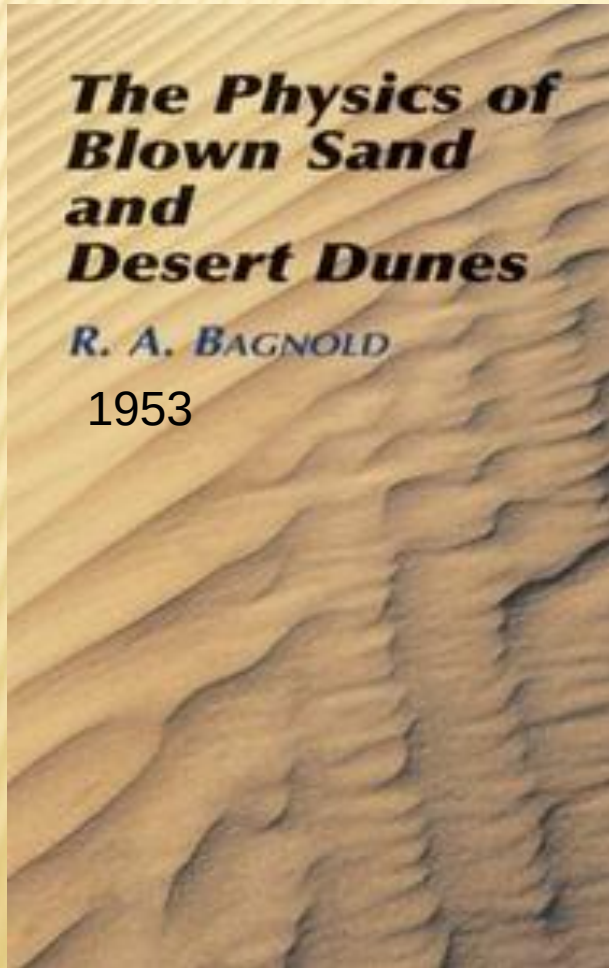


SAND DUNES: PROCESSES, ECOLOGY AND MANAGEMENT

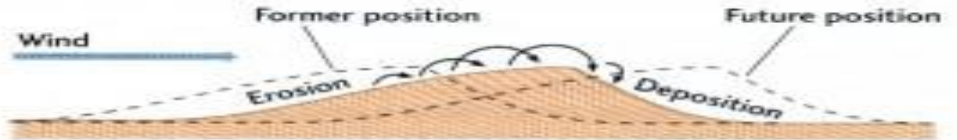


PHYSICS OF DUNE FORMATION

Draw 1 for your notes



- 1 A ripple or dune advances by the movements of individual grains of sand. The whole form moves forward slowly as sand erodes from the windward slope and is deposited on the leeward slope.



- 2 Particles of sand arriving on the windward slope of the dune move by saltation over the crest...



- 3 ...where the wind velocity decreases and the sand deposited slips down the leeward slope.



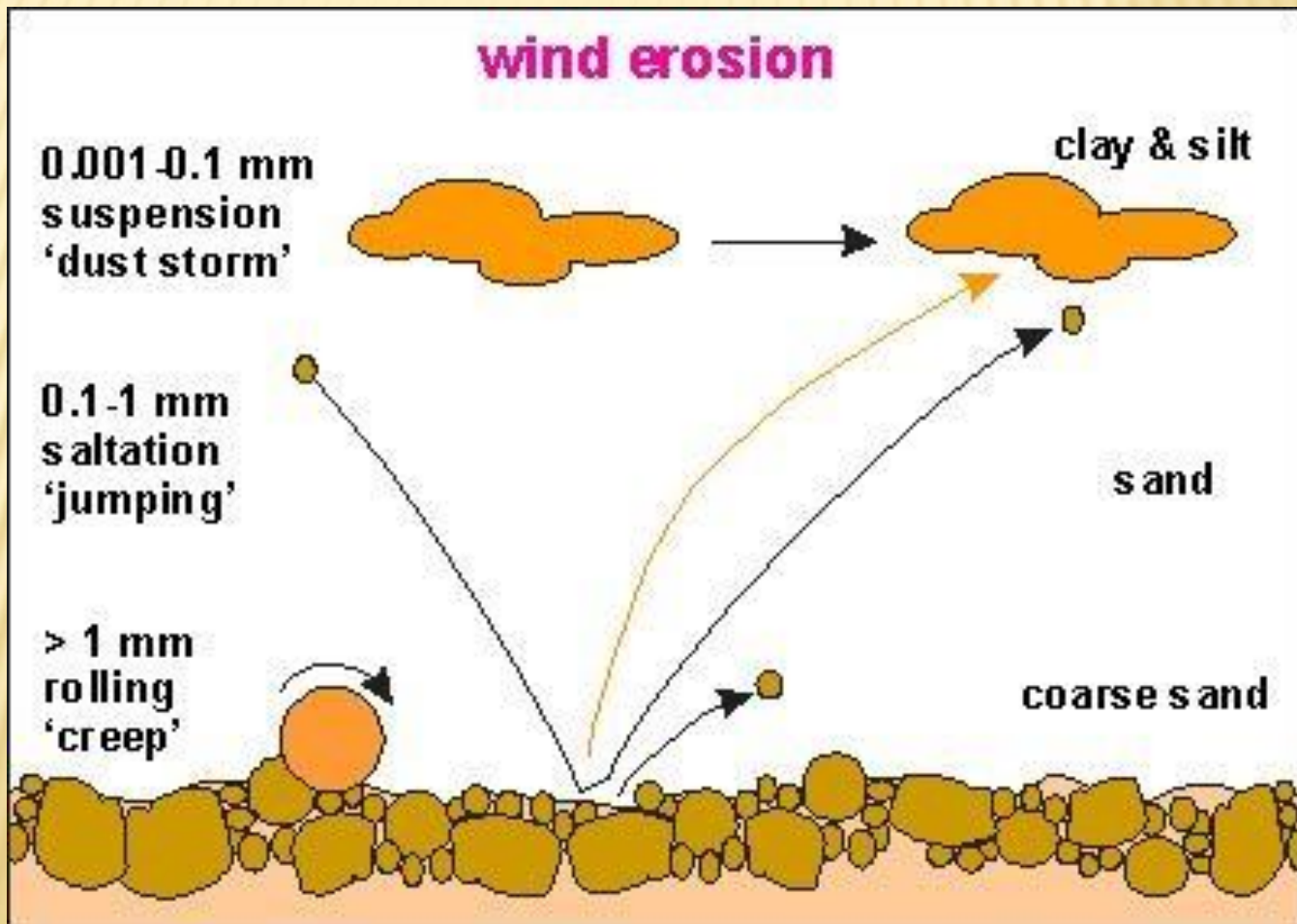
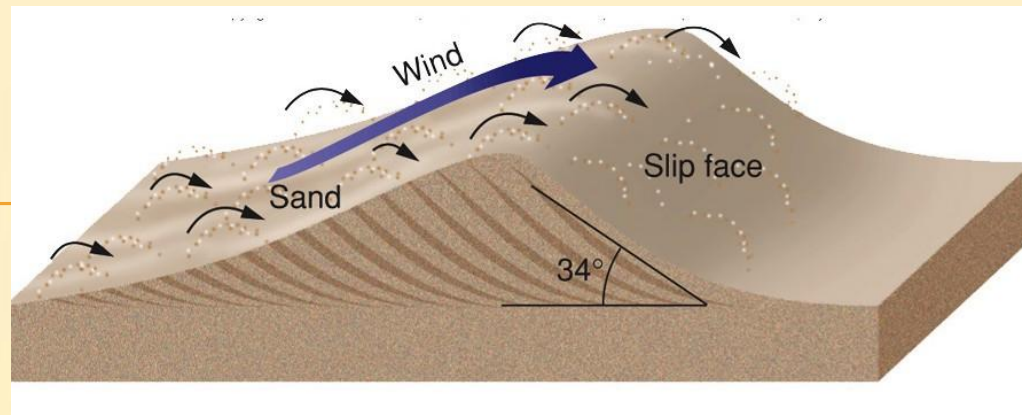
- 4 This process acts like a conveyor belt that moves the dune forward.



