CHAPTER 6 THINKING ABOUT ANIMAL POPULATIONS

6.1 Population size

Introductions such as this one 'signpost' what's coming next. Use them to keep track of the overall shape and direction of the text.

Chapter 5 talked about cycles. The diagrams emphasized how constituents flow in a cycle and revealed some of the interrelationships between the various components. It ended on a controversial form of pollution (acid rain), which is now known to have a damaging effect on animal and plant populations. This chapter asks a related question about an aspect of ecology of immediate and practical concern: What factors influence the numbers of individuals in a particular population?

Simple, common-sense thinking would suggest that favourable factors (plentiful food, for example) will raise numbers; unfavourable factors (disease, for example) will tend to reduce them. Can we adopt a more scientific approach and identify the factors that influence population size in a more systematic way?

Human beings are clearly a successful and numerous species. Estimates vary on the time of origin of *Homo sapiens*, but the best estimate is that we arose not much more than a hundred thousand years ago. In numerical terms, our species has certainly thrived (Figure 19).

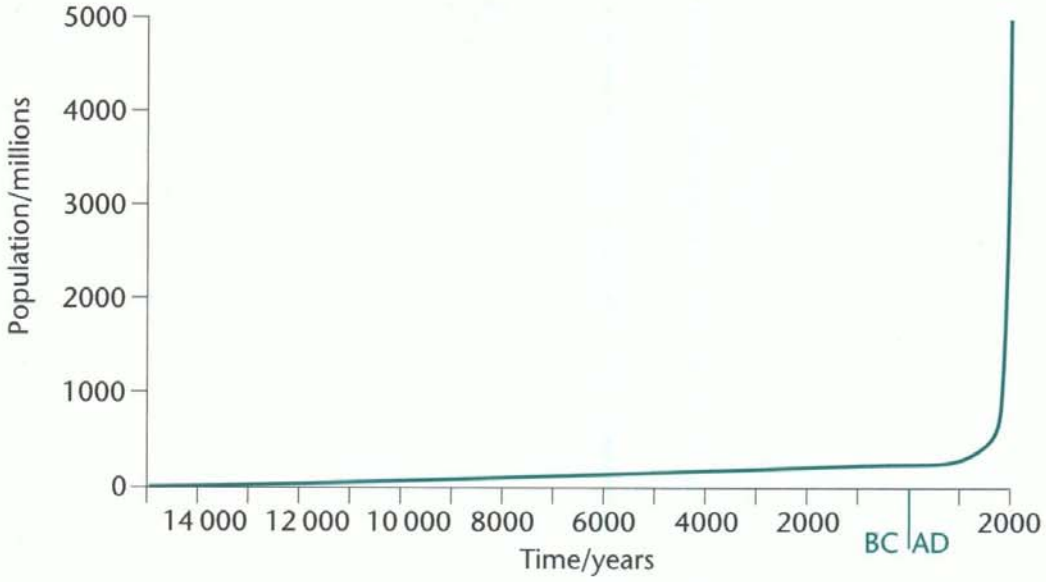


Figure 19 *Human population increase*

Figure 19 shows an marked increase in population. Only rarely is such a pattern of sustained growth displayed in wild animal populations. For many species of bird, for example, neither stability nor sustained population growth is attainable. Figure 20 shows the numbers of great tits breeding at a

particular site over a number of years. The numbers fluctuate wildly over the ten years or so shown.

