broad vegetation types changing over time?

The average bare sand cover (or cover of other broad vegetation types) can be compared for quadrats in different management units, or different habitat types, or to see if they change over time.

In terms of visualising data from this activity, percentage cover vegetation type and vegetation height from different quadrats and in different years could be mapped across the site to potentially highlight areas of concern which might inform future management. Information about disturbance and the distance of quadrats from the edge of transitions to other dune features (shoreline, fixed grassland) could be used to help with interpretation of this data.

7.4.2 Health indicator species and nitrogen indicator species

Data from this survey can be used to answer the following questions:

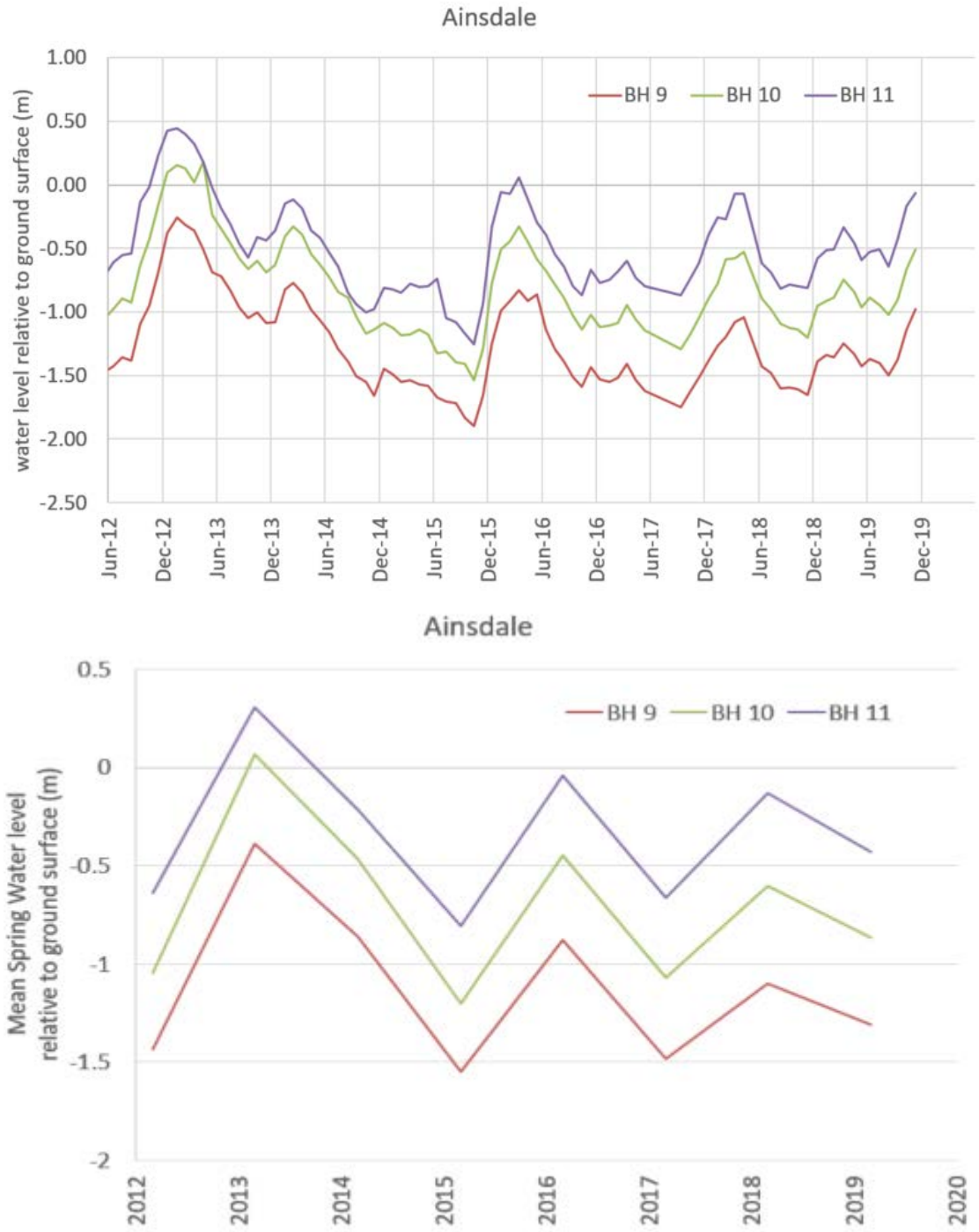
How is the percentage cover of positive and negative indicator species (or nitrogen-loving and nitrogen-sensitive species) changing over time?