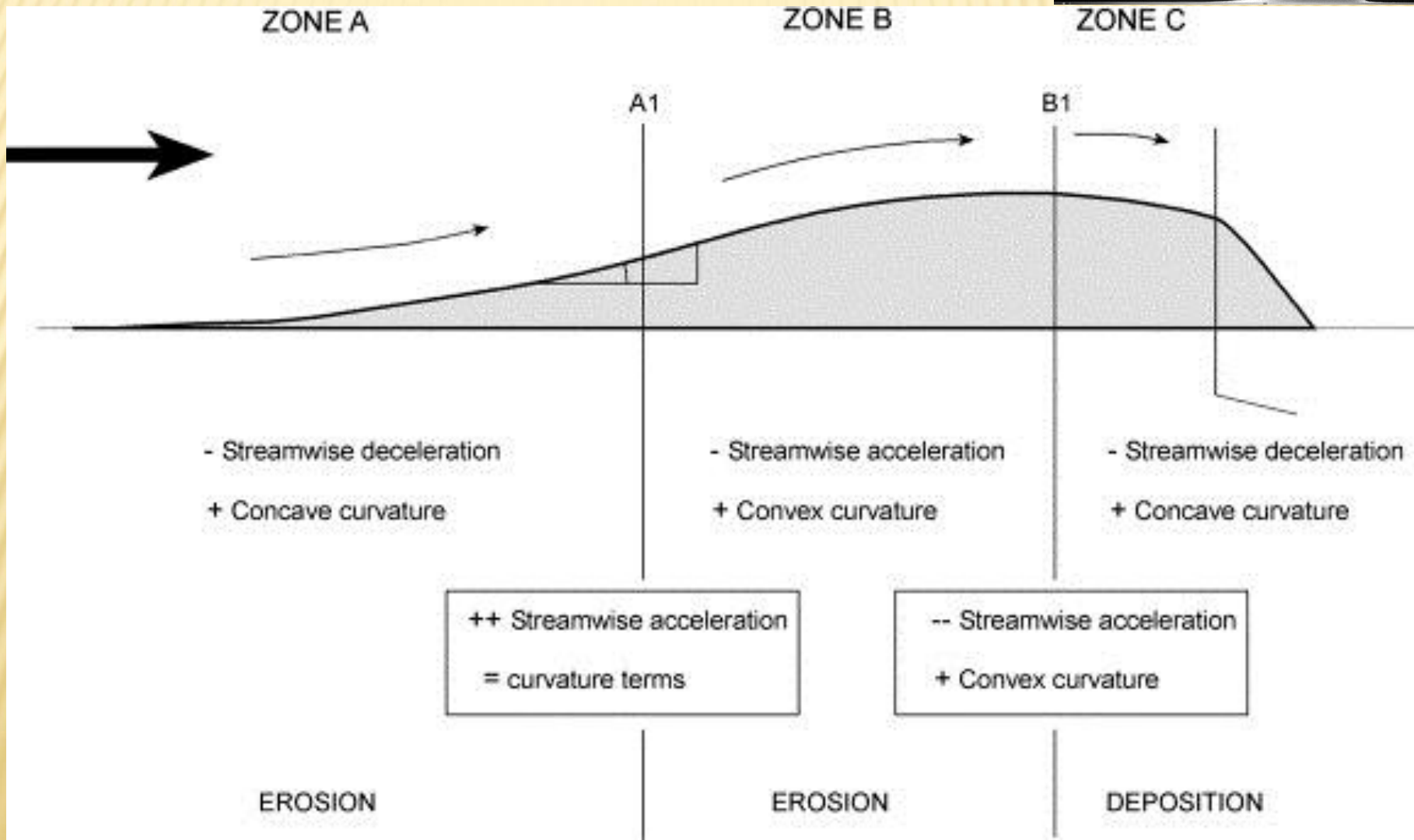
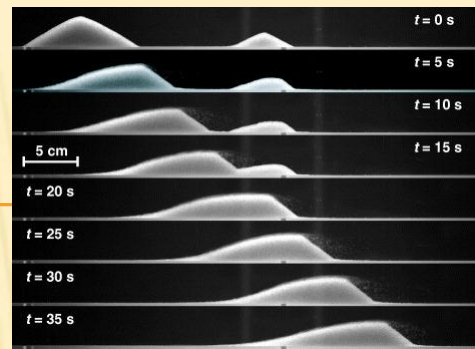
- 5 The dune stops growing vertically when it reaches a height at which the wind is so fast that it blows the sand grains off the dune as quickly as they are brought up.



SAND MOVEMENT



WHY DO DUNES MOVE?



HOW DO THEY FORM?

- ✗ They form when dry material from flat, open beaches is blown inland.
- ✗ Supply is generally from Quaternary glaciations therefore finite (in the UK)
- ✗ Dunes migrate and the succession of plants colonise and adapt to this environment forming a dune or psammosere ecosystem.
 - + A sere is an area of vegetation and a psammosere is an area of vegetation that sand forms.



SO WHAT IS A SAND DUNE?