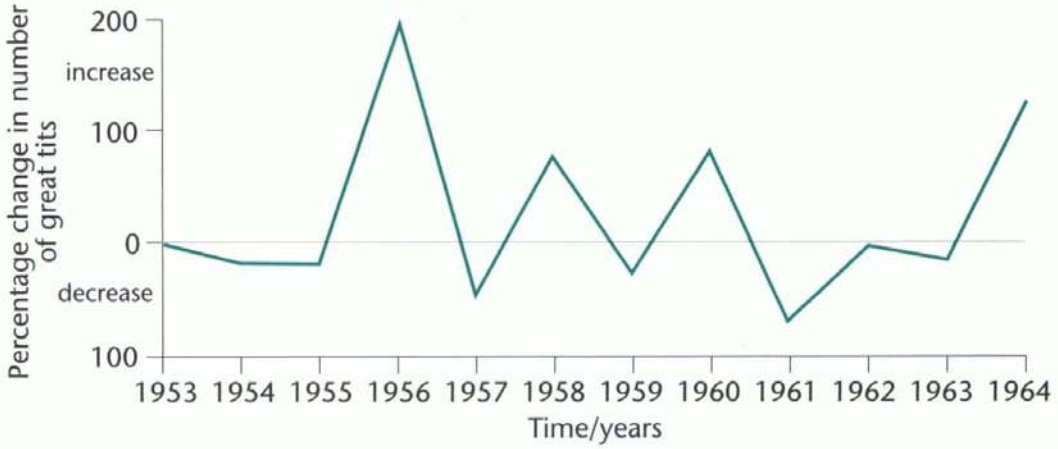


Figure 20 *Numbers of great tits breeding at a particular site in Sweden*

This instability reflects the fact that so many factors influence population size. A simple diagram helps us to categorize these factors in broad terms (Figure 21). Numbers can increase through the birth of individuals or through the arrival of individuals from other locations (that is, immigration) and decrease because of the movement of individuals away (emigration) or their deaths.

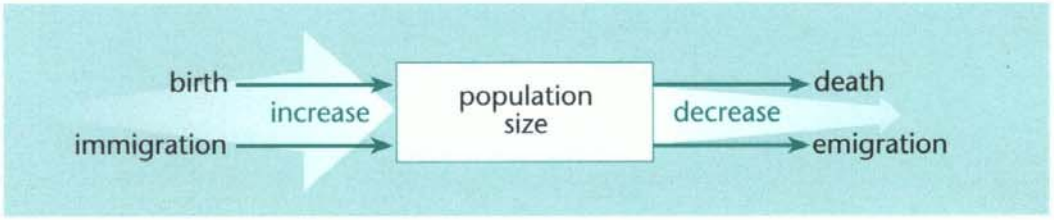


Figure 21 *Factors that influence population size*

Factors that influence birth and death rates are especially significant. In the example shown in Figure 20 the main influence was availability of food. In Sweden, great tits feed on beech seeds. During the winter, a proportion of the young birds die but far fewer are lost if extra food is available. When numbers increase, population density increases – in other words, the numbers of great tits per unit area of habitat increases. In good years mortality rates are low and large numbers of great tits emigrate to new habitats.

So, the size of a population is influenced largely by the availability of food at lower trophic levels. The abundance of parasites and predators can also have an influence. Because resources are limited, the extent of competition from fellow individuals will be important, especially when population density is high. These are examples of biological factors that influence population size. There are also *physical factors* that influence the numbers of individual plants and animals. These factors include temperature (and, for plants, light). The availability of water is also important to both animals and plants.

6.2 A case study: rabbits and vegetation

At this point I want to introduce the first of two specific case studies that relate to change in populations. The first case study concerns rabbits; the second case study concerns populations of red grouse. But first, an obvious question …

Why a 'case study'?

Sometimes, even for the best of students, learning is a struggle. Now and again you'll have to wrestle with what may seem to be a great number of disparate facts and a wide range of different examples. The risk is that you'll become so submerged in the details that you lose sight of the underlying principles – what I've called the 'take-home message'.

Biology has a reputation for being 'full of facts'. Adopting study techniques that help you to 'see the wood for the trees' is especially important.

One way around this is to concentrate on particularly vivid or revealing examples in some detail. With a clearer focus, fewer extraneous facts and, one hopes, a good story, the principles can emerge more clearly. For example, the importance of interrelationships comes through both of the following case studies. What's more, the take-home message from a particular case study should have a wider application.

Bare ground, devoid of all plant and animal life, is a rare sight. A newly erupted volcanic island is one example; a more familiar example might be an abandoned quarry. Suppose this land were simply left alone. With time, simple organisms such as lichens would start to colonize it, even growing on bare rock. Gradually, plant species would gain a foothold as seeds and fruits were brought in by wind or water. As the plants decompose and the rocks are weathered, a soil base would develop, which in turn would allow new plant species to be established. First insects and then larger animals would move in. The important point to remember is that the mix of species present changes over time in a predictable sequence. This process of gradual change is technically termed **succession**.

