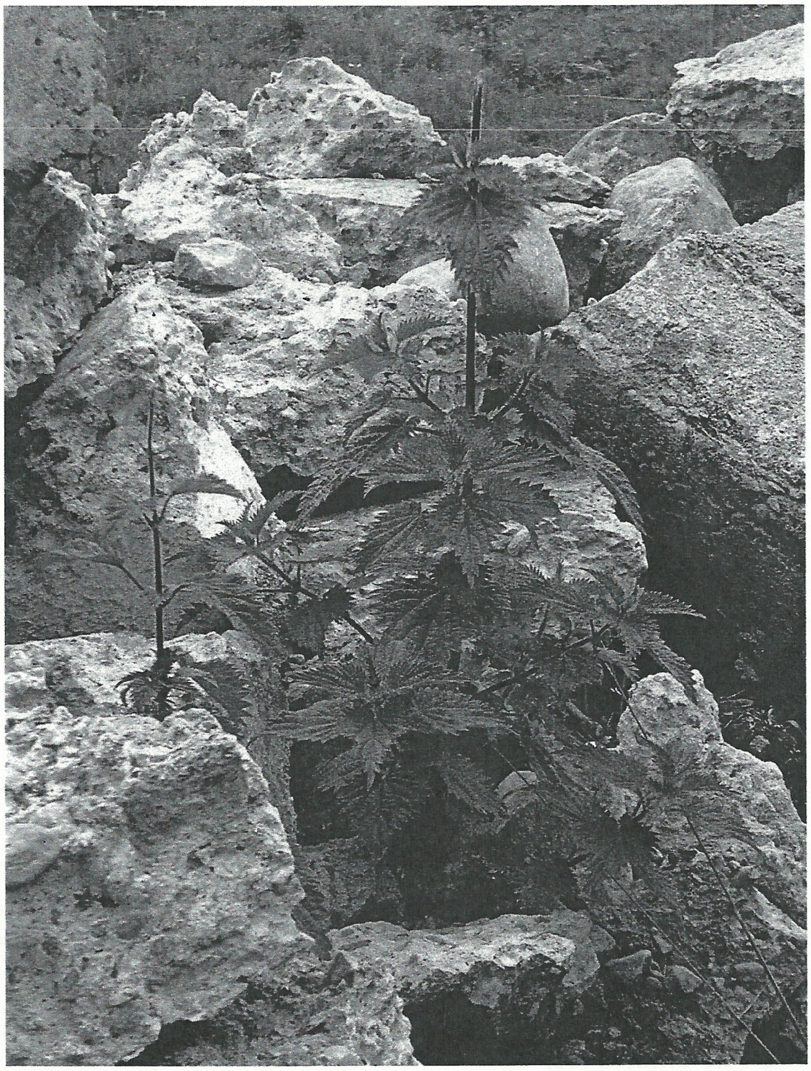
PRESTWICK ACADEMY

HIGHER GEOGRAPHY



BIOSPHERE

BIOSPHERE: Can-Do's

Physical Core

By the end of this topic you should be able to:

- draw annotated diagrams to describe the properties of Podsols, Brown Forest soils, and Gley soils, referring to horizons, colour and texture
- identify the type of soil shown in a soil profile diagram, and describe the features which help to identify the soil type
- describe and explain the effects of climate, relief and drainage on the formation of Podsols, Brown Forest soils, and Gley soils.
- explain fully what is meant by the term climax vegetation
- describe and explain the changes in the types of plants (succession) to be found across a sand dune transect, referring to the names of specific plants
- explain why vegetation finds it difficult to grow on sand dunes
- describe how coastal plants are adapted to survive in sand dune habitats

GMTs

- *describe and analyse podzol, brown earth and gley profile*
- *describe and analyse data from soil surveys shown e.g. on a soil catena*
- *describe, interpret and explain data from vegetation surveys and distributions with reference to plant successions on sand dunes shown e.g. on cross sections and transects*
- *comment on the accuracy of statements which describe soil and vegetation patterns shown on maps, etc.*

INTRODUCTION.

Our planet is the only one in our solar system to have life! It is present only because of a unique set of characteristics on the planet, one of which is soil.

Soil is the interface between the organic (living or once-living) and the inorganic materials, like the rocks, and there is a constant exchange of materials between these two states. It is the basis of all life on the planet, and without it we would not be able to grow our crops or raise our animals.

The study of soil is called Pedology, and there are over fifty different types of soil, depending on the conditions in the area. We will be studying the creation of soils in general, and of three case study soils in particular.