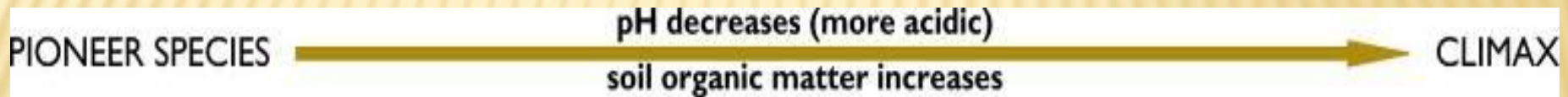
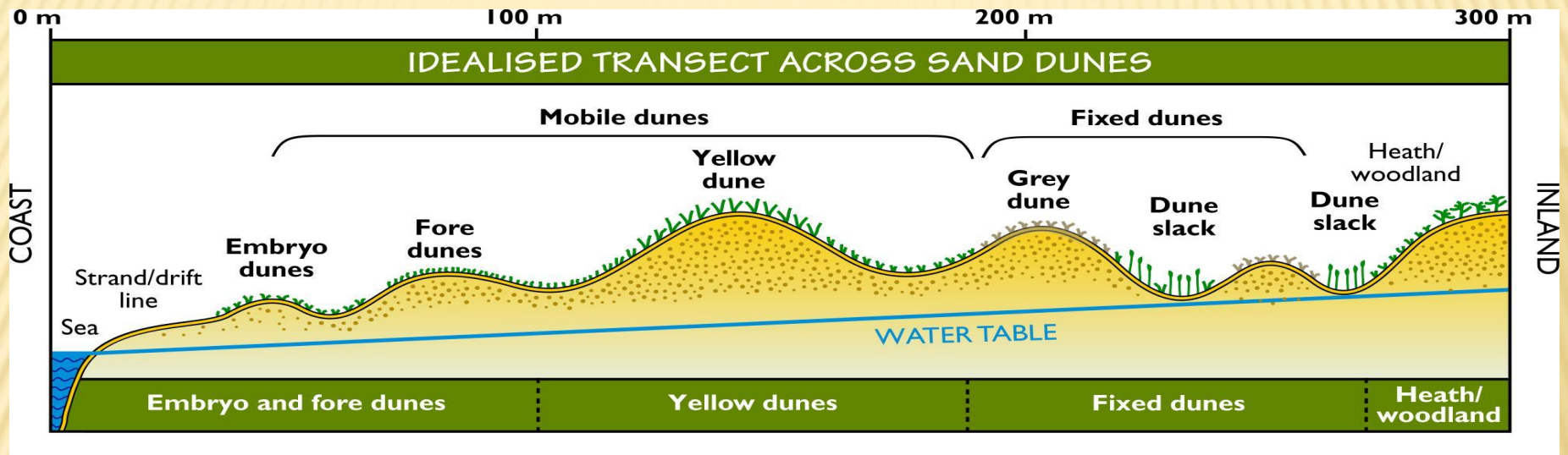


WHAT IS NEEDED TO CREATE SAND DUNES?

- ✗ A plentiful supply of sand
- ✗ Aeolian processes
- ✗ Strong winds to transport sand particles through saltation
 - + Sand slows, deposits, creates small hills
- ✗ Obstacles reduce wind speed and traps the sand e.g. a plant
 - + Plants are therefore central to the formation, growth and character of sand dunes
- ✗ Vegetation reduces wind speed and increases deposition therefore used for erosion management



Transect



pH 8
principally
sand and
pockets of
marram
grass

Marram,
sea
rocket

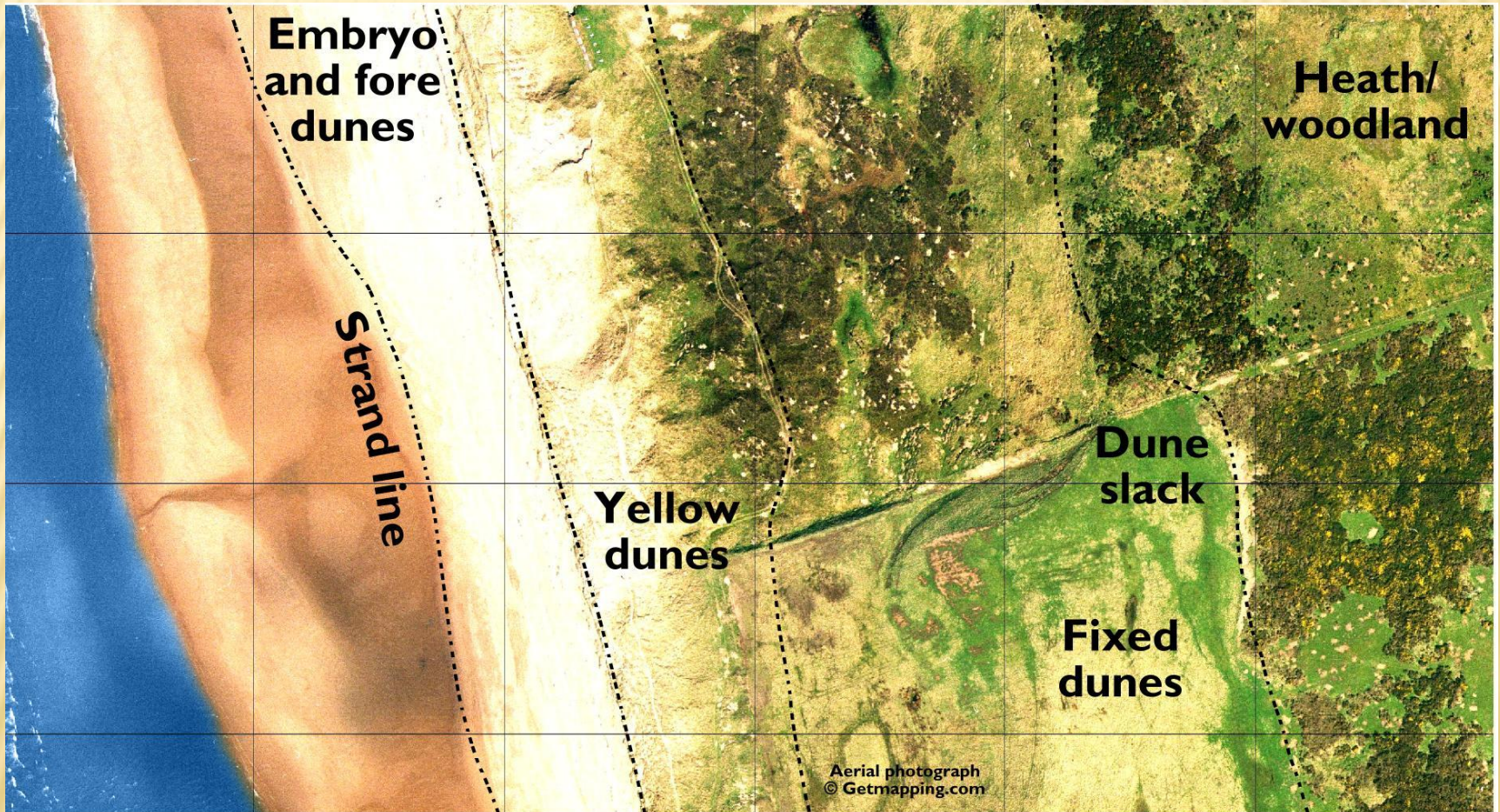
80% plant cover
(predominantly
marram)

Sheltered, dune
heath,
buckthorn, red
fescue, gorse

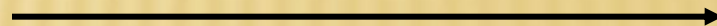
Near
water
table
therefore
willow,
moss,
reeds

Woodland:
birch, alder,
oak.

AERIAL VIEW



youngest
dunes



oldest
dunes

EMBRYO DUNES

- ✗ Spring high tide: strand line, fixation, plants start to grow.
- ✗ Wet sand therefore builds up with deposits of windblown sand
- ✗ High anemometer reading = dune migrates inland
- ✗ They are the first to develop.
- ✗ They become stabilised salt tolerant species: sea twitch grass, sea rocket and marram grass (Early colonisers).
- ✗ Waxy leaves and leaves rolled (reduced transpiration)
- ✗ If sand accumulates by >30 cm marram dominates
- ✗ Marram can deal with 1m annual accumulations and can spread by 3m annually



EMBRYO CONT'D

These embryo dunes may disappear as quickly as they form but some may eventually be colonised by plants which **stabilise** the sand. Conditions here are very extreme:.