A similar process occurs on land cleared by fire or the physical removal of vegetation: a few short-lived (that is, annual) plants become established, completing their life cycle from seed to flowering plant in a single year. Later, species of grasses are established; then small trees and shrubs (hawthorn, for example) come to dominate the landscape. The number of different species (that is, the biodiversity) increases. Your garden lawn would provide a good example of succession, assuming you were willing and able to watch nature reclaim it over a period of fifty years or so.

If left undisturbed for many years, a woodland containing mature trees develops to a point at which few new species of plant appear: the community 'settles' and the balance of species remains more or less the same. This is true of many oak woodlands in Britain. Oak woodland is not inevitable – accidental fires, or severe climatic conditions, may slow or even prevent its onset (see Figure 22).

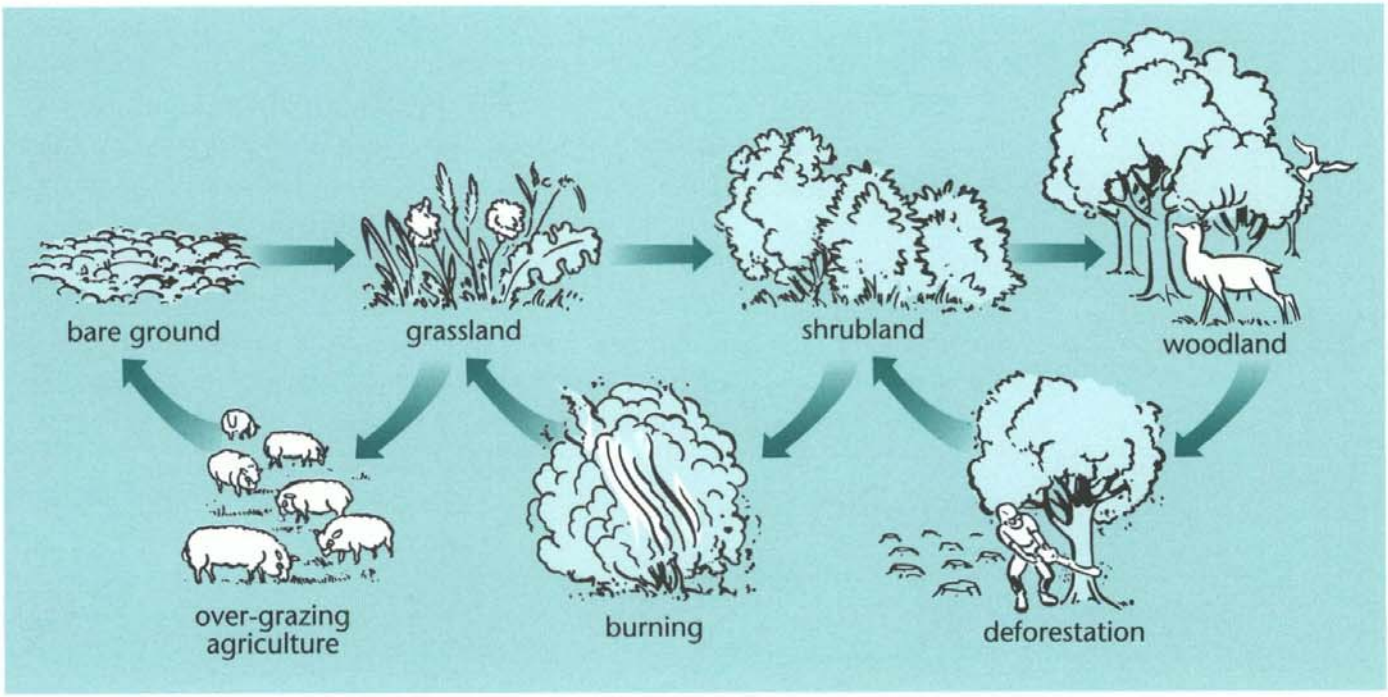
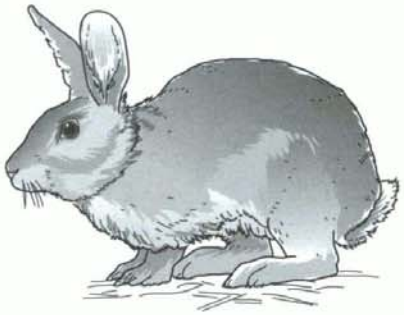