The sum of indicator species cover for each indicator type can be compared for quadrats in different management units, or different habitat types, or to see if they change over time.

In terms of visualising data from this activity, percentage cover of positive and negative indicator species from different quadrats and in different years could be mapped across the site to potentially highlight areas of concern which might inform future management. Information about disturbance and the distance of quadrats from the edge of transitions to other dune features (shoreline, fixed grassland) could be used to help with interpretation of this data.

7.5 Water table depth

Data collected from dipwells can be used to calculate average annual or average seasonal (e.g. spring = Mar, Apr, May) water table depth in different dune slacks. Other metrics can also be useful, such as annual median water level. Plotting monthly measurements and annual or seasonal summaries can then be used to detect trends over time, and to compare against guideline water levels for different communities or species.



Example of water table data, showing (top) monthly water level measurements at Ainsdale NNR, with considerable variability between years; (bottom) the same data summarised to average Spring Water Level (average of Mar, Apr and May measurements). Vegetation at BH9 is a former slack now mainly grassland, BH10 is transitional between grassland and dune slack, BH11 is good quality SD15 dune slack community.

7.6 Disturbance

Data analysis can map location of disturbance by type to build up a picture of spatial patterns across the site related to animal or human activity. This can also be used to show change over time. The information can provide site managers with more detailed understanding on where animals are most active on the site, or where activity by people might prompt changes in management, or more frequent visits by site managers.

7.7 Key species survey

Although data from such surveys are difficult to analyse statistically because of the variation in recorder effort from year-to-year, records from the survey in each year can be overlaid on a map which can give a suggestion as to whether the species are increasing or declining in different parts of the site. Such changes may reflect management work that has been undertaken on sites; the arrival and establishment of new invasive species; or an increase in nutrients in a particular part of a site.

7.8 Further information on downloading, visualising and processing app data from the database

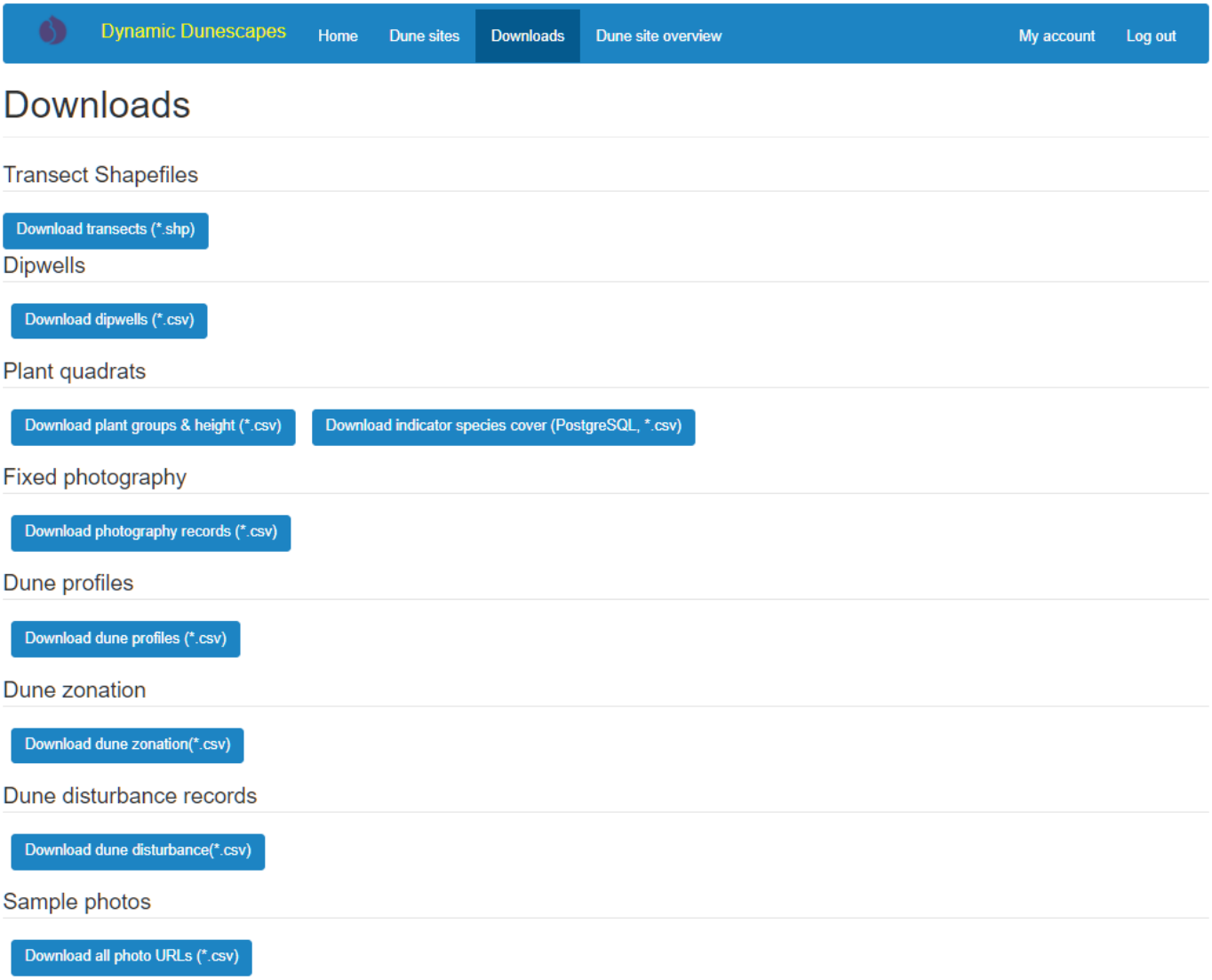
7.8.1 Downloading data from the database