- > **highly alkaline pH values** (over 8) from the calcium carbonate of the shell fragments;
- > **rapid drainage** (because sand does not hold water well) and the desiccating effect of on-shore winds ;
- > **high salinity** from frequent immersion in sea water;
- > **no humus** for nutrients;
- > **high wind speed** and lots of salt spray.

CONSEQUENTLY DUNES MAY NOT GROW HIGHER THAN 1M

FOREDUNES

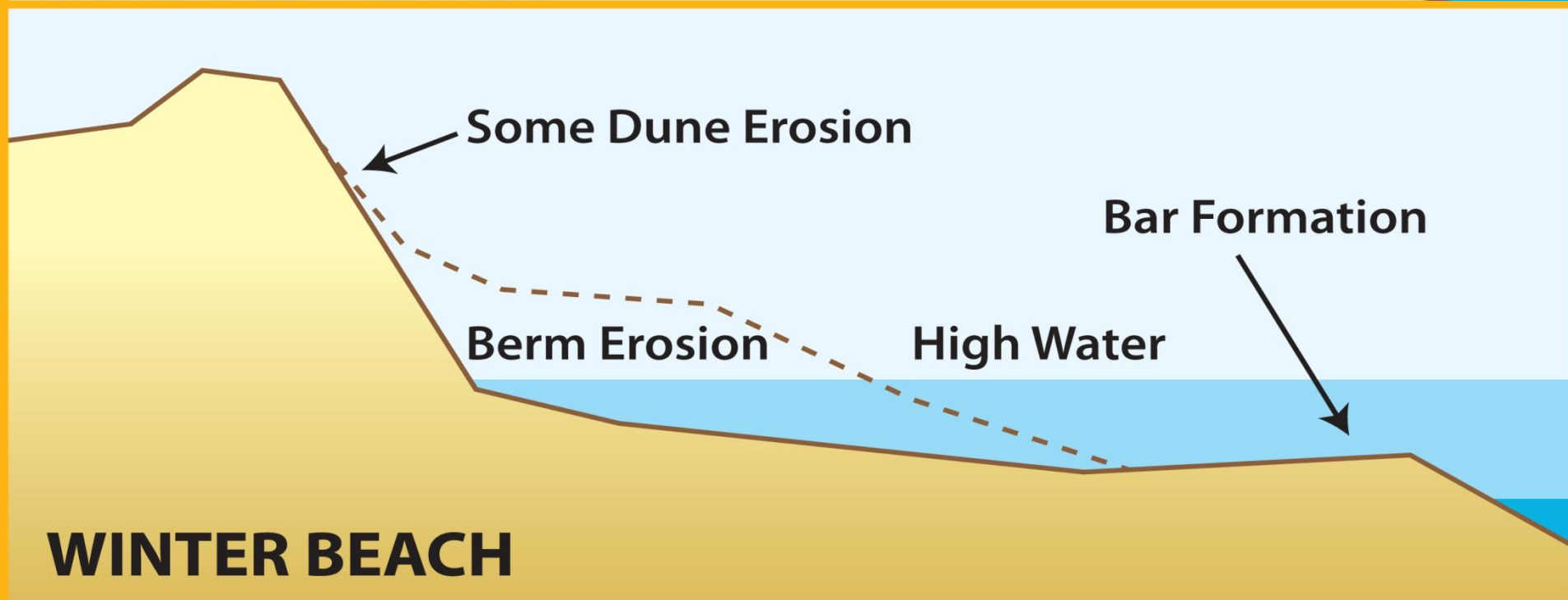
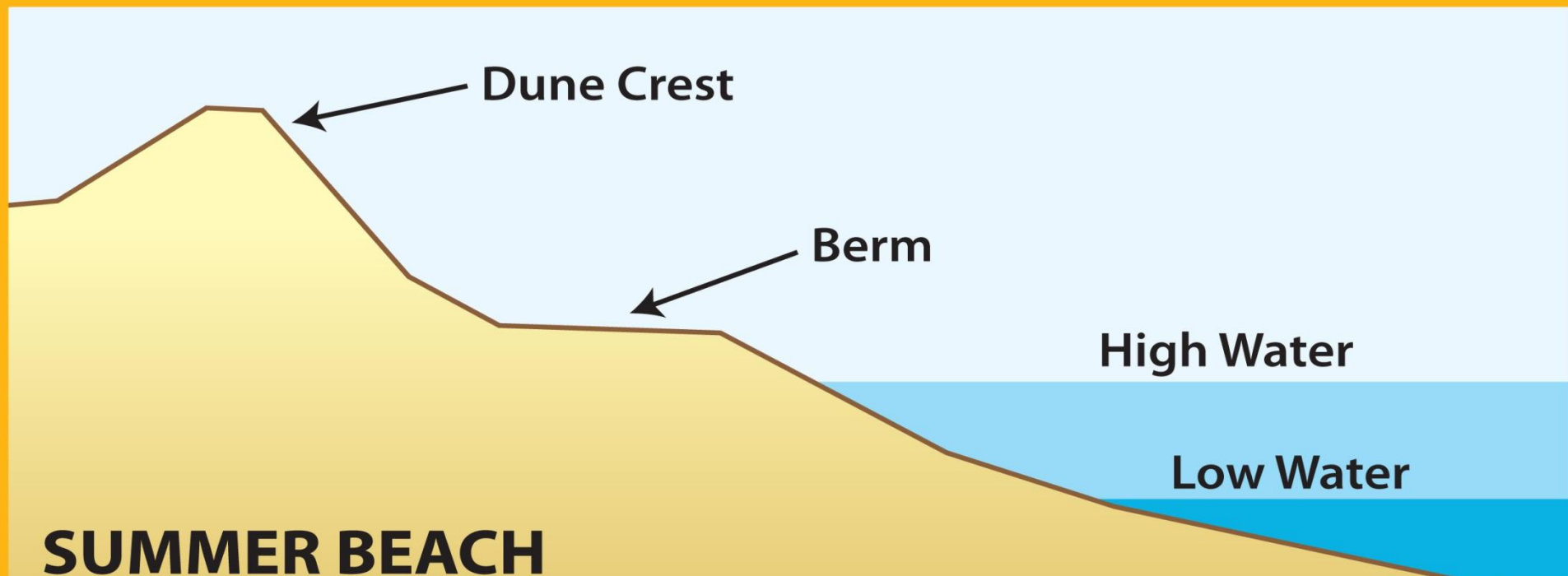
- ✗ As more sand accumulates, embryo dunes join to form fore dunes. They can be up to 5m in height.
- ✗ A lack of humus gives them the name yellow dunes. They become more grey as bacteria and plants are added.
- ✗ Plants include lyme grass, marram (rhizomes) and sea holly
- ✗ Need to be drought resistant, withstand burial, less salinity and reduced shell (Calcium carbonate) means > acidity



Lyme grass



Marram grass



YELLOW DUNES

- ✗ Larger and more biodiversity
- ✗ Humus layers develops
 - + Decay plants and small fauna droppings
 - + Humus 'captures' water and nutrients
 - + pH about 7.5 (leaching of carbonates)
 - + Less salinity
 - + Marram, creeping fescue and sand sedge, lichen and sea holly



GREY DUNES



- ✗ They grey dunes can become 10-30m in height before supply of fresh sand is cut off by increasing distance from the beach.
- ✗ Sheltered
- ✗ There may be parallel ridges of old dunes separated by low-lying, damp slacks. Heath plants dominate the area due to acidity, humus and moisture content all increasing.
- ✗ Paths cut by humans and animals expose area of sand
- ✗ Vegetation 100%
- ✗ More competition = > diversity
- ✗ Buckthorn, gorse, brambles then > humus and acidity leads to heathers.