Figure 22 *The colonization of chalk downlands*

If areas such as the North and South Downs of England were to be left undisturbed, what is currently a chalk grassland would change into mature woodland. This was the original vegetation up to about 3000 years ago, when Neolithic peoples cleared the ground for agricultural purposes. A thousand years or so earlier, Mesolithic peoples may have burnt woodland to increase the number of open areas in which prey could be hunted.

Nowadays, these chalk downlands are extremely rich habitats for a number of plant species. For example, a number of rare orchids are found there, as well as the early gentian, a plant not found in mainland Europe. The unique flora and fauna are partly the result of the presence of rabbits and sheep that graze the area.



wild rabbit

Figure 23

As grazing herbivores, rabbits have particular preferences for some plant species, especially juniper and hawthorn. Other plant species are unpalatable (elder bushes, for example) and tend to be ignored; these species are likely to increase in numbers when rabbit numbers increase because rabbits eat competing plants.

In general, grazers such as rabbits tend to reduce the height of vegetation. Think what might happen to many tree seedlings in grass in the company of grazers; unlike grasses, the growing points of these seedlings are some way off the ground (grasses tend to grow from their base up, whereas young trees grow from the tip down). This means that young trees are especially likely to be killed by grazing rabbits, so areas where rabbits are plentiful tend to have few trees. The activity of rabbits also creates 'gaps' in the vegetation where the soil is disturbed by scratching. This bare chalky ground helps the growth of the ragwort, which is a common South Downs plant. If rabbits don't provide bare patches of this sort, other competing plants 'move in' and monopolize the area, and the ragwort seeds find it difficult to establish themselves.

Rabbits and myxomatosis

The characteristic flora and fauna of any location comprise a mix of long-established native (that is, indigenous) species and other species introduced from elsewhere in the fairly recent past. Rabbits appeared in the UK more recently than you might think; they probably arrived with the Norman invasion.

The introduction into the UK of the rabbit disease **myxomatosis** occurred in the early 1950s. The disease is caused by the myxoma virus, which spread to the UK from France where it was deliberately introduced to help reduce the amount of damage caused to farm crops by rabbits. In some rabbit species, notably *Sylvilagus brasiliensis*, the Brazilian rabbit, the myxoma virus is widespread in the population but has little effect on the rabbit 'host'. But if the European rabbit, *Oryctolagus cuniculus*, is exposed to the same virus it has dramatic and usually fatal effects. The rapid spread of the virus through a rabbit population is achieved mainly via the rabbit flea, which can readily hop from one individual to the other, especially after the death of the host rabbit.

By 1954 the virus was infecting rabbits throughout the UK. Officially, the government of the day did its best to eradicate the disease as soon as it arrived in the UK. But its efforts were thwarted by farmers who deliberately spread the virus – many farmers transported rabbits who had recently died of the disease to their own land. The effect of the disease on the rabbit population was devastating. The epidemics of myxomatosis eventually petered out as rabbits developed a natural immunity.

The traditional South Downs vegetation reflects a particular form of plant–animal interrelationship – that of *grazing*. When there are few rabbits or sheep around, the plant community changes. Fast-growing plants and species that have leaves quite far from the ground spring up and overshadow the traditional plants. Previously unfamiliar species start to dominate the landscape. Grazers limit the growth of some species – for example, tree seedlings are not allowed to flourish. The community is held in a state of suspense, preventing its development into woodland. The added advantage is

a greater biodiversity of plant types. We're left with the rather incongruous implication that unfamiliar and rather rare plants are preserved by grazing!