Go to the dynamic dunescapes data website https://dunescapes.brc.ac.uk/

Log in if required

Click on 'downloads'

Select the relevant files & download them. These will download all data associated with that activity/type (see screenshot below).



As well as the collected data relating to the activities available on the app, two other downloads are provided:

- A full list of the plant indicator species recorded with percentage cover, and by quadrat, either as a matrix or in a 'stacked' format.
- For Sample photos, a list of the storage location (URL) of all the photos recorded in the app. This file includes information on the type of activity ('Type'), the date and location, and the unique i.d. of that record ('Sample ID') which can be cross-referenced to the i.d. of the activity you are interested in. The final column provides the URL for that photo.
  E.g. Sample ID '14589845' in the file '*full-photo-list'* links to the same Sample ID for quadrat 'Dune slack (scrape) monitoring - Quadrat 5' at Oxwich recorded on 9th June 2021, in file '*quadrat-indicator-species-cover*'.

7.8.2 Visualising data using the on-line visualising tool

Go to the visualising website https://olipes.shinyapps.io/dataVisR/

This will prompt you to upload the relevant files on the activity you want to view the data for.

For most activity types, you will be able to select or filter what you view by site, with some additional filtering by group, transect or quadrat as appropriate. Additional filtering may let you narrow down the date range or select a particular year, depending on the data type. As data builds up in the database, this will become increasingly necessary. There is some test data in the database from the testing phase which may look unusual, but can be ignored.

The on-line visualisation allows you to produce simple graphs for each of your data types. It also shows a selection of the data in a table so you can see what it looks like. For more detailed analysis it is recommended to use the raw data in the .csv files – see the sections below. Each function is briefly described here.

- **Dipwells**: shows the water level over time for each dipwell (after selecting to show those you wish to view). The data are inverted for visualisation purposes, i.e. negative numbers show the depth below the top of the dipwell. These data can be further adjusted to show depth below ground surface, or absolute height above sea-level by additional processing.
- **Zonation**: shows the width of each habitat along your transect in sequence, allowing you to compare the same transect across years.
- **Profiles**: shows a line graph of the profile along your transect, allowing you to compare different transects, or the same transect across years.
- **Quadrat Health and Nitrogen indicators:** allows you to view bar graphs of the combined cover of positive or negative health indicator species for each quadrat, or the nitrogen-loving or nitrogen-sensitive species.
- **Quadrat plant groups and height**: allows you to view bar graphs of the combined cover of broad vegetation categories (shrubs, grasses, herbs, mosses and lichens, scrub, bare ground), and separately view a graph of the average height of vegetation in that quadrat.
- **Fixed photography**: gives the information associated with all fixed photography records, but you need to refer to the photo URLs file to download the photo
- **Full photo list**: gives the information associated with all photos and the activities they were linked to, plus the URL of the storage location of the photo. Link to this file using 'Sample ID' from other surveys.
- **Disturbance**: gives grid references and date for all features noted using this activity, and comments where provided.