SLACKS

- ✗ Between grey / mature dunes
- ✗ WT surface = seasonal (permanent) water
- ✗ Sedges, rushes, willow.
- ✗ Bird species

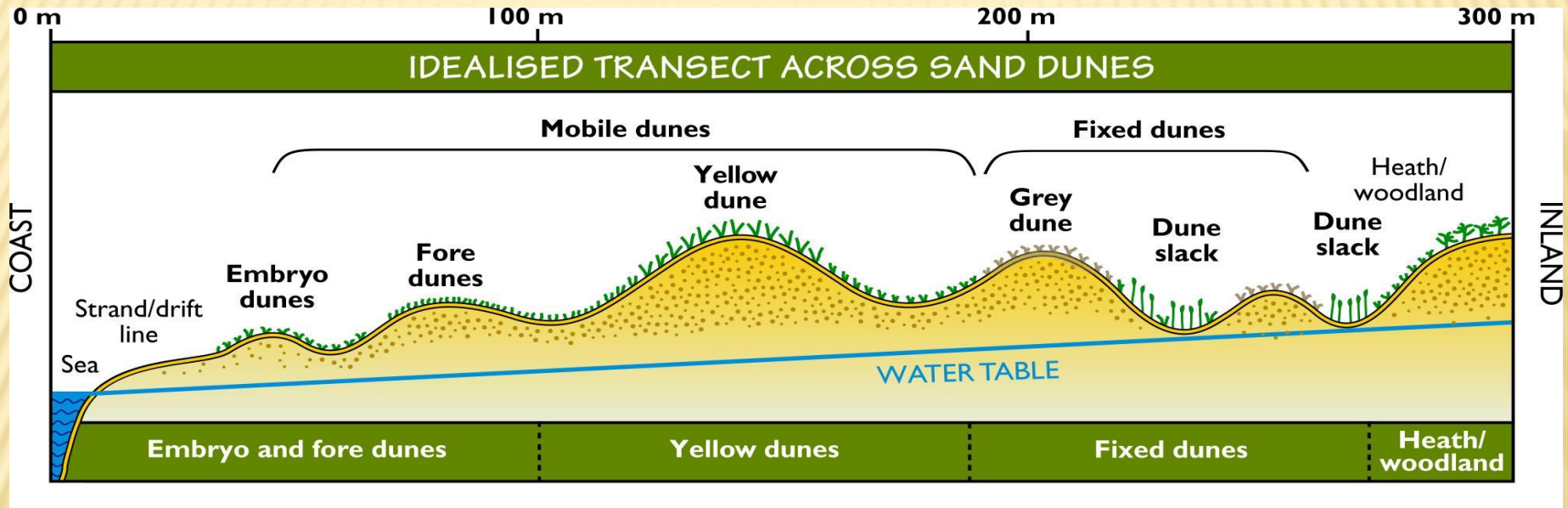


MATURE DUNES

- ✗ High humus/water
- ✗ Climax community
- ✗ Oak



A transect across a sand dune system



The transect above has hidden 'hotspots'. Move your mouse over the diagram and these will be revealed. Progress across the transect using these hot spots.

You can return to this diagram at any time by using the return button



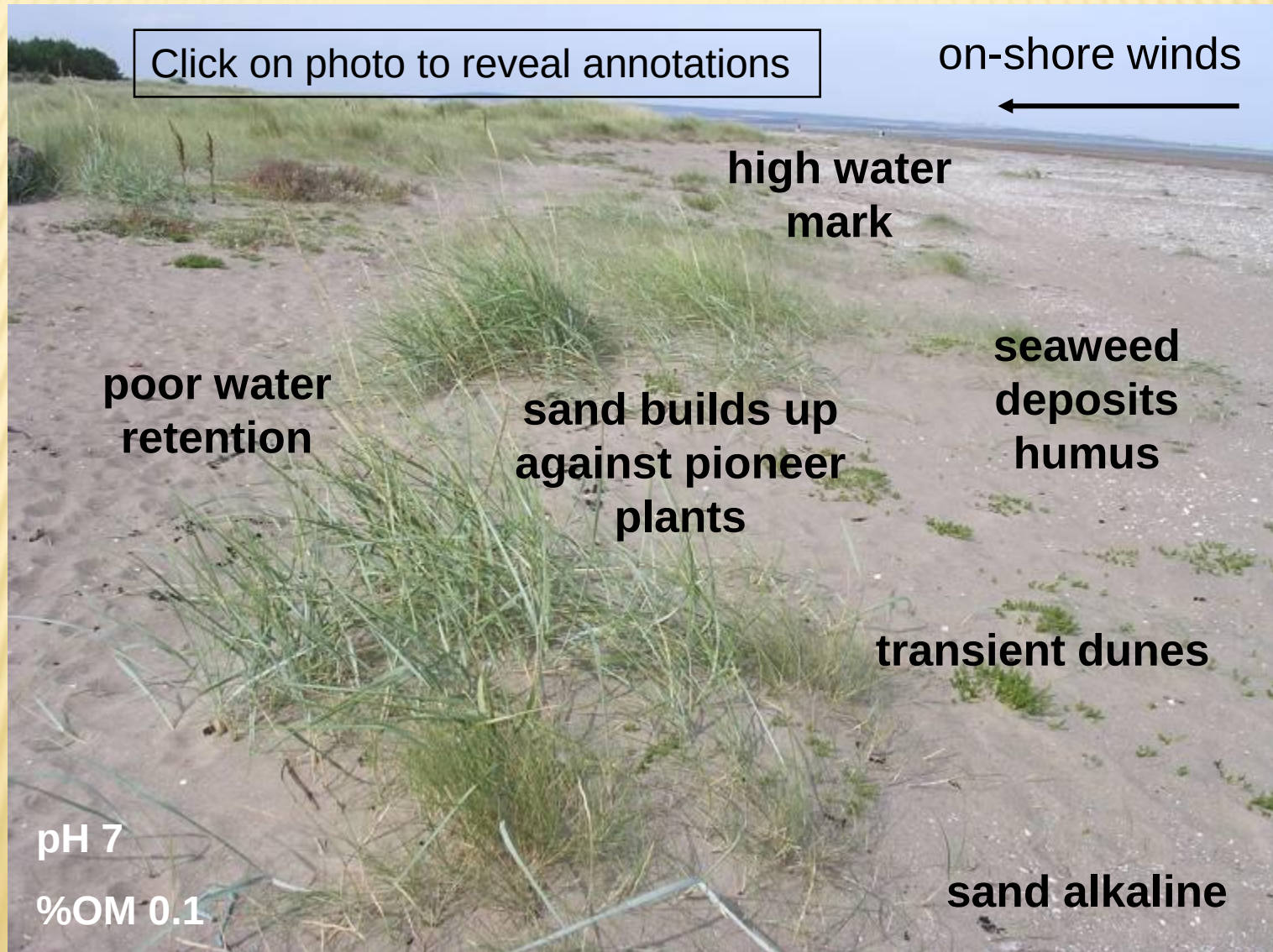
You can advance quickly from one slide to the next by using this button