SOIL IS MADE UP OF FOUR COMPONENTS

- Mineral matter is the product of weathering and comes from rocks.
- Air in the soil carries gases to and from the plant roots and animals. It is in the pore-spaces when water is not.
- Water is held in the pore-spaces and carries dissolved salts- plant food.
- Organic matter is the largest fraction. It comes from plant and animal remains that are gradually broken down into a brown material called humus. It is the major source of the three main plant foods- nitrogen, sulphur and phosphorus. It holds water, improves soil structure and provides the energy for plant (and animal) growth.

SOIL CREATION

As soon as a barren surface like a lava flow, glacial outwash plain or a beach begins to be colonised by flora and fauna, soil development is said to have begun.

Organic debris decays and is mixed with the inorganic mineral matter by living organisms.

The amount of mixing varies with depth, and this creates layers called horizons. The whole vertical section is called a profile.

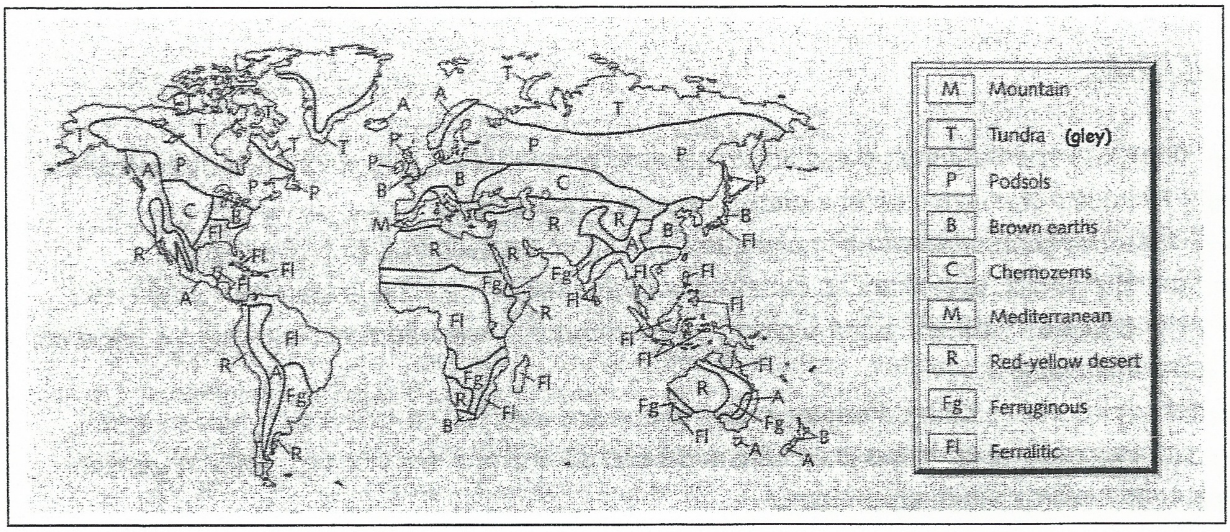
There are four terms regarding soil layers that you need to be familiar with- they will be in your jotter. Leaf litter, fermentation layer, regolith and humus layer.

There are many different types of soils around the world.

ZONAL SOILS are widespread and well developed

INTRAZONAL SOILS are more localised and less well developed

AZONAL SOILS are very young and not developed from the barren area.



ILLUVIATION and ELUVIATION?

These two terms are to do with the movement that minerals makes in the soil spaces. If the temperatures in the region are hot, there is likely to be a great deal of evaporation. This sucks up the moisture from deep in the soil towards the surface and away. This will bring dissolved minerals up to the surface layers them if their chemistry is right, and may even leave a salty crust on the surface, like in the salt flats of the deserts. The minerals have been dissolved into the ground-water- a process called <u>eluviation</u>, and when they are re-precipitated it is called <u>illuviation.</u>

In wet regions, heavy rain or snowmelt will collect (eluviate) minerals from near the surface, and illuviate them again deeper into the soil layers. This is a soil-damaging process called LEACHING, and removes good plant food to deep layers where shallow roots cannot reach them. The illuviated layer is called a HARD-PAN; it is often reddish-orange in colour, and can be crusty and hard.

Soils where minerals are brought up are called PEDOCALS(soil with calcium salt) and soils where minerals get dragged to the depths are called PEDALFERS(soil with iron and aluminium). All three of our case study soils are pedalfers.

