Success with succession

Ecological succession is a topic that seems to cause students trouble. Former A-level senior examiner Martin Rowland looks at why this might be and offers a guide to help students demonstrate their understanding

Both as a teacher and as an examiner, I regularly found ecology to be a subject that caused problems for students. For some, the problem resulted from poor recall. Students often confused the terms **population** and **community** or community and **ecosystem**. For others, the problem resulted from poor understanding. This was particularly true when students were asked to explain ecological succession. Recall and understanding are both part of assessment objective 1 (AO1), which makes up 30–35% of the marks in your final A-level biology examinations.

What is ecological succession?

Ecological succession is the process by which communities change over time. Although some of the mature woodland communities that you might see in the UK today were planted, others are natural. They developed from previous communities. Each intermediate community in this development timeline is called a seral stage and the final mature community is called a climax community.

During successive seral stages, the species diversity, biomass and primary production of the community increase. If conditions remain stable, however, these features of a climax community remain stable. Natural occurrences, such as forest fires, and human activities, such as logging, result in conditions changing. This, in turn, affects a climax community.

Understanding primary succession

Primary succession starts with an uninhabited habitat — for example, bare rock, a sandy beach or a newly formed pond. Initially, these habitats are inhospitable and only a few hardy species can tolerate these conditions. Table 1 shows examples of the first colonisers — pioneer species — of a range of habitats.

So, what are you expected to understand about primary succession? Let's answer this by considering primary succession on land. Figure 1 shows part of the island of Kaua'i, geologically the oldest of the Hawaiian islands. This island emerged from the sea by volcanic activity around

Table 1 Pioneer species in different types of habitat

Type of habitat	Typical colonisers
Bare rock including cooled, solidified lava	Lichens — a mutualistic combination of algae and fungi
Sand	Marram grass and sea couch grass
Fresh water	Freshwater algae
Salt water	Marine algae

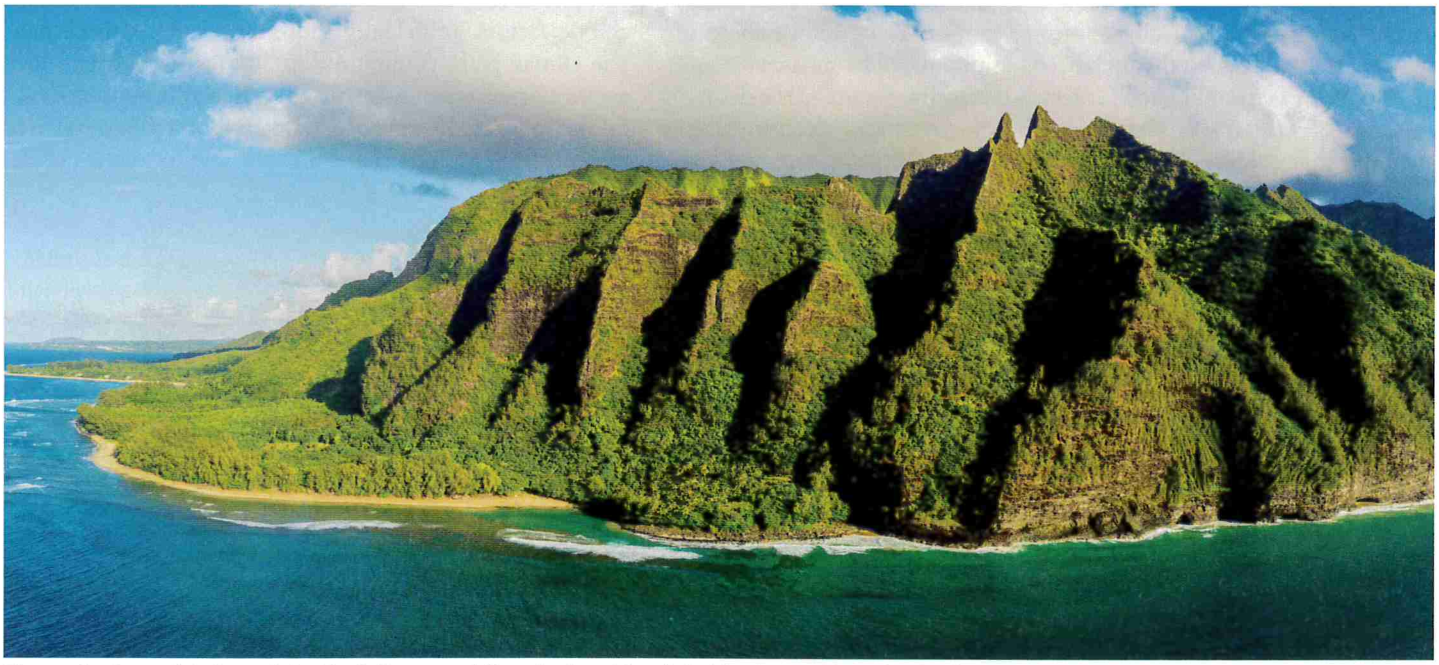

Figure 1 An aerial view of the Na Pali coast of Kaua'i, the oldest inhabited Hawaiian island. About 5 million years ago, this island was barren volcanic lava

5 million years ago. After it had cooled down, pioneer species colonised its bare volcanic rock and primary succession began on the island. You can see from Figure 1 that it is now covered by mature forest.