Animals other than rabbits were affected by myxomatosis too, reflecting the complex interrelationships at work. Animals that preyed on rabbits – foxes, badgers and buzzards, for example – all fell in numbers. The minotaur beetle, which has larvae that feed on the dung pellets of rabbits, experienced a sharp depletion. Bird populations were influenced too: the stone curlew population suffered because it prefers to live on ground that is closely cropped by rabbit grazing. The wheatear declined because its favoured nesting place is abandoned rabbit holes. On the other hand, species that compete with rabbits (notably the brown hare) thrived in the immediate aftermath of myxomatosis.

Activity 27 Relating your study to an assignment

Study skills

You'll often find yourself reading text in preparation for a writing task. Suppose you've been asked to write about 400 words on 'the influence of rabbits on ecosystems'. Go back over what you've read so far in this chapter, and draw a diagram that summarizes the interrelationships between rabbits and other downland wildlife. One way to approach this is to put 'rabbits' at the centre of the diagram then add links to other organisms at the edge of the diagram, using arrows to show the interrelationships; for example, rabbit holes are inhabited by wheatears.

Your diagram may well differ from Figure 24, but it should show some of the interrelationships described in the text.

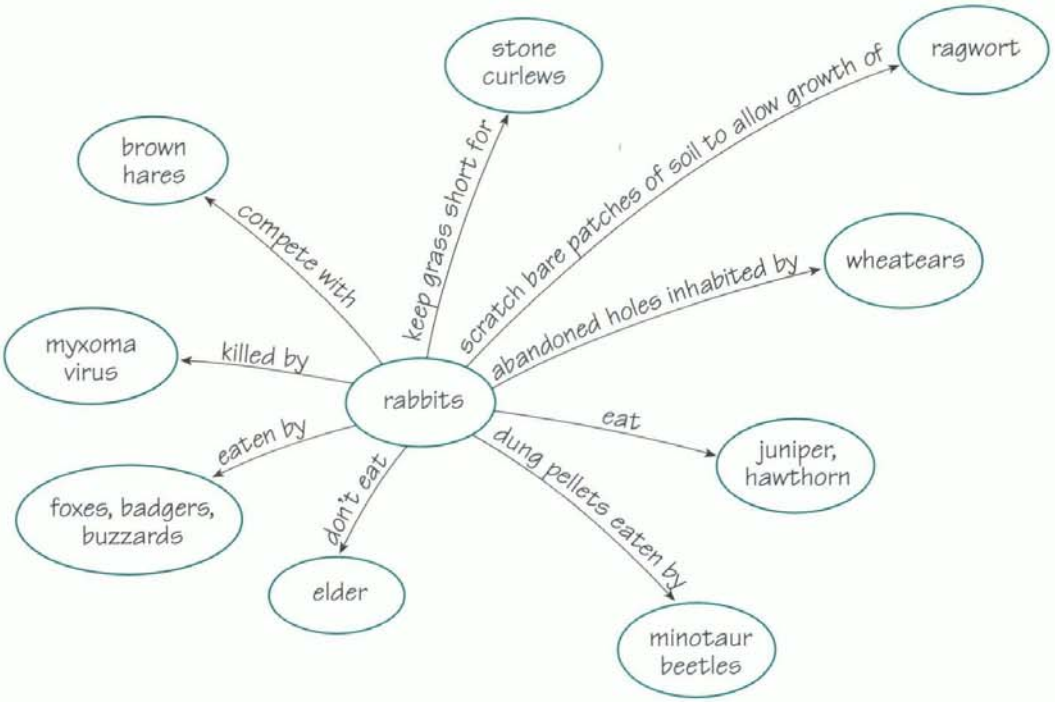


Figure 24 *Interrelationships between rabbits and other organisms on downland*

Nowadays the rabbit population of the UK has largely recovered. For reasons that aren't fully understood, some rabbits were resistant to myxomatosis; they had what I earlier termed 'natural immunity'. These individuals flourished and produced offspring that were themselves resistant, whereas rabbits that weren't resistant produced far fewer offspring. The result was that resistant rabbits became increasingly common and the rabbit population expanded.