Pedocals draw minerals up to the surface.

illluviating ↑

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Pedalfers draw minerals down to the lower layers in a process called leaching.

illluviating

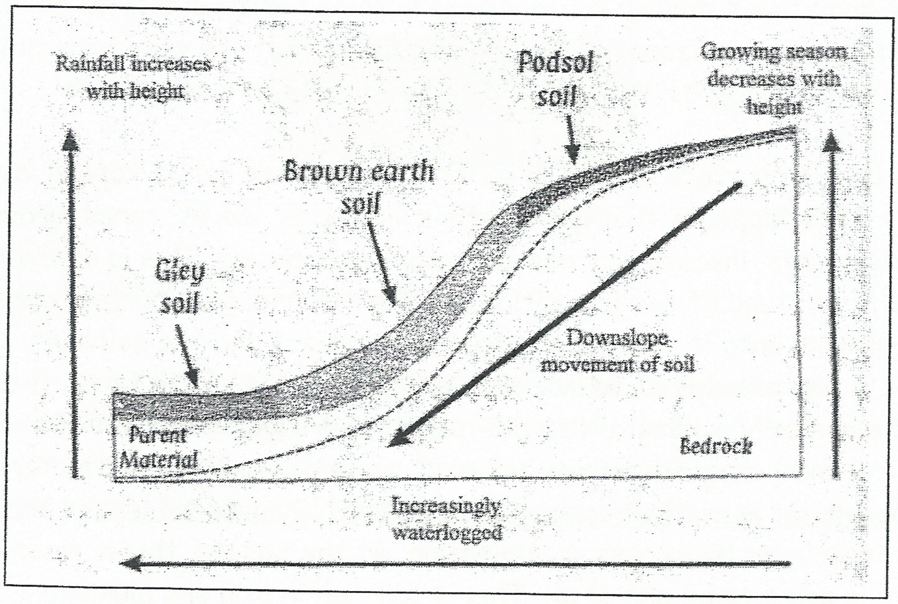
HOW IS SOIL FORMED?

Studies of soils show that the development of a soil is controlled by five major factors;- Parent material, climate, relief, organisms and time!

1. There is the **parent material**- rock.
If it is a limestone or a chalk, it will be an alkaline soil, and will grow different things to a soil formed from an acid rock like sandstone or clay. How easily it is broken up below the surface matters, too. Hard rock will take longer to form a soil, and it will make a coarser, more gritty one, too!

2. The **climate** is important; we have already discussed **precipitation**, but the **temperature** plays a big part, too. Hot, humid regions help to break up the parent rock more quickly, but cold can also break up particles, and ice can abrade and pluck fragments off. Too cold and soil organisms cannot survive and work the soil into a good texture. Soil is affected by the type of vegetation that grows and decays on and in it, and the different insects and animals that live there. So different climate zones will develop different soils because of those factors.

3. **Relief** of the region is another factor. High up and it is affected more by greater precipitation and lower temperatures, low down it is drier and warmer, usually. Steep slopes mean fast run-off of water and greater erosion, with thin and infertile, gravelly soils developing. Flat land means more leaching and waterlogging, but perhaps a greater chance to accumulate soil washed down slopes. The aspect (direction) of a slope can affect its warmth and its wetness, too. Those facing west or south are richer in moderate latitudes.



4. Organisms play a very important role in the creation of soils. All the creepy crawlies from moles to worms, wood lice to spiders, fungi to bacteria all help to break down the organic and inorganic matter to make a soil. If there are plenty, and a good variety, soil will develop and keep healthy. If there are few or none, the soil will be dead. The number of organisms varies with many of the other factors we have already discussed; so you see, all the factors are inter-connected! The organisms feed on the other organic matter- both dead and alive- and on inorganic matter too. They leave behind deposits that add nutrients to the soil. Bacteria and fungi assist in this, and other biota- small animals and insects- mix and alter the soil. Of course, man also can have a hand in soil change, not always for its improvement!

5. Time is one of the most easily forgotten factors. It can take 400 years for 10mm of soil to form, and 3000 to 12000 years for it to get deep enough to farm. As we shall see when we look at the case study of plant succession in the second half of this unit, soils need certain conditions to develop properly; then one can perhaps 'grow'. Soil cannot form quickly, and if there is little time when the environment is stable/settled, soil cannot form. Constant interference in the situation- by people or nature- and soils will not develop their full potential.