7.8.3 Off-line analysis of downloaded data

For separate analysis of downloaded data, the following text outlines some additional possible ways of looking at the data. These instructions assume that users are familiar with Excel, and/or can learn using on-line tutorials how to

add filters to columns allowing you to sort or sub-set the data that you see, and how to construct and use pivot tables and pivot charts.

Dipwells

You will need to convert the 'water table depth' to a negative number before viewing by date.

You can use line graphs in pivot charts to show water levels over time, using Site, Group, Dipwell in the Columns box to create individual lines for each dipwell. Pivot charts do not allow you to show x-y charts. but if you want these to be true to the dates shown you will need to sub-set the data you want using column filters, then copy to a new sheet and create an x-y chart.

The data show depth below the top of the dipwell.

You can correct for the 'upstand' (the amount the dipwell protrudes above the ground surface) to calculate the **water depth below ground surface**. This is important if you need to refer to eco-hydrological guidelines for different dune slack plant communities.

If you have accurate elevation measurements (preferably to the nearest centimetre - vertical accuracy), you can calculate the absolute height of the **water table above sea level** for each time point)

Zonation

Select the transect and date combination you are interested in.

Check that the records are in sequence order (sort by Sample ID).

Using a stacked bar graph you should be able to view the transect in sequence

Profiles

Select the transect and date combination you are interested in. Plotting requires some additional calculations:

Distance along the x axis is calculated using this formula =COS(RADIANS(J3))*K3

Distance on the y axis is calculated using this formula =SIN(RADIANS(J3))*K3

Where J3 is the cell in column labelled 'Slope angle' and K3 is the cell in column labelled 'Slope distance'

You then need to calculate a cumulative distance along the x axis and cumulative height along the y axis before plotting as an x-y graph

Health and Nitrogen indicators

You can filter only to include the species on the Shortlist (=1), these are the shortlist of species defined for use in the app for each habitat. However, a longer list of indicator species is available in the database and users may have added cover values for these when in the field.

In the pivot table you can select by: Site, Group, Quadrat, Year in the Rows box

In the Columns box you decide whether to view Health indicators (select 'Health Type') or Nitrogen indicators (select 'Nitrogen Type'). This then determines which data you view in the Values box, described below. For each one, use the 'Sum' values option:

i.e. selecting Health indicators (Health Type), you should sum for each quadrat the Health % cover values

i.e. selecting Nitrogen indicators (Nitrogen Type), you should sum for each quadrat the Nitrogen % cover values

Plant groups and height

Separate graphs can be constructed for cover of each plant group and for vegetation height.

In pivot tables, the cover of plant groups can be presented as separate bar charts for each cover type, or as a stacked proportional bar chart. Each cover type is added separately into the Values box. To visualise in other ways, such as pie charts, the data would need stacking. These can be created separately if required by copying the data out of pivot table summaries.

The individual height measurements are also provided, as well as the average, if further processing is required.

8 Appendix A: Indicator species selection

Below are lists of positive and negative plant indicator species to be used for activities 4 and 7. There are different lists for (1) indicators of general dune health (mobile and fixed dunes) and specific indicators of nitrogen deposition (fixed dunes only); (2) mobile and fixed dune zones; and (3) separate lists for fixed dunes and heath in acidic dune systems. These lists provide a list of 'core' species for each of these situations which can be added to on a site-by-site basis, for example, to include species of particular concern or interest. When selecting new species it is recommended that these are relatively straightforward to identify (it may be worth trialling identification of new species with a few volunteers to test how reliably this is done). It is also recommended that not too many species are added to the list in order to keep the task manageable for volunteers.