Natural selection

Charles Darwin noticed that, in any species, there is some variation between individuals – perhaps one plant or animal is slightly larger than another, or more resistant to disease. When there is a struggle for existence, perhaps as the result of a shortage of food or a new disease, some individuals survive longer and leave more offspring. These individuals are said to have a greater **fitness** than the others. Here, 'fitness' has a very specific meaning – it means the ability to survive to produce offspring. If the characteristics responsible are inherited by the offspring, the offspring will have greater fitness, and so more will survive to reproduce. As a result, the characteristics of the population may change over time; for instance, it may become more resistant to disease. Darwin called this process **natural selection**, and he saw it as one of the main drivers of **evolution**, which is biological change over time.

In certain locations, rabbits are now thriving to such an extent that they are damaging the environment through extensive soil erosion. This has prompted some authorities to instigate controversial plans for the extensive gassing of rabbit warrens, with the aim of conserving the unique chalkland environment. But rabbit numbers on the Downs are probably still not back to pre-myxomatosis levels, so the traditional plants of the downland remain threatened. To prevent the loss of these plants grazing has to be supplied by human interference. Flocks of sheep are moved from site to site to graze. Human intervention can also take a more direct form – some hawthorn trees have been removed 'by hand'.

Activity 28 The difference rabbits make

pages 261 to 264

In the mid-1950s, numbers of rabbits on the South Downs fell because of myxomatosis. The vegetation (and therefore the animal population) changed as a result. Table 3 records the vegetation in 1954 (before myxomatosis) and 1967 (after myxomatosis) at a typical site. Use the data in Table 3 and information from Activity 27 to write a summary of the effects of the disease in no more than 400 words. Section 6.2 of Chapter 9 of the SGSG (pages 261 to 264) contains some practical advice about planning and writing assignments.

Table 3 Vegetation before and after myxomatosis at a hypothetical site

1954	1967
ragwort plentiful	ragwort scarce
elder bushes plentiful	fewer elders
trees rare	small trees established
juniper rare	juniper flourishing
40 different plant species	15 different plant species

Writing tasks of this type are far from easy. Of course, you need to make what you write *interesting* . It mustn't be aimed over the head of the average reader; remember you have knowledge that casual readers do not. Specialist terms will have to be explained. You need to think about the *audience* .

What is the take-home message?

We've seen yet more evidence that *interrelationships* are at the heart of ecosystems. Change one component and many other things are influenced. We've also seen that change is the norm, not the exception.

The examples of interrelationship you've come across show just how susceptible ecosystems are to change. Sometimes the term the 'balance of nature' is used to imply that natural systems have a natural robustness and stability. This is far from true; any alterations (for example, disease, introduced species, loss of resources) are likely to alter the balance rather than preserve it. Of course, change isn't undesirable in itself, *value judgements* have to be brought into play when the merits of change are debated. Conservation policies require decisions on what is 'right'. And as the next section reveals, deciding what is right is problematic and involves more than science alone.

Another important general principle emerges, one that is true of conservation policy world-wide: effective conservation usually requires active interference. For example, habitats are not to be simply 'left alone' to their own devices – proactive management is required, which means human interference to achieve desirable ends.

Activity 29 Being your own examiner

Study skills

Remember to test how much you understand by thinking of tasks and questions to set yourself. (One approach was mentioned in Activity 27.)

(a) How do rabbits influence the types of plant species present?

(b) In no more than two or three sentences, give an example of the effect of natural selection on rabbit populations.

(c) What management practices are used to preserve chalkland ecology?

You can probably think of others. Each question requires different approaches and levels of detail – where it's given, the length of the answer required is a useful guide. The golden rule is to make what you say *relevant* to the question – don't simply to write down 'all you know' about the topic.

As you gather material for what you write you'll need to make *selections* from your notes. In (a), for example, your answer must emphasize what would happen if the rabbits were absent. In (b) the term 'natural selection' must be prominent. Writing of this type must demonstrate that you've understood what you've read.

6.3 Using your scientific judgement

You'll appreciate that learning about science is not simply a process of absorbing information passively. You are faced with decisions – choices and dilemmas: how long to study, what topics to go over again, what's important. And increasingly the science you learn will raise a different set of questions, equally taxing. These are a mixture of moral and practical problems: how to think about the science you learn, how it should be applied, how it affects people.