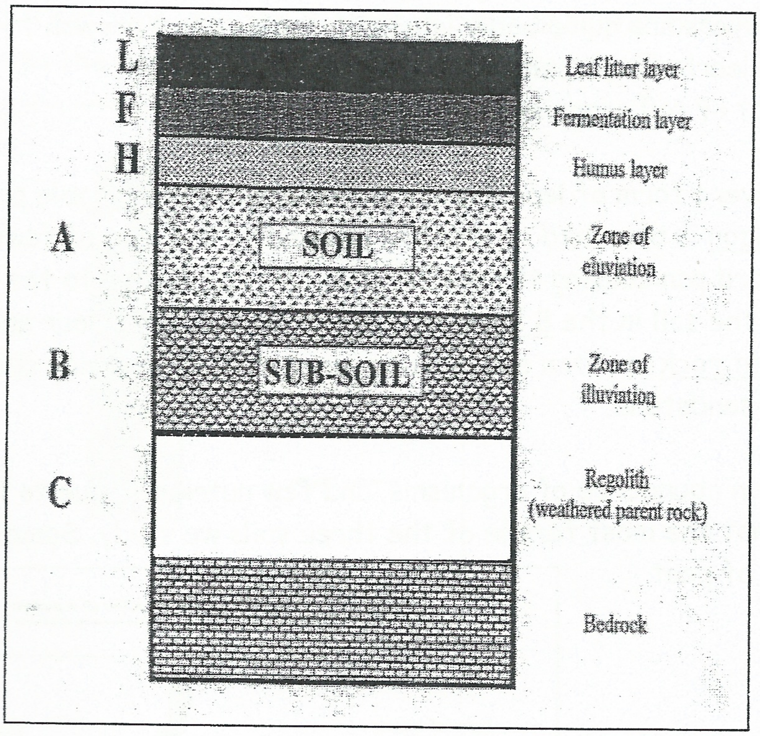
SOIL PROFILES

Soils will naturally develop a set of vertical layers called HORIZONS. They differ from each other in their colour, texture, mineral composition and humus content. Organisms vary throughout the horizons, as well as the moisture content.
Most soils develop three main horizons, called (from the surface down) the **A, B** and **C** horizons. There are sometimes smaller sub-divisions in some horizons, but we do not need to go into that much at Higher. Horizons are not any set depth, but can vary tremendously from a few centimeters to several metres. You will seldom see a scale on a soil profile!

The A horizon has the soil surface as its top surface. It is often called 'topsoil' by gardeners and other amateurs. It is topped with organic debris like twigs, leaves, cones, grass and the dead bodies of birds, plants, insects and animals, busy decomposing. This is called LEAF LITTER, and is the first stage of decomposition. As the material gets buried by newer material falling or blowing onto it, the decomposition increases, and the soil layer gets darker and wetter; organic material holds on to moisture well! The material will ferment away quietly, giving off heat and eventually making a HUMUS- plant food- layer. The rest of the A horizon is where the chemical and biological activity takes place, breaking down the material into a (hopefully) rich topsoil. It is in this horizon that LEACHING takes place; the transfer downwards of plant nutrients by excess precipitation. At the base of this horizon will be a HARD PAN if there is going to be one at all. This is soil rich in iron and aluminium, washed out of the upper layers and precipitated back into a mineral deposit. It often needs a pick- or digger- to break it up on a building site! It is sometimes called the zone of eluviation- the robbed zone!

The B horizon is often called the sub-soil. It is coarser than the layer above, and is sometimes topped by a hard pan. It has larger pieces of mineralized material in it sometimes. It has only a little organic material/ humus and seldom any soil organisms except some bacteria. Often there is not enough air in the pore spaces to support organisms other than anaerobic ones. It is sometimes called the zone of illuviation- where stolen minerals are deposited!

The C horizon is the lowest layer. It comprises the parent rock that has started to weather below ground. It is full of hard, rocky, lumpy fragments, getting more like solid rock as you go down. It has even less humus than the layer above.



CASE STUDY SOIL TYPES.

We need to study three soil types at Higher, shown in the diagram below.
You will need to be able to sketch the profile of any or all three of them, and describe their characteristics and what factors were important in creating them.
When describing a soil, its colour, texture and horizon definition must be described and explained!

SOIL CASE STUDIES.

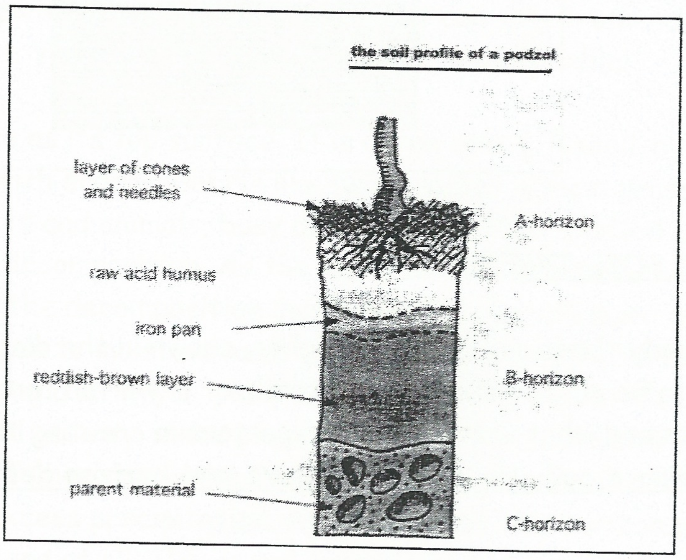
The three soils are;
A *BROWN EARTH*- sometimes called a brown forest or grey brown forest.
A *PODSOL*- sometimes spelled podzol.
A *GLEY*- a.k.a. tundra gley.