You can go from this slide to the revision materials by using this button



Embryo and Fore Dunes: the environment



Embryo and Fore Dunes: the plants

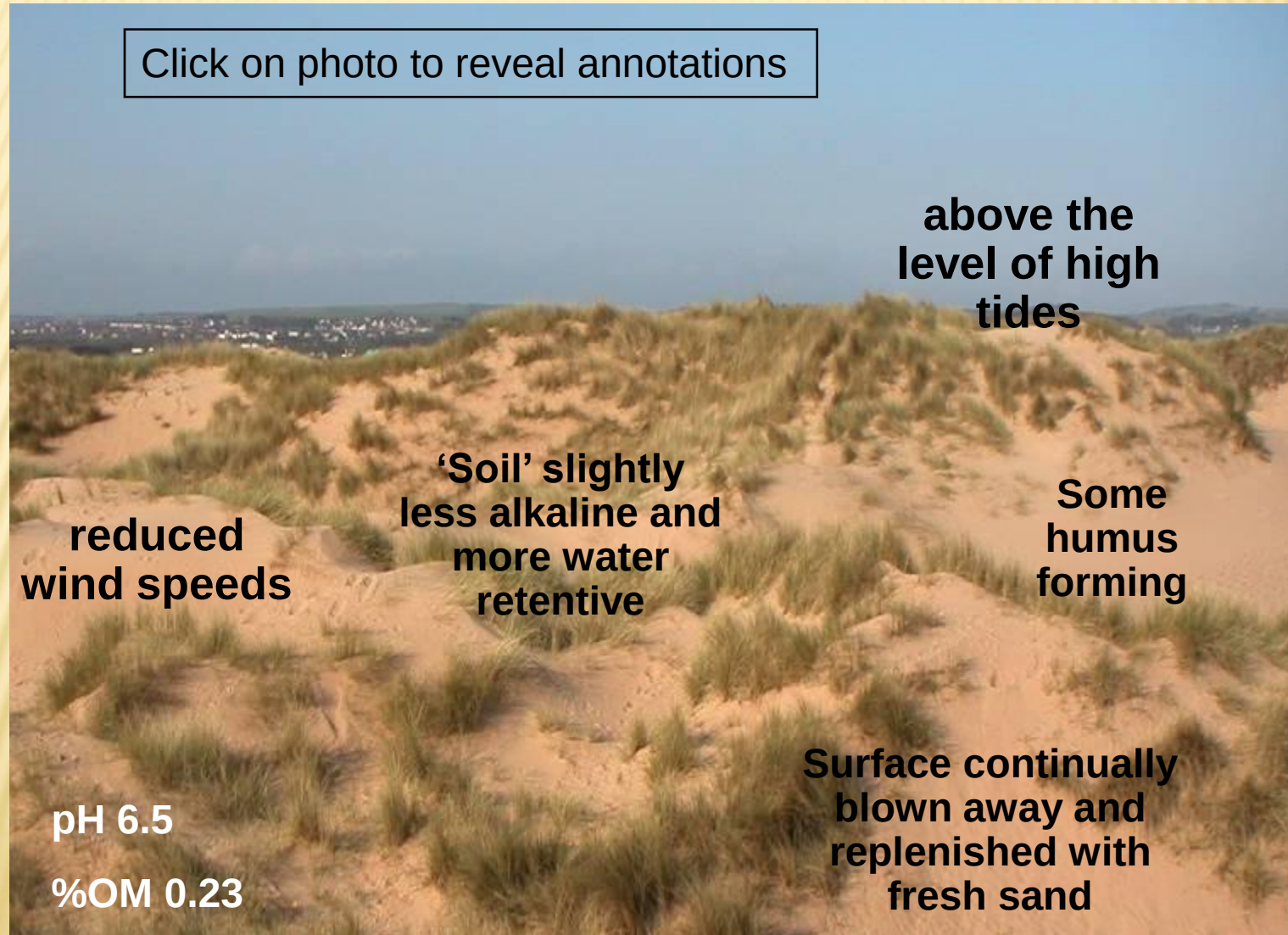
The plants which grow here have adaptations which allow them to grow in a difficult environment :

- waxy leaves to retain moisture and withstand winds
- prostrate (low) habit to avoid strong winds
- deep tap roots to obtain available moisture
- high salt tolerance



Yellow Dunes: the environment

Click on photo to reveal annotations



Yellow Dunes: the plants

The dominant plant species is
Marram grass:

- ✗ Salt tolerant
- ✗ Thrives on being buried by sand
- ✗ Inrolled leaves to reduce moisture loss
- ✗ Long tap roots
- ✗ Underground rhizomes stabilise the sand



Other plants such as Ragwort, Red fescue and Sand sedge begin to appear



Grey Dunes: the environment

Click on photo to reveal annotations

sheltered by higher,
seaward dunes

lower pH

little mobile
sand

sand no longer
accumulating

higher humus
content

a more closed vegetation
community in which
marram grass is no longer
able to compete

pH 5 - 6

%OM 1.0

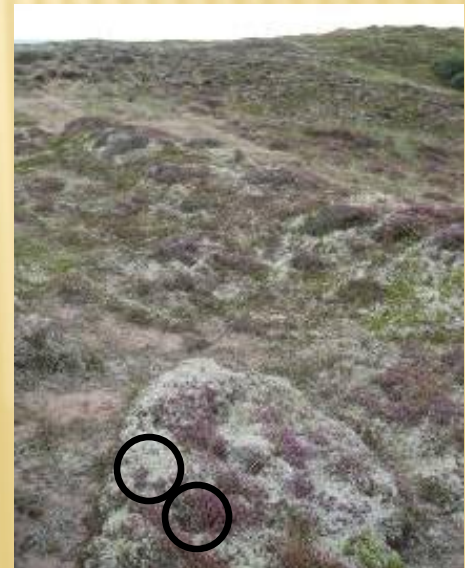


Grey Dunes: the plants



- higher species diversity
- mainly perennials
- marram becomes more sparse
- surface lichens give 'grey' appearance

Older grey dunes may have extensive covering of lichens and heather



Dune Slacks: the environment

Click on photo to reveal annotations

occur in low lying hollows
between dune ridges

soil acidic

relief
intersects the
water table

pH 4 - 5

water table high –
especially in winter

%OM 8.5



Dune Slacks: the plants

The community which develops here comprises moisture-loving plants commonly found in many fresh water wetland areas e.g.