With a topic such as ecology wrestling with these 'bigger' questions forms part of the learning process. You have to learn about science in ways that help you to come to personal decisions. What study techniques can you use when 'big questions' arise? Is the evidence for pollution strong enough? Is that particular conservation tactic justifiable? What follows is one example of a personal decision-making process, rooted in science, and based on a genuine, contemporary problem.

The conservation of red grouse

This section involves Side 2 of the audio-cassette. It relates to the shooting of red grouse, a game bird, about the size of a small chicken, found exclusively on the upland moors of northern and western Britain. In recent years about 400 000 red grouse have been shot every year, generating a gross income of about £10 million.

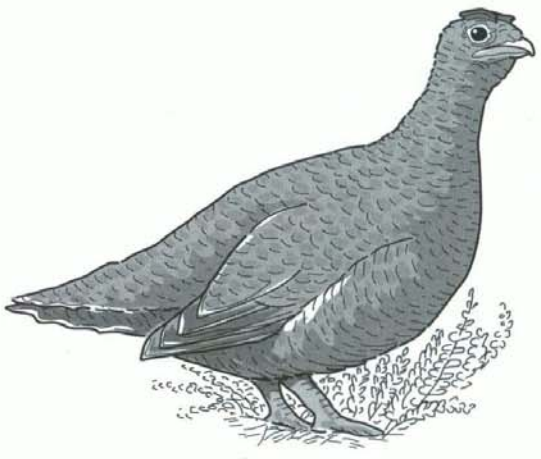


Figure 25 *Red grouse*

You'll hear a variety of different points of view on the audio-cassette. You'll need the following background information to help you make sense of the arguments.

A dilemma for conservationists

1 A grouse moor is a man-made ecosystem, and it has a distinctive flora and fauna. The dominant plant is heather, which provides cover for grouse and is the major source of food for the birds.

2 If the habitat were simply 'left alone' it would gradually change; grasses would take hold and shrubs and small trees would become more of a feature. Such a habitat would no longer be able to support large numbers of grouse.

3 The grouse moorland habitat is managed by gamekeepers to maximize the numbers of red grouse for shooting. Animals that feed on red grouse or their eggs have to be shot: foxes, crows and wildcats, for example.

4 Patches of heather are occasionally burned to encourage the growth of new heather shoots, which is an especially beneficial food source for young grouse.

5 Managed moorland of this type attracts a wide variety of animals and plants that thrive in this particular habitat. For example, meadow pipits are common on heather moorland.

6 Red grouse moorland has attracted increasing numbers of rare birds of prey. Such birds are called *raptors* and their diet includes grouse, especially the young and the eggs. In particular, the numbers of *hen harriers* have increased significantly over the past few years.

7 At one time, the hen harrier was a relatively common bird throughout the UK, but numbers declined sharply, largely as the result of human persecution. Hen harriers are now protected by law; it is illegal to shoot the birds or to interfere with their breeding (for example, by disturbing their nests).

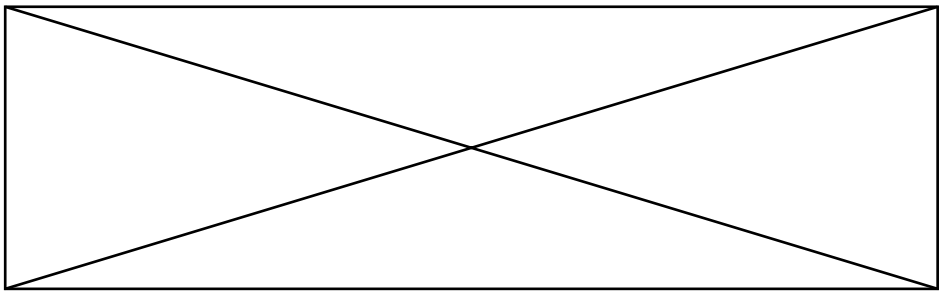
8 The numbers of grouse in managed moorland habitats have been in overall decline for the past 30 years or more. The ecological reasons for this long-term fall are complex. The moorland has not always been well-managed; for example, increased grazing by sheep discourages the growth of heather. Grouse numbers are also adversely affected by disease.

