



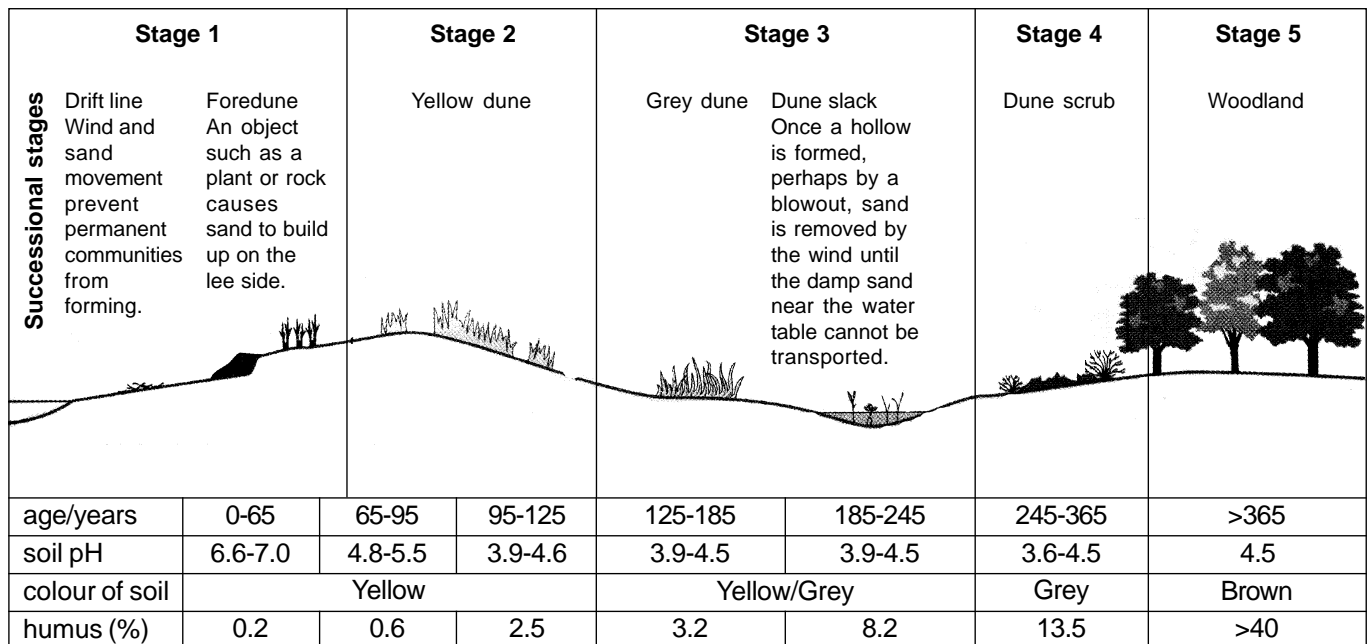
Age And Diversity In Sand Dunes

Sand dunes are diverse ecosystems, involving a complex interaction between plant communities and environmental conditions. Within the dune system, the communities identified are produced by the processes of succession and zonation:

Succession refers to the changes in species composition of an area over *time*; communities of plants and animals change the environment in which they are living, making such conditions better or worse for other species.

Zonation refers to the variation of species or communities over a particular *area*. For example, variations in salt spray, inundation and the height and salinity of the water table, will result in quite different species occupying different areas of the dune

Figure 1. Succession and zonation in a sand dune system



1. Young dunes

Dominant vegetation:

Sand wort (*Honkenya peploides*) and *Cakile maritima*

Dune characteristics:

Colonisation occurs through annual species arriving by wind and water. These grow rapidly, exploiting detritus deposited by water, reproduce then die. Species present are able to tolerate occasional covering with high salinity groundwater. This provides initial stabilisation, which is increased by the presence of some perennial species.

2. Mobile dunes

Dominant vegetation:

Marram grass (*Ammophila arenaria*)

Dune characteristic:

Marram grass is the most widespread and extensive colonising vegetation of mobile sand dunes above high water, but only as long as it avoids inundation and salt spray. It is a robust perennial grass, making it highly effective at dune building and stabilisation.

Marram is spread by underground shoots (rhizomes) and spreads most vigorously when stimulated by continued sand burial. As the shoots grow larger they stabilise the dunes, increasing their height up to 20m. In addition, they add organic matter, aiding water retention. At this stage however, there are still large areas of bare sand.

3. Semi-fixed or yellow dunes

Dominant vegetation:

Marram grass (*Ammophila arenaria*) and red fescue (*Festuca rubra*)

Dune characteristics:

The initial harsh conditions have been made more favourable, so that although marram grass is usually still dominant, species diversity has increased. The dune is characterised by the presence of small perennial flowering plants and mosses. Mosses, in particular, provide localised zones of favourable conditions. However, generally the soils are dry and nutrient poor, because there has been little increase in humus and organic matter.

Marram grass now has reduced vigour, due to increased competition for water and nutrients and increased stability.

4. Fixed-dune grassland

Dominant vegetation:

Red fescue (*Festuca rubra*) and other grasses

Dune characteristics:

Vegetation cover increases due to the presence of more humus and organic matter, which increases water retention and nutrient availability. Marram grass is still common, but is not dominant and there is a reduced presence of mosses. Even low nutrient availability precludes dense vegetation cover. Nitrogen is the main limiting nutrient since the sources are restricted to detritus deposited by the sea and wind, and nitrogen-fixing organisms. In addition, the vegetation is restricted by the rate of soil development and grazing by rabbits and cattle. Grazing can maintain a high species diversity in the fixed-dune grassland by preventing tall growing species becoming dominant.