Indicators of dune health

The Common Standards Monitoring Guidance for Sand Dune Habitats (2004) was used as the starting point for the selection of plant species that are positive and negative (including invasive species) indicators of the health of mobile dune (including strandline, embryo and mobile dunes) and fixed dune grassland (including semi-fixed and fixed dunes) areas separately. Each species was assessed in terms of how widespread it is and how easily identifiable and the most charismatic species that represented a range of plants families were chosen in order to come up with a list of around 5 positive and 5 negative indicator species in each category. These lists were then modified through consultation with sand dune experts to produce the lists below.

Strandline, embryo and mobile dune

Mobile dune positive indicators	**Mobile dune negative indicators**
Sea sandwort (*Honkenya peploides*)	Common ragwort (*Senecio jacobaea*)
Common saltwort (*Salsola kali*)	Spear thistle (*Cirsium vulgare*)
Marram grass (*Ammophila arenaria*)	Creeping thistle (*Cirsium arvense*)
Sea rocket (*Cakile maritima*)	Common nettle (*Urtica dioica*)
Sea holly (*Eryngium maritimum*)	Ryegrass (*Lolium perenne*)

Mobile dune acidic grassland positive indicators	**Mobile dune acidic grassland negative indicators**
Sea sandwort (*Honkenya peploides*)	Pirri-pirri bur (*Acaena novae-zelandiae*)
Common saltwort (*Salsola kali*)	
Marram grass (*Ammophila arenaria*)	
Sea rocket (*Cakile maritima*)	
Sea bindweed (*Calystegia soldanella*)	

Semi-fixed and fixed dunes

Fixed dune grassland positive indicators	**Fixed dune grassland negative indicators**
Lady's bedstraw (*Galium verum*)	Bramble (*Rubus fruticosus agg.*)
Eyebright (*Euphrasia officinalis*)	Spear thistle (*Cirsium vulgare*)
Bird's-foot trefoil (*Lotus corniculatus*)	Common nettle (*Urtica dioica*)
Self heal (*Prunella vulgaris*)	Sea buckthorn (*Hippophae rhamnoides*)
Yellow rattle (*Rhinanthus minor*)	Rose species (*Rosa spp.*)
Cladonia lichens	Travellers joy (*Clematis vitalba*)

Fixed dune acidic grassland positive indicators	**Fixed dune acidic grassland negative indicators**
Sheep's bit (*Jasione montana*)	Spear thistle (*Cirsium vulgare*)

Common cat's ear (*Hypochaeris radicata*)	Rose species (*Rosa spp.*)
Buck's horn plantain (*Plantago coronopus*)	European gorse (*Ulex europaeus*)
Squirrel-tail fescue (*Vulpia bromoides*)	Ling (*Calluna vulgaris*)
Marram (*Ammophila arenaria*)	Heath star-moss (*Campylopus introflexus*)
	Pirri-pirri bur (*Acaena novae-zelandiae*)
	Rhododendron (*Rhododendron ponticum*)

Dune heath

Heath positive indicators	**Heath negative indicators**
Marram (*Ammophila arenaria*)	Sycamore (*Acer pseudoplatanus*)
Sand sedge (*Carex arenaria*)	Holly (*Ilex aquifolium*)
Sheep's bit (*Jasione montana*)	Scot's pine (*Pinus sylvestris*)
Common cat's ear (*Hypochaeris radicata*)	Heath star-moss (*Campylopus introflexus*)
Cladonia lichens (*Cladonia* spp)	
Juniper hair-cap moss (*Polytrichum juniperinum*)	

Dune slacks

Dune slacks positive indicators	**Dune slacks negative indicators**
Bird's foot trefoil (*Lotus corniculatus*)	Creeping thistle (*Cirsium arvense*)
Creeping willow (*Salix repens*)	Common nettle (*Urtica dioica*)
Water mint (*Mentha aquatic*a)	Ragwort (*Senecio jacobaea*)
Marsh pennywort (*Hydrocotyle vulgaris*)	Bracken (*Pteridium aquilinum*)
Self-heal (*Prunella vulgaris*)	
Bog pimpernel (*Anagallis tenella*)	Sea buckthorn (*Hippophae rhamnoides*) *
Pointed Spear moss (*Calliergonella cuspidata*)	
Liverworts (e.g. *Aneura pinguis*)	

* This species is invasive on many sites, but is a considered a native on some sites in Lincolnshire and Norfolk.