What is special about pioneer species?

To explain the features of pioneer species, you need to refer to **abiotic factors** in the environment. The abiotic factors associated with bare rock result in a pretty hostile habitat. Even so, the rock does not remain bare for long. It becomes colonised by one or more pioneer species — the primary producers that first inhabit an area. Why primary producers? The answer is simple; bare rock provides nothing that will support consumers. The pioneer species are unlikely to be flowering plants, because plant roots can only penetrate a soil-like medium and plants survive only if that medium provides water and key inorganic ions.

Figure 2 shows lichens growing on bare rock. These develop either from spores or from dry fragments of lichen that are blown by the wind and randomly land on the rock. A lichen is not a single organism. It is a mutualistic relationship between two, or sometimes three, types of organism — a unicellular alga (and/or in some cases, a cyanobacterium) and a filamentous fungus. The thread-like fungal filaments (hyphae) in the lower layer of the lichen are able to cling to bare rock and those in the upper layer provide a waterproof cover. Algal cells, sandwiched between these two layers of fungal hyphae, are able to photosynthesise (see Figure 3). The abiotic factors associated with bare rock severely restrict the primary production of these lichens and they often increase in diameter by only 1 mm per year. Figure 2 has a magnification of ×1, so you can see that the lichens, although well established, have remained small.

How do pioneer species change the habitat?

Despite their low primary production, over time the lichens change the abiotic factors. The fungal hyphae penetrate the rock surface, causing it to crumble. When the lichens die, decomposers (such as airborne bacteria) act on their remains and release inorganic ions. Together, the mixture of crumbling rock, the decaying remains of lichens and inorganic ions forms a primitive soil-like medium. This medium now allows other primary producers to grow. Typically, spores of moss that are blown there can germinate and grow, so the rock becomes populated by mosses.

The cycle of crumbling rock and ever-increasing masses of the decaying remains of primary producers continues, forming a deeper soil-like medium that enables the seeds of larger plants to germinate and grow. This results in the formation of an increasing mass of soil with greater fertility and water-holding ability, enabling yet larger plants to grow. All this continues until a climax community is formed, which is complex and stable (see Figure 4). In the UK, the whole process might take 100–150 years. At each seral stage along the route, the biodiversity of the plant and animal communities increases.

What happens to the primary producers from earlier seral stages?

To answer this successfully, you should refer to a **biotic factor** — particularly to interspecific competition. The producers in each successive seral stage are better able to trap sunlight and absorb water and inorganic ions from the developing soil than those in the previous seral stage. As a result, they become dominant as they outcompete the producers in the previous seral stage, which either disappear or are restricted to small areas within the developing plant community. Examples of this include lichens or mosses restricted to growing on the damp branches of trees or dead wood in a park or woodland.

How can you explain the appearance of consumer communities?

Here you should refer to food webs and ecological niches. An increase in the diversity of primary producers provides a greater range of food types for primary consumers which, in turn, might be preyed on by secondary consumers. Later, as shrubs and trees develop, the community provides more ecological niches, including nesting sites and feeding sites for animals, which encourage yet more animal species diversity.

Why do different parts of the world have different communities?

One reason for this is that different ecosystems have different abiotic factors, principally those associated with climate. The climax plant community in an area of land in which access to free water is restricted is likely to be dominated by **xerophytes**. If access to water is limited because it is frozen, the xerophytes must also be able to tolerate colder

Figure 2 Various lichens have colonised this once bare rock

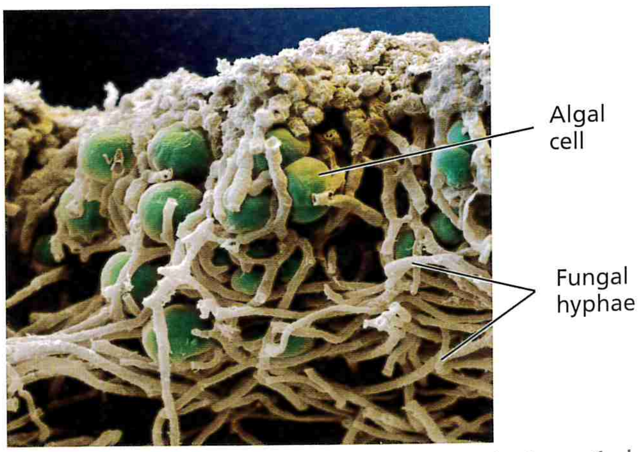

Figure 3 Coloured scanning electron micrograph of a vertical section through a hammered shield lichen (*Parmelia sulcata*) ×900