Dune Heath/Woodland: the environment

Click on photo to reveal annotations

**well sheltered
from winds**

**maritime influence
is minimal**

acidic soil

nutrient rich

pH 4

**soil has high organic
matter content**

% OM 12.1



Dune Heath / Woodland: the plants



Heather

Human interference means that true mixed woodland climax vegetation is rarely seen on dune systems in the UK

Most dune systems develop into a community of heathland, woody perennials (often spinous) and scattered trees



Heather



Sea buckthorn

Revision
materials



Psammosere: summary of stages

Stage in dune succession				
Mobile dunes		Fixed dunes		
Embryo and fore dunes	Yellow dunes	Grey dunes	Dune slack	Heath/ woodland
• On-shore winds • Seaweed (humus build up) • Sand building up • Transient • Alkaline sand	• Surface continually blown away and replenished by fresh sand • Reduced wind speed • Top of dunes above high tide level	• Increased humus content • Surface lichens • Sand no longer accumulating • Marram grass not able to compete well	• Damp, low lying hollows • High water table in winter • Soil acidic and pH variable	• Acid soil and increased organic matter content • Nutrient rich • Shelter developed
• Scattered individuals • Low growing prostrate habitat • Waxy leaves • Salt tolerant	• Salt tolerant • Thrives on being buried by sand • Inrolled leaves • Long tap roots • Underground rhizomes to stabilise sand	• Many plants now co-existing • Mainly perennials • Stablising plants liking increased organic matter content	• Moisture loving plants	• Acid loving plants co-existing • Woody perennials plus understory species
Photo courtesy of Carl Farmer  e.g. Sandwort	 e.g. Marram grass	 e.g. Grey lichen and heather	 e.g. Rushes	 e.g. Heather and woodland



“A Question of Psammoseres”

1

2

3

4

5

6

7

8

9

Use 'end show'
command to exit
presentation

1



What type of dunes are forming in the foreground of this photograph?

2



This photo shows ground cover somewhere within a dune system. What stage of the psammosere is it associated with?

Can you name any of the plants growing in the photo?



3



What is the dominant species in this photograph? At which stage of the psammosere would you expect to find it?

How is this plant adapted to its environment?



4



This photo shows ground cover somewhere within a dune system. What stage of the psammosere is it associated with?

What is the dominant species? Why is the other plant also able to grow here?



5



In which stage of the dune succession would plants like these be found?

How are they adapted to the environment there?

Can you name either of the species shown?



6



What name is given to areas of open water such as this which are found within dune systems?

Name some of the plants which you might expect to find growing there



7



This photo shows ground cover somewhere within a dune system

What stage of the psammosere is it associated with?

Can you name any of the plants growing in the photo?



8



The climax vegetation of a dune succession would look similar to this photo

What is meant by the term 'climax vegetation'?

Why is a community of plants like this one rarely found in dune systems in the UK?



9



The photo shows a dense community of foreshore plants

Name some of the plants you would expect to find here and explain how they are able to survive in this environment



PRESSURES

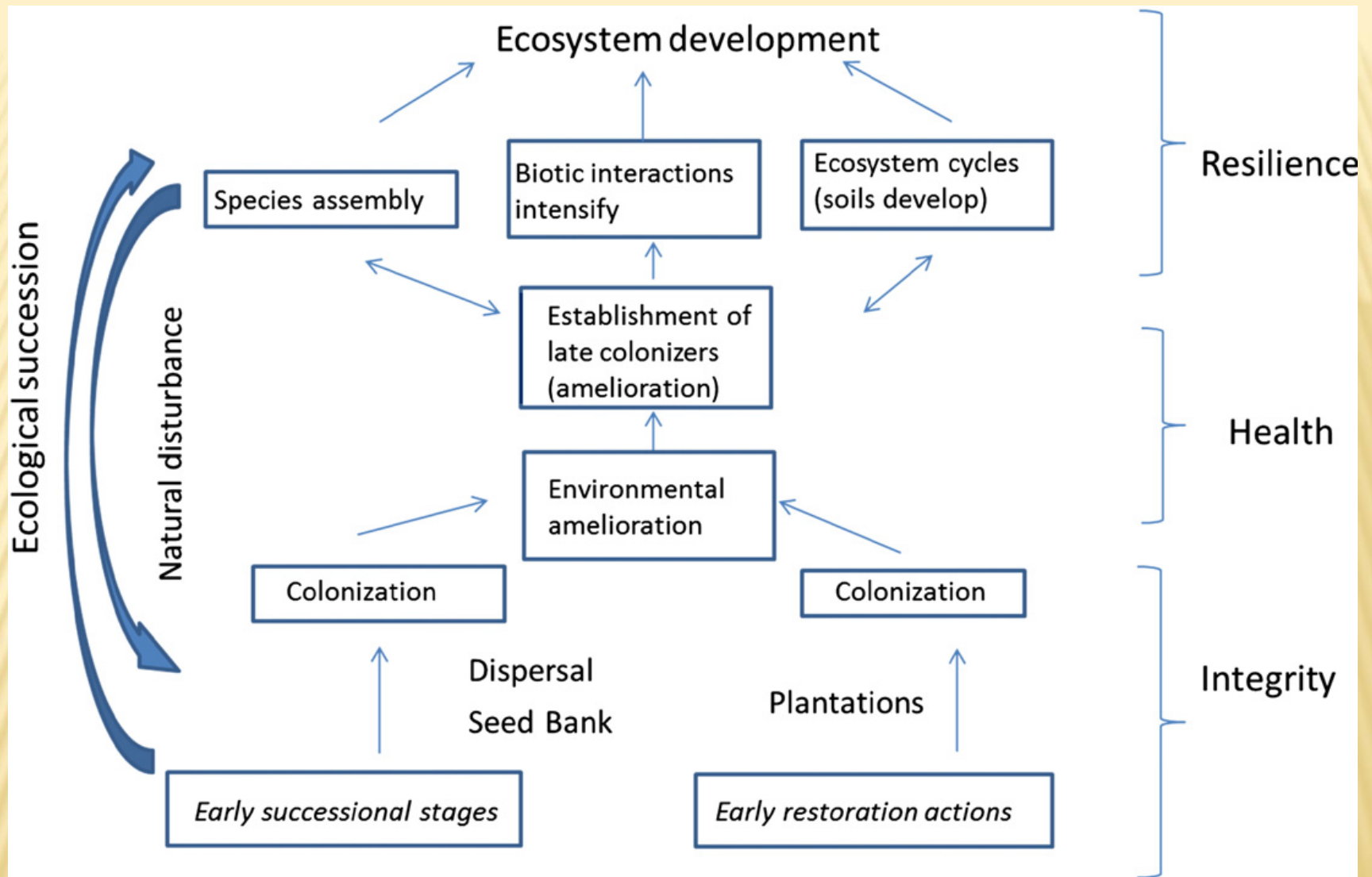


<http://www.youtube.com/watch?v=fwbS7kl7xAU>

DUNE MANAGEMENT

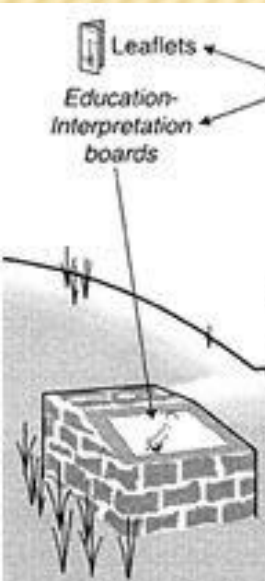
Restoration and preservation of coastal dunes is urgently needed because of the increasingly rapid loss and degradation of these ecosystems because of many human activities. These activities alter natural processes and coastal dynamics, eliminate topographic variability, fragment, degrade or eliminate habitats, reduce diversity and threaten endemic species. The actions of coastal dune restoration that are already taking place span contrasting activities that range from revegetating and stabilizing the mobile substrate, to removing plant cover and increasing substrate mobility. (Lithgow, et. al., 2013: 214)