1. Podsols. (podzols)

- These are soils of a cool, wettish climate.
- They often are found on upper slopes rather than flat land.
- They develop best under vegetation that causes quite strongly acidic conditions- like coniferous trees, with their needles and cones.
- They have a well-developed hardpan of iron and aluminium.
- Their upper layers are quite badly leached, limiting plant growth to un-demanding types.
- They have a clearly developed set of horizons.
- They lack a lot of soil organisms.

Podsolisation is a severe form of leaching. It has an easily-recognisable profile as seen in the diagram. The A horizon is bleached of iron and aluminium, and sort of fawn-grey in colour, and waterlogged. The hard pan causing the waterlogging is reddish due to the iron accumulating. Below the hard pan the soil in the B horizon is often yellowish in colour and sticky like clay. The C horizon/parent rock is often of glacial origin, being boulder clay above an acid bedrock type like granite or sandstone.

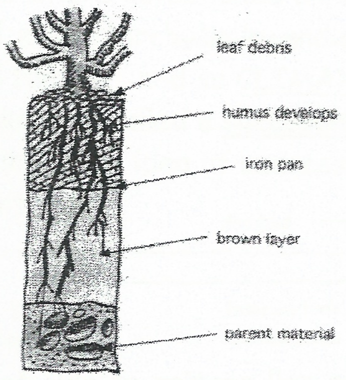
Such a soil has not an abundance of organisms, and few nutrients, due to the leaching and waterlogging. It is not the most fertile of the three soils we study. Sometimes the surface develops a covering of peat.



2.Brown Forest. (Grey-Brown Earth)

- These are soils of a milder, wettish climate.
- They often are found on gentle slopes rather than flat land.
- They develop best under vegetation that causes less acidic (MULL) conditions- like deciduous trees. These enrich the soil as they fall and decay in Autumn.
- They may have a slightly-developed hardpan of iron and aluminium.
- Their upper layers are slightly leached and slightly waterlogged.
- They have a poorly developed set of horizons.
- They have quite a lot of soil organisms.

The **A horizon** is brown in colour and crumbly in texture. There is a lot of humus in this layer from the vegetation. The humus is not as acid as a podsol. There are lots of organisms in the soil and they mix the soil, spoiling the clarity of the horizons. There is a thin brown iron hardpan between A and B horizons, and the **B horizon** itself is lighter brown the lower it goes. The C horizon is similar to the podsol, although perhaps not so clay-like.



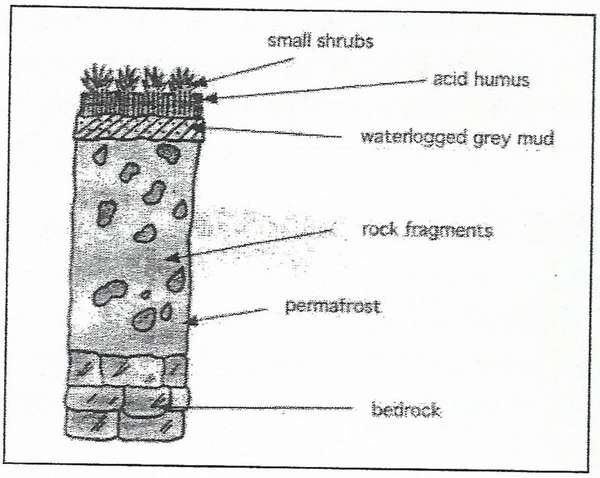
the soil profile of a brown earth soil

3. Gley. (Tundra- gley)

- These are soils of a very cold, wet climate.
- They often are found on low, flat land, often near a river.
- They develop serious waterlogging that starves soil of oxygen; few plants can grow.
- They develop an extreme form of MOR (acid) humus.
- Their upper layers are blue-grey in colour due to oxygen deprivation.
- They have a poorly developed set of horizons due to freeze-thaw mixing the layers.
- They have virtually no soil organisms because of the acidic and anaerobic conditions.
- In extreme areas of the tundra, permafrost exists as the B and/or C horizons.

The plants that live on the surface are highly specialized, like heather, lichen and mosses. Trees are usually absent; tundra translates as 'without trees'. The **A horizon** is poorly defined and is an unhealthy grey colour. Leaf litter seldom exists, and if there is a top layer, it is black; it decomposes so slowly it is virtually preserved. Leaching cannot happen, as the soil pore spaces are so clogged by water in the summer and ice in winter that movement cannot happen. There is no hard pan as a consequence. The **B horizon**- if it can be determined- is blueish, sticky, wet and almost lifeless. Angular fragments from the C horizon can often migrate upwards as boulders.

