19.6 Succession

Learning objectives

- Describe changes that occur in the variety of species that occupy an area over time.
- Define the terms succession and climax community.
- Explain how managing succession can help to conserve habitats.

Specification reference: 3.7.4

We have seen that **ecosystems** are made up of all the interacting **biotic** and **abiotic** factors in a particular area within which there are a number of **communities** of organisms. As we look around at natural ecosystems, such as moorland or forest, we may get the impression that they have been there forever. This is far from the case. Ecosystems are dynamic. This means that they change day to day as populations fluctuate, sometimes slowly and sometimes very rapidly. **Succession** is the term used to describe these changes, over time, in the species that occupy a particular area.

One example of succession is when bare rock or other barren land is first colonised. Barren land may arise as a result of:

- a glacier retreating and depositing rock, sand being piled into dunes by wind or sea, volcanoes erupting and depositing lava, lakes or ponds being created by land subsiding, and silt and mud being deposited at river estuaries.

Stages of succession

Succession takes place in a series of stages. At each stage new species colonise the area and these may change the environment. These species may alter the environment in a way that makes it:

- less suitable for the existing species. As a result the new species may out-compete the existing one and so take over a given area.
- more suitable for other species with different adaptations. As a result this species may be out-competed by the better adapted new species.

In this way there is a series of successional changes which alter the abiotic environment. These alterations can result in a less hostile environment that makes it easier for other species to survive. As a consequence new communities are formed and biodiversity may be changed and/or increased.

The first stage of this type of succession is the colonisation of an inhospitable environment by organisms called **pioneer species**. Pioneer species make up a pioneer community and often have features that suit them to colonisation. These may include:

- asexual reproduction so that a single organism can rapidly multiply to build up a population.
- the production of vast quantities of wind-dispersed seeds or spores, so they can easily reach isolated situations such as volcanic islands
- rapid germination of seeds on arrival as they do not require a period of dormancy
- the ability to photosynthesise, as light is normally available but other food is not. They are therefore not dependent on animal species
- the ability to fix nitrogen from the atmosphere because, even if there is soil, it has few or no nutrients
- tolerance to extreme conditions.

Imagine an area of bare rock. One of the few kinds of organism capable of surviving on such an inhospitable area is lichens. Lichens are therefore pioneer species. Lichens can survive considerable drying out.

Hint

Pioneer communities put some organic material into the soil when they die. This allows recycling to start and increases mineral ions in the soil allowing other species of plants to grow.

In time, weathering of the base rock by the action of the lichens produces sand or soil, although this in itself cannot support other plants. However, as the lichens die and decompose they release sufficient nutrients to support a community of small plants. In this way the lichens change the abiotic environment by creating soil and nutrients for the organisms that follow. Mosses are typically the next stage in succession, followed by ferns. With the continuing erosion of the rock and the increasing amount of organic matter available from the death of these plants, a thicker layer of soil is built up. The organic material holds water making it easier for other plants to grow. Again these species change the abiotic environment, making it less hostile and so more suitable for the organisms that follow, for example, small flowering plants such as grasses and, in turn, shrubs and trees. These species provide more sources of food, leading to more food chains that develop into complex food webs and lead to more stable communities. In the UK the ultimate community is most likely to be **deciduous** oak woodland. This stable state comprises a balanced equilibrium of species with few, if any, new species replacing those that have become established. In this state, many species flourish and there is much biodiversity. This is called the **climax community** which remains more or less stable over a long period of time. This community consists of animals as well as plants.

▲ **Figure 1** *Lichens, with their ability to withstand dry conditions and to colonise bare rock, are frequently the first pioneer species on barren terrain*

Synoptic link

To appreciate successional change it would help to look again at Topics 13.1 Food chains and energy transfer, 13.2 Energy transfer and productivity and 13.3 Nutrient cycles

The animals have undergone a similar series of successional changes, which have been largely determined by the plant types available for food and as **habitats**. The dead lichens provide food for animals such as detritus-feeding mites. The growth of mosses and grasses provides food and habitats for insects, millipedes, and worms. These are followed in turn by secondary consumers, such as centipedes, which feed on these organisms. The development of flowering plants, including trees, helps to support communities of butterflies and moths as well as larger organisms, such as reptiles, mammals, and birds.