Indicators of nitrogen deposition

The selection of nitrophiles (nitrogen-loving species) and nitrophobes (nitrogen-hating species) broadly followed and extended the methodology of Jones & Stevens (2017) which focused only on the selection of nitrophiles. The process was as follows:

- Species lists for fixed dune grasslands were derived from National Vegetation Classification community species lists. The NVC communities considered were: SD7, SD8, SD9 and SD10. Mobile dune communities were not included because nitrogen plays a much smaller role than other factors in determining species composition in mobile dunes compared to fixed dune grassland.
- For each of these species, the Ellenberg nutrient score was obtained from the Online Atlas of the British Isles (www.brc.ac.uk/plantatlas/). This is a scale from 1 to 9 with low numbers showing the species is adapted to low nutrient availability and high numbers showing the species is adapted to high nutrient availability.
- The Ellenberg values that covered the 20 % most nutrient loving and 20 % most nutrient sensitive species were selected. For nutrient loving species, this was 6 and 7 (there were no species with Ellenberg nutrient scores higher than this) and for nutrient sensitive species, this was 2 (there were no species with Ellenberg nutrient scores lower than this).

- For each of the species with these Ellenberg values, the ease of identification and extent of UK distribution were considered and those with widespread distributions and for which identification is straightforward were selected. From these, the most charismatic species that represented a range of plants families and were not already selected for the dune health indicator species were chosen in order to come up with a list of 5-6 nutrient loving and 5-6 nutrient sensitive species for inclusion in the quadrat survey.
- Again, the final list was modified slightly, following consultation with experts.

Fixed dune grassland

Calcareous dune Nitrogen sensitive species	**Calcareous dune Nitrogen loving species**
Kidney vetch (*Anthyllis vulneraria*)	Cocksfoot (*Dactylis glomerata*)
Harebell (*Campanula rotundifolia*)	Silverweed (*Potentilla anserina*)
Biting stonecrop (*Sedum acre*)	White clover (*Trifolium repens*)
Devil's bit scabious (*Succisa pratensis*)	Curled dock (*Rumex crispus*)
Hare's foot clover (*Trifolium arvense*)	Creeping thistle (*Cirsium arvense*)
	Sow-thistle (*Sonchus* spp.)

Acidic dune nitrogen sensitive species	**Acidic dune nitrogen loving species**
Mossy stonecrop (*Crassula tillaea*)	Cocksfoot (*Dactylis glomerata*)
Early hair-grass (*Aira praecox*)	Silverweed (*Potentilla anserina*)
Lesser Cudweed (*Filago minima*)	White clover (*Trifolium repens*)
Field woodrush (*Luzula campestris*)	Greater plantain (*Plantago major*)
Dune fescue (*Vulpia fasciculata*)	Cleavers (*Galium aparine*)
	Sow-thistle (*Sonchus* spp.)

Dune slacks

Dune slack Nitrogen sensitive species	**Dune slack Nitrogen loving species**
Bird's foot trefoil (*Lotus corniculatus*)	Ground ivy (*Glechoma hederacea*)
Blue-green / glaucous sedges (*Carex flacca, Carex panicea, Carex nigra*)	Creeping buttercup (*Ranunculus repens*)
Marsh orchids (*Dactylorhiza spp.*)	Woody nightshade (*Solanum dulcamara*)
Devil's bit scabious (*Succisa pratensis*)	Hemp agrimony (*Eupatorium cannabinum*)
Liverworts (e.g. *Aneura pinguis*)	Creeping thistle (*Cirsium arvense*)
	Sow-thistle (*Sonchus* spp.)