The **C horizon** is the bedrock- usually ancient 'shield' rocks like basalt or granite. They are hard and acidic, slow to break up and are usually impermeable. The whole profile usually has been set solid in permafrost since the Ice Age.



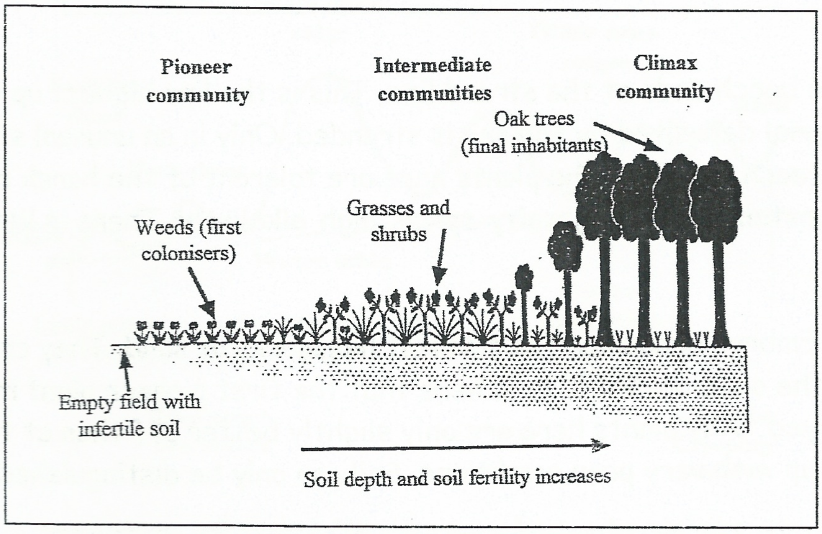
This marks the end of the soil section of this topic.

VEGETATION SUCCESSION.

This section is teaching the principles of what happens to an area that has been left with no soil, and one starts to form from scratch. You need to know the principles and then to apply them to a case study area, in this case, a sand dune environment.

In a plant-free environment, (like after a landslide, eruption, tsunami, on a beach constantly scoured by the sea, or an industrial wasteland), eventually one type of plant will get a foothold. This is called a **pioneer plant**. It can get just enough nutrients from the environment to survive. It's waste products- dead leaves, roots and fluids- slightly enrich the ground around it.

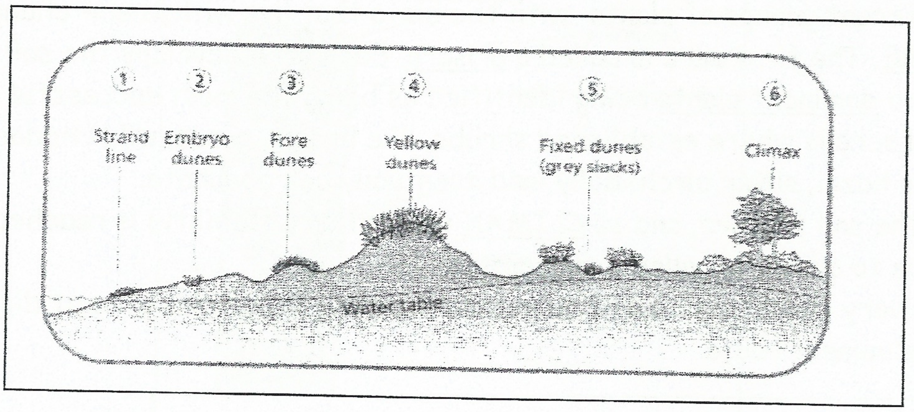
As the young soil is altered, a second or third type of plant will find it likes these conditions. It too joins the plant community, and alters the soil a bit more. Eventually, the soil is changed enough for the original pioneer plants to die out, and a different set to colonise. as time goes on, different groups of plants- with the biota that live with them- change. Each stage is called a **SERE**. The first sere is called a prisere. Each sere develops the soil a bit more, with one or two dominant plants being identified as being the most successful in those conditions. The final sere is where established shrubs, like broom, gorse, wild rhododendron and trees like rowan, hazel, silver birch, holly, and eventually oak dominate.
These do not alter the soil further, and so **CLIMAX** vegetation (stability) is reached. The changes from prisere to climax is called a **succession**.
The diagram gives a very simplified idea of succession; it shows the same area at different times along the development route.



During the succession, the qualities of the soil change, and you need to know the details of these. They involve the water content, the soil depth, the fertility (humus content) and the numbers of biota per cubic metre it can support. Mostly, until climax is reached, when all becomes stable, the number of plant species increases with time. Often plant height increases as well, as the deeper soil can support taller plants with deeper root systems.