During any succession there are a number of common features that emerge:

- **the non-living (abiotic) environment becomes less hostile**, for example, soil forms (which helps retain water) nutrients are more plentiful, and plants provide shelter from the wind. This leads to:
- a **greater number and variety of habitats and niches** that in turn produce:
- **increased biodiversity** as different species occupy these habitats. This is especially evident in the early stages, reaching a peak in mid-succession, but decreasing as the climax community is reached. The decrease is due to dominant species out-competing pioneer and other species, leading to their elimination from the community. With increased biodiversity comes:
- **more complex food webs**, leading to:
- **increased biomass**, especially during mid-succession.

Climax communities are in a stable equilibrium with the prevailing climate. It is abiotic factors such as climate that determine the dominant species of the community. In the lowlands of the UK, the climax community is deciduous woodland. In other climates of the world it may be tundra, steppe, or rain forest.

Another type of succession occurs when land that has already sustained life is suddenly altered. This may be the result of land clearance for agriculture or a forest fire. The process by which the ecosystem returns

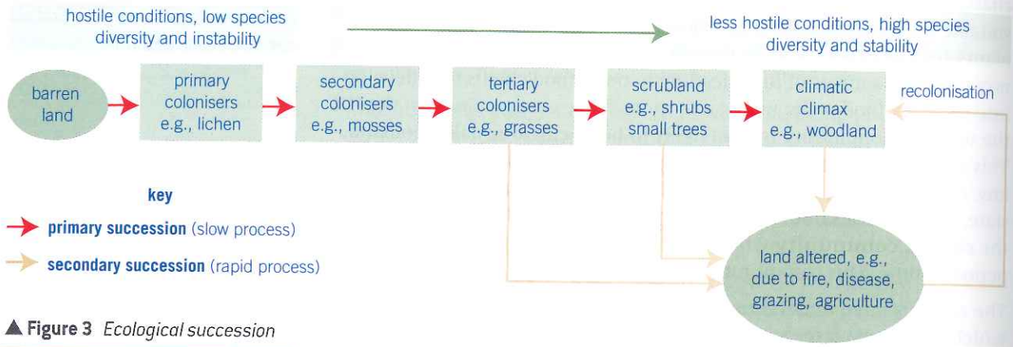
Hint

The climax community is determined by the limiting abiotic factor. For example, trees may not develop on very high mountains because it is too cold, too windy, or the soil layer is too thin (especially at the start of a succession).

▲ **Figure 2** *Deciduous woodland is normally the climax community in lowland Britain*

to its climax community is the same as described above, except that it normally occurs more rapidly. This is because soil already exists in which spores and seeds often remain alive in the soil, and there is an influx of animals and plants through dispersal and migration from the surrounding area. This type of succession is called **secondary succession**. Because the land has been altered in some way, for example, by fire, some of the species in the climax community will be different.

Figure 3 summarises the events of ecological succession on land.



▲ **Figure 3** *Ecological succession*

Maths link

MS 3.1, see Chapter 22.

Summary questions

1 State the general name given to the first organisms to colonise bare land.

2 Describe how changes in the environment lead to increased biodiversity during succession.

3 State the name that is given to the stable, final stage of any succession.

▲ **Figure 4** *The grassland in the foreground is grazed by sheep and so is prevented from reaching its natural climax. The land behind the fence has not been grazed for many years and has reverted to the climax community of woodland. This is therefore an example of secondary succession*

Warming to succession

Many glaciers in the northern hemisphere have been melting over the past 200 years. This retreat is, in part, the result of the additional global warming that has taken place since the industrial revolution and the burning of fossil fuels that has accompanied it. When glaciers melt and retreat they leave behind gravel deposits known as moraines. The retreat of the glaciers in Glacier Bay, Alaska, has been measured since 1794 and so the age of the moraines in this region is recorded.