Full list of indicator species

Latin name	Common name	short list	long list	strandline, embryo, mobile dune	fixed, semi-fixed dune	dune heath	dune slack	Health indicator	Nitrogen indicator
Vascular plants									
Acaena novae-zelandiae	Pirri-pirri-bur	1	1	1				Negative health	
Acer pseudoplatanus	Sycamore	1	1			1		Negative health	
Agrostis capillaris	Common Bent		1		1			Positive health	
Aira praecox	Early Hair-grass	1	1		1			Positive health	Nitrogen sensitive
Ammophila arenaria	Marram	1	1	1		1		Positive health	
Anagallis tenella	Bog Pimpernel	1	1				1	Positive health	
Anthyllis vulneraria	Kidney Vetch	1	1				1		Nitrogen sensitive
*Arrhenatherum elatius**	False Oat-grass		1	1	1		1	Negative health*	
Astragalus danicus	Purple Milk-vetch		1		1			Positive health	
Atriplex	Orache		1	1				Positive health	
Cakile maritima	Sea Rocket	1	1	1				Positive health	
Calluna vulgaris	Heather	1	1		1			Negative health	
Calystegia soldanella	Sea Bindweed	1	1	1					
Campanula rotundifolia	Harebell	1	1		1				Nitrogen sensitive
Carex arenaria	Sand Sedge	1	1		1	1	1	Positive health	
Carex flacca	Glaucous Sedge	1	1		1		1	Positive health	Nitrogen sensitive
Carex pilulifera	Pill Sedge		1		1			Positive health	
Cerastium fontanum	Common Mouse-ear		1		1			Positive health	
Cirsium arvense	Creeping Thistle	1	1	1	1		1	Negative health	Nitrogen loving
Cirsium palustre	Marsh Thistle		1				1	Negative health	
Cirsium vulgare	Spear Thistle	1	1	1	1		1	Negative health	
Clematis vitalba	Traveller's-joy	1	1		1			Negative health	
Crassula tillaea	Mossy Stonecrop	1	1		1				Nitrogen sensitive
Crepis capillaris	Smooth Hawk's-beard		1		1			Positive health	
Dactylis glomerata	Cock's-foot	1	1		1				Nitrogen loving
Dactylorhiza	Marsh Orchid	1	1				1		Nitrogen sensitive

Latin name	Common name	short list	long list	strandline, embryo, mobile dune	fixed, semi-fixed dune	dune heath	dune slack	Health indicator	Nitrogen indicator
Deschampsia flexuosa	Wavy Hair-grass		1		1			Positive health	
Elytrigia juncea	Sand Couch		1	1				Positive health	
Equisetum variegatum	Variegated Horsetail		1				1	Positive health	
Erodium cicutarium	Common Stork's-bill		1		1			Positive health	
Eryngium maritimum	Sea-holly	1	1	1				Positive health	
Eupatorium cannabinum	Hemp-agrimony	1	1				1		Nitrogen loving
Euphrasia officinalis	Eyebright	1	1		1		1	Positive health	
Festuca ovina	Sheep's-fescue		1		1			Positive health	
Festuca rubra	Red Fescue		1		1		1	Positive health	
Filago minima	Small Cudweed	1	1		1				Nitrogen sensitive
Galium aparine	Cleavers	1	1		1				Nitrogen loving
Galium palustre	Marsh-bedstraw		1				1	Positive health	
Galium saxatile	Heath Bedstraw		1		1			Positive health	
Galium verum	Lady's Bedstraw	1	1		1			Positive health	
Geranium molle	Dove's-foot Crane's-bill		1		1			Positive health	
Glechoma hederacea	Ground-ivy	1	1				1		Nitrogen loving
Hippophae rhamnoides	Sea-buckthorn	1	1		1		1	Negative health	
Honckenya peploides	Sea Sandwort	1	1	1				Positive health	
Hydrocotyle vulgaris	Marsh Pennywort	1	1				1	Positive health	
Hypochaeris radicata	Common Catsear	1	1		1	1		Positive health	
Ilex aquifolium	Holly	1	1			1		Negative health	
Jacobaea vulgaris	Common Ragwort	1	1	1	1		1	Negative health	
Jasione montana	Sheep's-bit	1	1		1	1		Positive health	
Leymus arenarius	Lyme-grass		1	1				Positive health	
Linum catharticum	Fairy Flax		1		1			Positive health	
Lolium perenne	Ryegrass	1	1	1	1		1	Negative health	
Lotus corniculatus	Bird's-Foot-Trefoil	1	1		1		1	Positive health	Nitrogen sensitive
Luzula campestris	Field Wood-rush	1	1		1			Positive health	Nitrogen sensitive
Mentha aquatica	Water mint	1	1				1	Positive health	