In a non-sand dune environment, plants like dandelion, daisy, couch grass, and rose-bay willowherb are typical pioneer plants. They give way to brambles, stinging nettles. Further into succession shrubs will grow, like buddleia and wild geranium, then trees like birch and sycamore will take root. Beech, oak, holly and other larger trees will take over to attain climax. After this, only some outside influence like a storm, flood or the interference of man will bring further changes.

We need to learn about a case study with examples of plants to illustrate it, and at Higher we study coastal sand dune formation. Here, there is a very clear transition of plants from the high tide line inland, and it is this that you need to learn. Sand dunes follow a set layout which you will need to learn up. There are six stages or **seres**.



1. STRAND LINE: The beach ends at the strand line. This is the line highest up from the water where the material deposited by the sea is stranded. Only in an unusual storm or very high tide will the sea reach this line. The plants here are tolerant of the harsh conditions- **strong winds, sand constantly shifting, salty spray, high alkalinity**. There is little evidence of any soil.

2. EMBRYO DUNES; Embryo dunes are the smallest hummocks of sand. They create a tiny area of shelter from the on-shore wind. It is here that the first pioneer plant may grow. They are very easily destroyed. Any plants here are only slightly better off than at the strand. They have still to put up with very poor conditions. Soil can only be distinguished using chemical analysis.

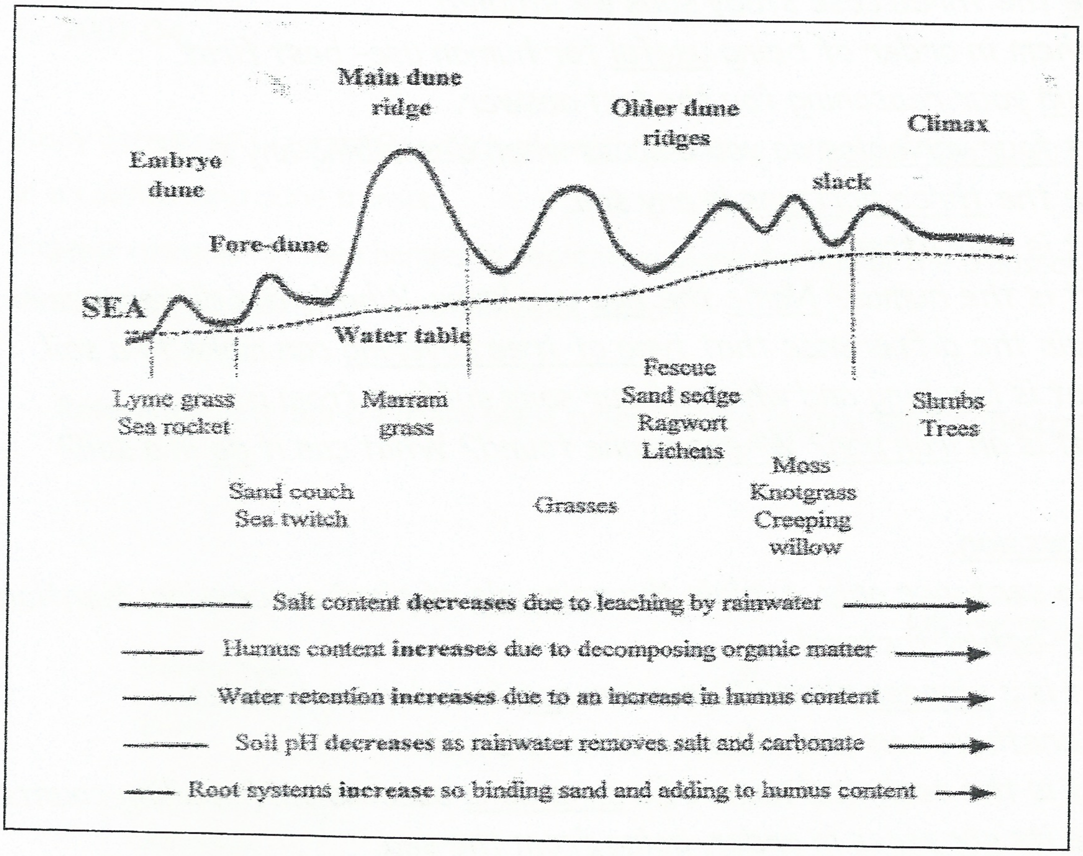
3. FOREDUNES; Fore dunes are starting to look like proper dunes, though they are still very small. There is an increase in the amount of humus in the sand, and a little less saltiness in the environment. The plants here are modifying their environment and a wider variety of plants can be found here as a result. Their roots are helping to bind the sand grains together and this allows them to get more fresh water.