9 Apart from the long-term decline, numbers of red grouse vary in the short term. There are cycles of population increase and decrease (rather like the pattern in Figure 20), and the time from peak to peak is typically about five years. The cause of these population cycles is not known but they are not related to shooting.

10 Because the numbers of raptors (especially hen harriers) increased while grouse numbers decreased, those who managed grouse moors became convinced that the harriers were particularly to blame for the poor 'bags' of grouse in recent years.

11 Gamekeepers were prevented from interfering with hen harriers because of EU conservation laws. Some felt that numbers of harriers should be limited to a set 'quota' and that excess birds should be removed to other sites. Conservationists opposed such moves, on the grounds that they would be ineffective and illegal.

12 A number of concerned organizations agreed to support a five-year study of the relationship between hen harriers and grouse numbers at Langholm moor in south-west Scotland. The report concluded that the large numbers of raptors present contributed to the low numbers of grouse, although habitat mismanagement was important too. Shortly after the report was published, Langholm ended grouse shooting, as the following extract from *The Times* reveals.



(*The Times*, 27 October 1998, p. 3)

Soon you will be asked to listen to Side 2 of the audio-cassette. You will hear a variety of views, some of them from interested organizations. It's not important that you remember exactly 'who says what' or the details of the organizations they represent, but for the sake of completeness we'll list the participants here.

Pippa Greenwood, horticulturist and broadcaster.

Ian Newton, The British Ecological Society.

Iain Bainbridge, The Royal Society for the Protection of Birds.

Dick Potts, Director General of the Game Conservancy Trust.

Des Thompson, Scottish Natural Heritage.

Gareth Lewis, Factor (manager) of the Buccleuch Estate, which includes Langholm Moor.

Contributions from these experts take up the first ten minutes of Side 2 of the audio-cassette.

These 'expert' contributions were then played to three volunteers and I recorded their subsequent discussion. None of these brave student volunteers had any special knowledge of the subject, although they were supplied with the background information you've just read. I was interested in their reactions. What sense could they make of what they had heard? When you listen to the students' discussion on the audio-cassette you can compare their reactions to the 'experts' with your own. What I wanted to find out was how the students would react to controversy and the sometimes bewildering variety of conflicting opinions.

Activity 30 Listening and disagreeing

Study skills

Now listen to Side 2 of the audio-cassette. Make notes as you listen to the expert contributions. Stop the audio-cassette and replay any portions that you feel unsure about. At the end of the section decide whether you think the shooting of grouse is justified.

Then listen to the volunteers' discussion. Write down how their reactions compared with your own. Do you think that they 'took on board' the views of the experts? Finally, listen to my own thoughts at the end of the audio-cassette, where I reflect on what I feel can be learned from the exercise. Write down what you think you learned from listening.

In a controversial case scientific information can act as a guide to your thinking. But your views on other issues are vital too – animal welfare, the importance of commercial interests, how convincing you find the arguments for conservation.

Whatever decision you come to, you ought to be able to offer some reasons to support your decision. That way, decisions are more informed and considered – and you can feel more confident of your stance. Becoming confident of the science you know and of how it should or shouldn't be applied is an integral part of being a successful student. The fact that there is so much more to find out isn't a cause of anxiety – it's a reason for sustained interest.

Learning Outcomes

You should now understand that:

- many animal and plant populations are unstable because of their susceptibility to a range of biological and physical influences
- grazing (by rabbits and sheep) accounts for the unique flora of chalkland habitats by preventing the growth of shrubs and trees
- reductions in the rabbit population caused by myxomatosis have far-reaching influences on local animal and plant populations, reflecting the powerful interrelationships within this ecosystem
- conservation tactics often reflect the need to manipulate a particular environment for the benefit of particular species
- scientific information can provide a good basis for value judgements about the appropriateness of conservation tactics.

You should now be more able to:

- appreciate how a detailed case study can help establish key principles
- sense some of the difficulties involved in personal decision-making, and appreciate that a questioning and sceptical frame of mind aids the process
- use and understand the terms 'succession', 'natural selection', 'fitness' and 'evolution'.