Exam hint - When discussing succession, better students are able to understand the initial environment and suggest how it is changed to enable colonisation and development. For example, wind-borne seeds, inflow of nutrients, rising temperature, soil changes. In addition, marks are given for the weathering effects of plant roots and acids, shading and changing stability.

Sand dune structure

Distinct vegetation communities are found moving landward from the seaward dune edge with the changing environmental conditions. This can be seen in Figure 1 (previous page). Further inland, grasslands or heathlands may become established. In some situations, a scrub of brambles (*Rubus*), elder (*Sambucus*), hawthorn (*Crataegus*) and dwarf willow develops, which may eventually give rise to woodland climax community.

Exam hint - It is important that students appreciate the variety of factors that result in zonation. These include salinity, dune stability, water and nutrient availability (particularly nitrogen) and grazing levels. Better candidates are able to look at each of these elements systematically and explain how it changes at each stage of zonation.

Dunes slacks

An important influence on the rate of succession and the types of vegetation present is the height of the groundwater table, defined as the depth at which the sand is saturated with water. In depressions between the dune ridges, or **slacks**, water-logged condition may well be maintained, producing characteristic plant communities. For example, hydrophytes such as *Salix repens*.

Exam hint - Students should understand that due to the lack of water retention, availability of water generally limits vegetation growth on sand dunes. However, within dune slacks the reverse is true, with vegetation growth limited by waterlogged conditions, hence anaerobic conditions

Sub communities

Within each of these characteristic dune types are **sub-communities**. These are variations on the main community, representing a successional change to the next community with increasing nutrient and water availability. For example, moving from the mobile dune into the semi-fixed dune there is a red fescue sub-community, where although marram grass is still dominant there is an increasing amount of associated vegetation between the areas of marram grass.

Threats to sand dunes

The low fertility of dune soils, combined with the considerable amount of open ground available for colonisation produces a very high vegetation species diversity. This, combined with their aesthetic appeal and coastal location, makes them very attractive for recreation. In addition, dunes are under pressure from forestry, cropping, industry and housing. The result of this is that destruction is exceeding formation and dunes are becoming a diminishing natural resource in lowland Europe and N. America.

The main threats to dunes are;

- Planting of agricultural crops.
- Afforestation.
- Levelling for industrial development, housing, airports and golf courses.
- Drinking water extraction.
- Pollution. For example, enrichment by fertilisers leached from adjacent agricultural land and litter from tourists.
- Uncontrolled spread of introduced species.
- Direct removal of sand for mineral extraction.

Traditional management techniques

The basis of traditional management efforts is the protection of the best examples of a particular habitat and species concentration. Due to the pressure of development, only a limited number of sites can actually be protected. Traditional techniques include:

Afforestation

Planting trees has been used to stabilise shifting sands. This has the advantage of protecting coastal settlements and providing amenities. However, afforestation may cause over-stabilisation, restricting new dune development, and shading can reduce ground flora.

Dune stabilisation

Ammophila species have long been planted to stabilise dunes for coastal protection. In addition, organic material e.g. forestry trimmings and sprayed seed mixtures are used for stabilisation processes. However, over-stabilisation can result in reduced species diversity and loss of sand dune characteristics.

Integrated management techniques

The full extent of a site can rarely ever be protected. **Integrated management** involves recording distribution and size of dunes and then designating areas for particular purposes, specifically coastal protection, recreational use and wildlife protection.

Coastal protection prioritises maintenance of the coastline. This is usually achieved by planting dune-forming grasses, the removal of trees causing shade and the possible addition of fertilisers. Elsewhere of course, this can be part of the problem!

Recreation management involves provision for access via walkways which protect sand from erosion and fencing of unstable areas from trampling. This is known as **spatial zonation**.

Wildlife protection is the most complex management strategy. The aim is to maintain original plant and animal communities, which can be very difficult due to the complexities of the ecosystems. For example, problems occur in conserving dunes produced by long-term rabbit grazing. Mowing can maintain low-growing species threatened by reduced grazing, but this is significantly different to grazing.

Examples of sand dune management

Prior to the rabbit disease myxomatosis, **Braunton Burrows, Anglesey** was an unstable dune system due to unsustainable grazing processes. Management involved planting marram grass and sea buckthorn to prevent sand movement and conserve the dune system. However, this has resulted in reduced species diversity due to the success of the introduced species. Management is now trying to increase instability!

Tentsmuir dune system on the north east Scottish coast had a non-intervention management policy to maintain an actively growing system. However, a large proportion of the site has been afforested and the combined affects of shading, lowering of the water table and reduction of the rabbit population resulted in expansion of the scrub and coniferous trees. Goats have recently been introduced in an attempt to reverse scrub encroachment and active pine removal occurs.

These examples* hint at the difficulties of sand dune management, and how approaches continually change. This has led to the modern proposal that management must accept changes and instability as part of the characteristics of dunes. Unfortunately, increased stability in the absence of rabbits usually results in dunes becoming more attractive with more flowering plants. This results in a reluctance to re-introduce instability.

* Sand dune management strategies will be the subject of another Factsheet

Acknowledgements;

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