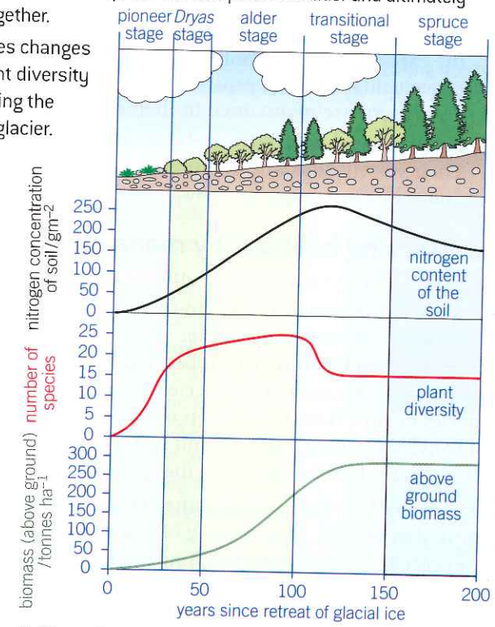
Although no ecologist has been present to watch the succession that has taken place on these moraines, they can infer the changes that have occurred by examining the plant and animal communities on the moraines of different ages. The youngest moraines (those nearest the retreating glacier) have the earliest colonisers (pioneer species), whereas those successively further away from the glacier show a time sequence of later communities.

Each stage of a succession has its own distinctive community of plants and animals that alters the environment in a way that allows the next stage and its community to develop. The stages that follow the retreat of an Arctic glacier are:

- **pioneer stage**. In the early years after the ice has retreated, photosynthetic bacteria and lichens colonise patches of land. Both of these pioneers fix nitrogen This is essential because nitrogen is virtually absent from glacial moraines. They also form tough mats that help to stabilise the loose surface of the moraines. When these pioneer species die, they decompose to form humus. Humus provides the nutrients that enable mosses to colonise. The pioneer stage occurs when the land has been ice free for 10–20 years.

- ***Dryas* stage**. Some 30 years after the ice has retreated, the ground is an almost continuous mat of the herbaceous plant *Dryas*. Its roots stabilise the thin and fragile soil layer formed from the erosion of the rocks that make up the moraine. Bacteria in root nodules of *Dryas* also fixes nitrogen, further adding nitrogenous nutrients to this poor-quality soil. Other plants found at this stage are the Arctic poppy and moss campion.
- **alder stage**. This arises about 60 years after the ice has retreated. Alder is a tree that has nitrogen-fixing nodules on its roots, enabling it to grow on nitrogen-poor soil. Alder sheds its leaves, which decompose into nitrogen-rich humus that further enriches the soil. The alder stage occurs some 50–70 years after the retreat of the glacial ice.
- **spruce stage**. About 100 years after the ice has retreated, spruce trees develop amongst the alder. A period of transition takes place and during the next 50 years or so the taller spruce out-competes the alder and ultimately displaces it altogether.

Figure 5 summarises changes in soil nitrogen, plant diversity and biomass following the retreat of an Arctic glacier.



▲ **Figure 5**

1 Using the information on the graphs, describe and explain the changes in above-ground biomass over the 200-year period.

2 a Using your knowledge of the nitrogen cycle, explain how nitrogen from the atmosphere becomes incorporated into the soil, causing its level to increase during the first 100 years after the glacier retreats.
b Suggest two reasons for the fall in soil nitrogen levels after 150 years.

3 Suggest a reason for:
a the rapid increase in plant species during the first 30 years after the retreat of the glacier.
b the fall in the number of plant species 100 years after the retreat of the glacier.

4 Explain why it would be more appropriate to use a transect rather than quadrats placed at random when investigating this succession.

▲ **Figure 6** Dryas *(mountain avens) is the most common pioneer species in Glacier Bay, Alaska. It is able to fix nitrogen and forms dense mats and therefore enriches and stabilises the thin fragile soil*

▲ **Figure 7** *Arctic poppy (yellow flower) and moss campion (pink flowers) are early flowering pioneer species on Arctic moraines*

▲ **Figure 8** *Spruce trees are the final succession stage following the retreat of glacial ice in the Arctic. They begin to grow around 100 years after the ice has retreated and persist as the dominant vegetation for centuries*