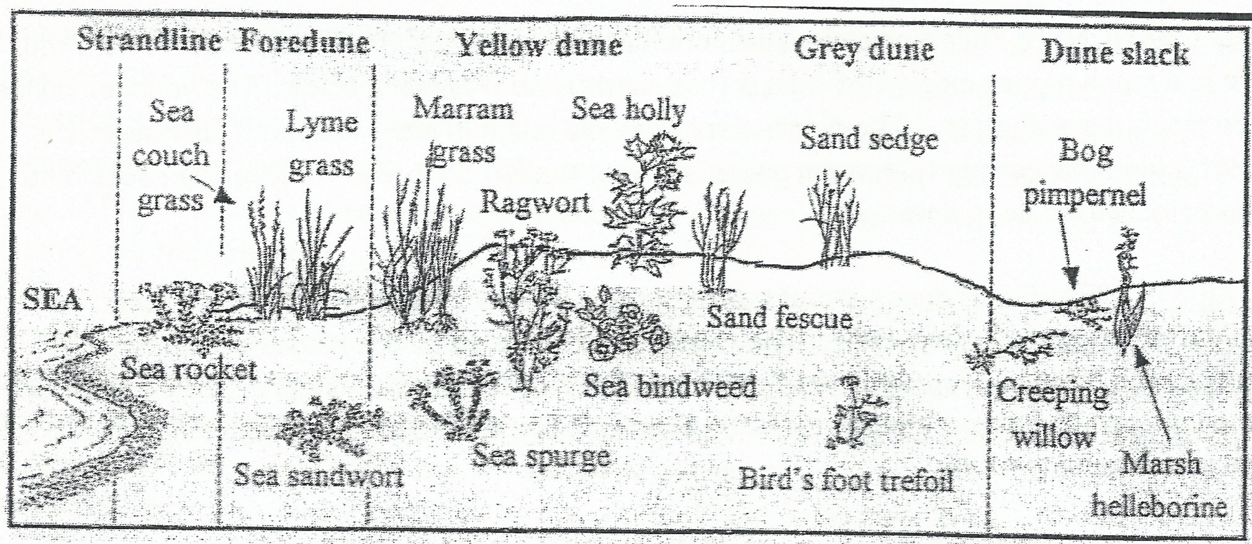
4. YELLOW DUNES; Yellow or main dunes are substantial dunes. They can be up to 10m tall. There is a much higher amount of humus (nutrients) and it is more acidic. The younger dunes create much more shelter. The plants here are less tough in many respects, although it is still not a kind environment. Marram grass is the dominant plant, and its long tap roots bind soil and find water deep down.

5. FIXED DUNES; Fixed dunes are often called grey dunes. They are lower and more consolidated than the yellow dunes. They have troughs between the ridges of sandy soil- called slacks. This area supports plants that require more shelter and more acidic conditions. Most need more moisture, and find it in the slacks; more specialist plants appear, like reeds, rushes and creeping willow.

6. CLIMAX VEGETATION; This is the last sere of the plant succession. The land here is damp, sheltered, acidic, rich in nutrients and humus. The plants here are as evolved as they are going to get- unless man or storms modify their environment again.

As the succession is traversed, you will notice that the qualities of the soil change. These qualities allow the different plant groups to take over from the earlier groups and survive in the new conditions. You need to learn what is changing, why, and the plants that are typical of each sere.





Here are some revision questions to help you remember the important details of the biosphere topic. If you can answer these questions fully, you are ready to sit the assessments for this part of the course.

A. soil types

1. Name the six variables that help to create any soil.
2. Name the three case study soils we studied.
3. Put them in order of being useful for human use- best first.
4. Explain your reasoning for the last answer.
5. What four variables do you discuss when describing any soil?
6. Name the three horizons in any soil.
7. What is leaf litter?
8. What is the humus? Name the two you know. What's the difference?
9. Explain the difference that type of tree covering can make to a soil.
10. What is leaching and which of our soils suffers from it?
11. What is an iron pan? Where is one found? What can it do in a soil?

B- Succession.

1. In two sentence only, explain the principle of plant succession. Mention no plants or actual factors!
2. What is a pioneer plant? Name two not found in sand dunes.
3. Give another, non-technical word for a 'sere'.
4. What is the technical name of a sand dune succession?(spelling counts!)
5. Name its six seres in order, going from the sea.

3. 2000 Q4

The term plant succession describes the changes in vegetation that develop through time in a particular habitat.

Describe the process of plant succession, referring to a coastal sand dune area.

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4. 2002 Q4

Study Reference Diagram Q4.

Select one of the following soil types:

(i) gley;
(ii) podzol;
(iii) brown earth.

With the aid of an annotated sketch diagram of a soil profile, explain how the major soil forming factors shown in the diagram have contributed to its formation.

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Reference Diagram Q4 (Main factors affecting soil formation)