Latin name	Common name	short list	long list	strandline, embryo, mobile dune	fixed, semi-fixed dune	dune heath	dune slack	Health indicator	Nitrogen indicator
Odontites vernus	Red Bartsia		1		1			Positive health	
Ononis repens	Common Restharrow		1		1		1	Positive health	
Pilosella officinarum	Mouse-ear-hawkweed		1		1		1	Positive health	
Pinus	Pine	1	1			1		Negative health	
Plantago coronopus	Buck's-horn Plantain	1	1		1			Positive health	
Plantago lanceolata	Ribwort Plantain		1		1			Positive health	
Plantago major	Greater plantain	1	1		1				Nitrogen loving
Polygala serpyllifolia	Heath Milkwort		1		1			Positive health	
Potentilla anserina	Silverweed	1	1		1		1	Positive health	Nitrogen loving
Potentilla erecta	Tormentil		1		1			Positive health	
Prunella vulgaris	Selfheal	1	1		1		1	Positive health	
Pteridium aquilinum	Bracken	1	1		1		1	Negative health	
Ranunculus flammula	Lesser Spearwort		1				1	Positive health	
Ranunculus repens	Creeping buttercup	1	1				1		Nitrogen loving
Rhinanthus minor	Yellow rattle	1	1		1			Positive health	
Rhododendron ponticum	Rhododendron	1	1		1			Negative health	
Rosa	Rose	1	1		1			Negative health	
Rubus fruticosus agg.	Bramble	1	1		1			Negative health	
Rumex crispus	Curled dock	1	1		1				Nitrogen loving
Salix repens	Creeping willow	1	1				1	Positive health	
Salsola kali	Saltwort	1	1	1				Positive health	
Sedum acre	Biting stonecrop	1	1		1			Positive health	Nitrogen sensitive
Solanum dulcamara	Woody nightshade	1	1				1		Nitrogen loving
Sonchus	Sow Thistle	1	1		1		1		Nitrogen loving
Succisa pratensis	Devil's-bit Scabious	1	1		1		1		Nitrogen sensitive
Thymus polytrichus	Wild Thyme		1		1			Positive health	
Trifolium arvense	Hare's-foot Clover	1	1		1				Nitrogen sensitive
Trifolium repens	White clover	1	1		1			Positive health	Nitrogen loving
Tripleurospermum maritimum	Sea Mayweed		1	1				Positive health	

Latin name	Common name	short list	long list	strandline, embryo, mobile dune	fixed, semi-fixed dune	dune heath	dune slack	Health indicator	Nitrogen indicator
Ulex europaeus	Gorse	1	1		1			Negative health	
Urtica dioica	Common nettle	1	1	1	1		1	Negative health	
Veronica chamaedrys	Germander Speedwell		1		1			Positive health	
Viola canina	Heath Dog-violet		1		1			Positive health	
Viola riviniana	Common Dog-violet		1		1			Positive health	
Viola tricolor	Wild Pansy		1		1			Positive health	
Vulpia bromoides	Squirrel-tail fescue	1	1		1			Positive health	
Vulpia fasciculata	Dune fescue	1	1		1				Nitrogen sensitive
Mosses, liverworts and lichens									
Calliergonella cuspidata	Pointed Spear-moss	1	1				1	Positive health	
Campylium stellatum s.lat.	Yellow Starry Feather-moss	1	1				1	Positive health	
Campylopus introflexus	Heath Star Moss	1	1		1	1		Negative health	
Cladonia	Cup Lichen	1	1		1	1		Positive health	
Dicranum scoparium	Broom Fork-moss		1		1			Positive health	
Hylocomium splendens	Glittering Wood-moss		1		1			Positive health	
Hypnum cupressiforme	Cypress-leaved Plait-moss		1		1			Positive health	
Marchantiophyta	Liverwort	1	1				1		Nitrogen sensitive
Peltigera	Peltigera		1		1			Positive health	
Pleurozium schreberi	Red-stemmed Feather-moss		1		1			Positive health	
Polytrichum juniperinum	Juniper Haircap	1	1			1		Positive health	
Pseudoscleropodium purum	Neat Feather-moss		1		1			Positive health	
Rhytidiadelphus squarrosus	Springy Turf-moss		1		1			Positive health	
Rhytidiadelphus triquetrus	Big Shaggy-moss		1		1			Positive health	
Tortula muralis	Wall Screw-moss		1		1			Positive health	

Notes:

**Arrhenatherum elatius* can be both a negative or a positive health indicator, depending on the type of NVC community it occurs in. For simplicity in constructing the app, it is listed only as a negative health indicator across all habitats. When analysing or interpreting data using the raw data downloads, it is possible to alter this for a habitat-specific analysis.

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