This article reviewed over 150 dune management articles.



Simplified mechanisms of ecosystem change during restoration actions and during natural succession, showing the three attributes (integrity, health and resilience) set by the Society of Ecological Restoration (SER) to assess progress of ecological restoration. Notice how, unlike ecological restoration, ecological succession can “go back” to early successional stages, after the impact of natural disturbances (Lithgow, et. al., 2013: 216).

MANAGEMENT



to avoid fragile areas

HOUSE DESIGN (MAINE US)



Example of Flow Through Foundation, Wells, ME. Image by PA. Slovinsky, 08/2008.

Example of Pile Foundation, Saco, ME. Image by PA. Slovinsky, 12/2009.

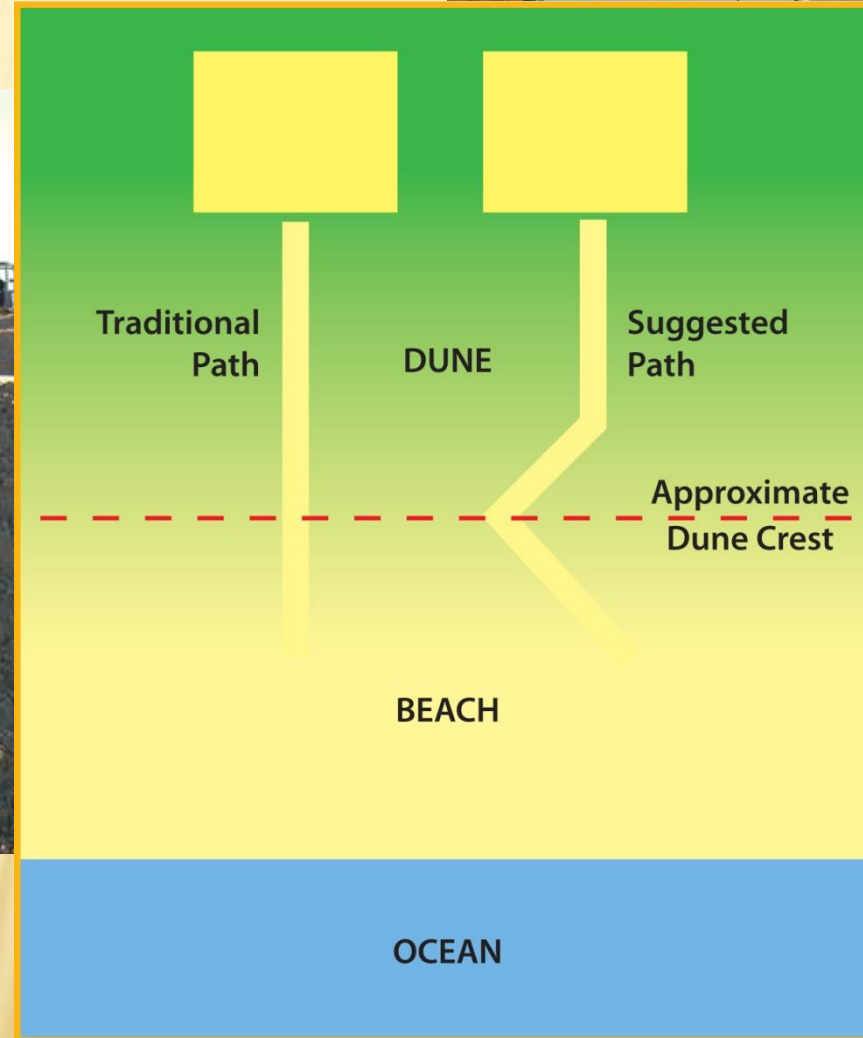


Pile foundations are typically used in more active flooding areas along open ocean coastlines, and provide much more open space for floodwaters to travel through. Piles are required in the frontal dune and in areas of the back dune classified as Erosion Hazard Areas

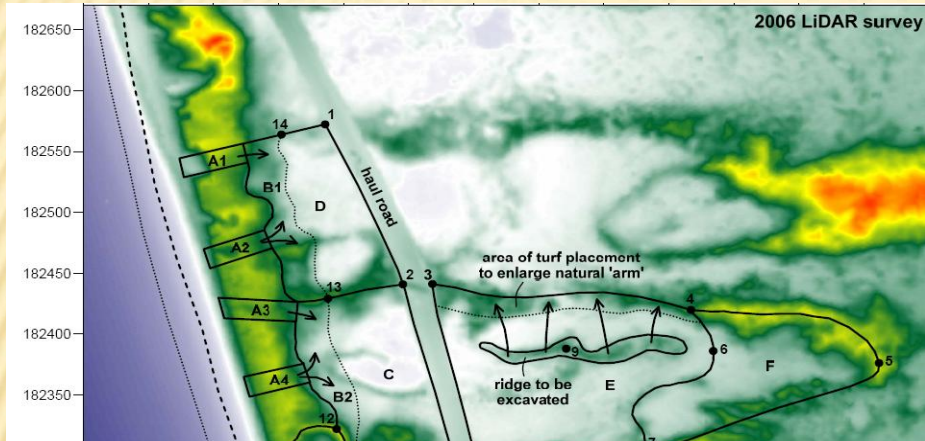
Flow-through foundations are typically block or poured cement foundations with adequate spacing (or hydraulic openings) for floodwaters to flow through the foundation without damaging the supports. These structures are acceptable in the A-zone areas of back dune environments that are not considered to be Erosion Hazard Areas

MANAGEMENT

Nourishment



STABILISE VS DESTABILISE?



CONSERVATION

Machair



Sa



**COASTAL DUNE
MANAGEMENT**
Shared Experience of European
Conservation Practice



Edited by
J.A. Heaston, S.E. Edmondson and P.J. Rooney

MANAGEMENT

<http://www.youtube.com/watch?v=lqFQqa2WFRo>

http://www.youtube.com/watch?v=vRAUBxY8w_c



Revision

A power point video on sand dunes

http://www.powershow.com/view/11b433-OTlKn/COASTAL_SAND_DUNES_PSAMMOSERES_powerpoint_ppt_presentation