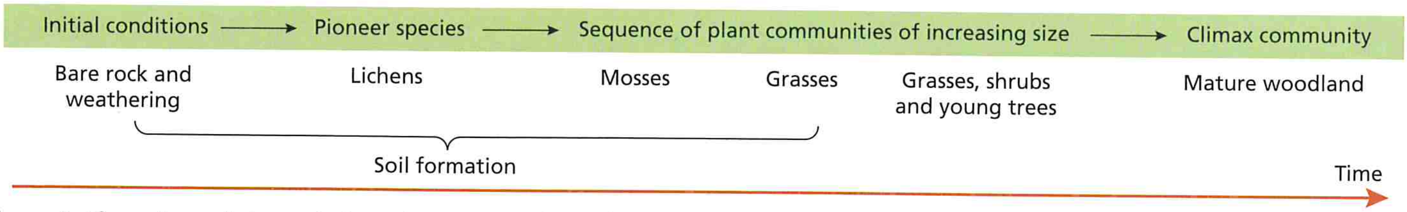

Figure 4 The main seral stages during primary succession on bare rock

Figure 5 A fire has devastated this area of scrubland in Australia, but these grass trees (*Xanthorrhoea australis*) have produced new growth

temperatures (such as coniferous trees in arctic forests) than those in a warm desert community (such as the giant cactus saguaro, *Carnegiea gigantea*, in the deserts of North America and Mexico — see front cover). In contrast, the climax plant community in an area in which free water is easily accessible is likely to be dominated by broad-leaved deciduous trees. Of course, climate and the nature of the plant community, in turn, influence the consumer communities.

Another reason for different communities is that a climax community has been disrupted. This leads us to secondary succession.

Understanding secondary succession

Not all examination boards include secondary succession in their biology specifications. Check your own to see if you can be expected to show recall with understanding (AO1) of this topic.

Secondary succession occurs when a previously established community is disrupted. This can occur naturally — for example, after a fire. Fires are common in the gum-tree forests of Australia. The grass trees (*Xanthorrhoea australis*) shown in Figure 5 have adaptations that enable them to withstand fires and flourish in the soil fertilised by ash after a fire. You can see in Figure 5 that a recent fire has cleared the soil of most plants, but the grass trees have survived and already begun to produce new shoots. They will be joined by other plants grown from seeds blown onto the surrounding bare, ash-fertilised soil, which germinate and grow. Consequently, although the fire has disrupted the plant community, succession will begin at an earlier seral stage and continue until a climax community is reached again.

Secondary succession can also result from human activity — for example, a farmer ploughing a field in Kent or another allowing sheep to graze on the hills of north Wales. The disruption knocks the plant community back to an earlier seral stage. As you might know from your own garden, as soon as this human activity ceases, succession resumes its inevitable path.

Synoptic link to conservation

You should always be on the lookout for synoptic links between different topics within your biology specification. Exam papers often include questions that require you to make these links.

Succession and conservation provide a synoptic link. Both primary and secondary succession lead to change in communities. In contrast, with conservation, our intention is to maintain an existing community in its current form. Succession and conservation can pull in different directions.

We can think of conservation in several contexts. For example:

- returning an ecosystem to its former diversity (e.g. see Biological Sciences Review, Vol. 29, No. 1, pp. 12–16)
- protecting a species of interest (e.g. see Biological Sciences Review, Vol. 29, No. 3, pp. 28–30)
- reducing the impact of alien invaders (e.g. see Biological Sciences Review, Vol. 31, No. 1, pp. 38–41)
- reducing conflict between wildlife and humans (e.g. see Biological Sciences Review, Vol. 31, No. 3, pp. 7–11)

Perhaps less often do we think of human practices designed to stop succession, protecting an earlier seral stage for our own advantage. The previous examples of ploughing fields or allowing farm animals to graze can be considered to be such acts of conservation, as can the 6-year cycle of burning heather moorlands to maintain a suitable habitat for grouse. I wonder if you would think of people providing opportunities for grouse shooting as conservationists.

Terms explained

Abiotic factor An ecological property associated with the non-living part of an environment, such as temperature, pH and humidity.

Biotic factor An ecological property associated with the living part of an environment, such as competition or predation.

Community All the interacting populations of organisms living in the same area at the same time.

Ecosystem An ecological unit that includes all the organisms living in a particular area (the community) and its physical and chemical components with which they interact.

Population All the members of a single species that live in the same area at the same time (and are capable of interbreeding).

Xerophyte A plant that is adapted to survive in a habitat that provides limited access to free water, such as a desert or frozen soil.

Dr Martin Rowland taught and examined A-level biology for many years. He is the author of several biology textbooks, which you can find by visiting **www.hoddereducation.co.uk**