CHAPTER 3
BIODIVERSE ECOSYSTEMS

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By the end of this chapter you will have covered the following material.

Science Understanding

- Ecosystems are diverse, composed of varied habitats and can be described in terms of their component species, species interactions and the abiotic factors that make up the environment (ACSBL019)
- Relationships and interactions between species in ecosystems include predation, competition, symbiosis and disease (ACSBL020)
- In addition to biotic factors, abiotic factors including climate and substrate can be used to describe and classify environments (ACSBL021)
- Species or populations, including those of microorganisms, fill specific ecological niches; the competitive exclusion principle postulates that no two species can occupy the same niche in the same environment for an extended period of time (ACSBL023)
- Keystone species play a critical role in maintaining the structure of the community; the impact of a reduction in numbers or the disappearance of keystone species on an ecosystem is greater than would be expected based on their relative abundance or total biomass (ACSBL024)

Corbis/Thomas Marent/Minden Pictures

Figure 3.1 ▶ Lemurs like these Coquerel's sifakas are only found in Madagascar.

Madagascar is classified as one of the biological hotspots of the world. It is home to a large proportion of unique wildlife. In fact, 98% of its terrestrial mammals, 92% of its reptiles, 68% of its plants and 4% of its birds are found only in Madagascar. Biological hotspots are considered extremely important to conserve due to the number of **endemic** species found in the area. There are 34 international hotspots worldwide, each with its own unique local species. Hotspots are reservoirs of the most diverse, yet most threatened, sites of **biodiversity** on the planet.

What factors influence the range and distribution of diverse organisms from one country to the next or even one region to another? Why are some species more sensitive to change than others? What are the reasons behind why particular species are only found in the harsh arid conditions of the Australian desert? This chapter will help to explain why Earth has such extensive biodiversity and how scientists use characteristics to classify **ecosystems**.

BIOLOGICAL HOTSPOTS

Discover more information about the 34 biological hotspots around the world.

A world of biomes

In order to understand how an ecosystem is classified, we must first comprehend how Earth is comprised of ecosystems. The sum of all ecosystems across the world is called the **biosphere**.

Enhanced views of Earth and its biosphere present patterns of browns and blues that identify the large terrestrial and aquatic **biomes**. Biomes are main categories of ecosystems across large geographical areas. The world's terrestrial biomes, for example, roughly correspond to major variations in vegetation types, climate, **topography** (the arrangement of physical features, both natural and artificial, of an area), and soil type. Tropical rainforests, deserts, grasslands and tundras are some examples of the world's major terrestrial biomes. Figure 3.2 shows the world's major biomes and their distribution.

Each biome, whether it is the savannah grassland in Australia or the savannah grassland found in Africa (Figure 3.3), has similar features. All savannah grasslands across the world are

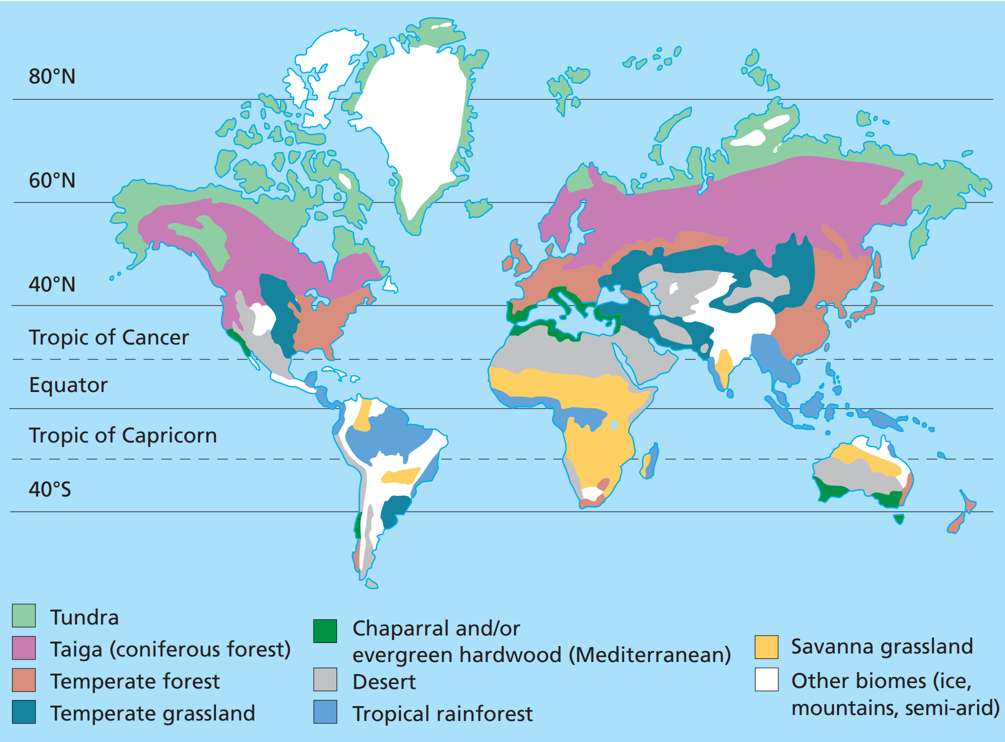

Figure 3.2
Distribution of the world's major terrestrial biomes

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Figure 3.3
A savannah grassland

characterised by grassland with very few trees, a dry season that can be very hot or cool and a wet season that is warm. Typically, savannah grasslands receive less than 490 mm of rainfall annually.

Lakes, oceans and rocky shores are examples of aquatic biomes, which form the largest section of the biosphere. Several factors influence the kinds of organisms that inhabit an aquatic biome and the relationships between these organisms. These include how permanent the body of water is, its salinity, its depth and nutrient availability.

TERRESTRIAL BIOMES

Use the website to gain more information on the world's terrestrial biomes.

Ecosystems, environments and habitats

The next explicit classification of an area is known as an ecosystem. A biome can accommodate a number of different ecosystems. An ecosystem is classified as the interactions between the **environment** and its **community**. Specifically, the community is the sum of all the living organisms in a **habitat** and the environment is the **abiotic** and **biotic** components of the ecosystem. This includes temperature, water availability, nutrient availability and other organisms that make up a part of another individual's environment. The other organisms may compete for food against the individual or prey upon it. They may even change the chemical or physical environment. Ecosystems are relatively self-contained and are able to support themselves by cycling or exchanging materials. For example, in a forest, leaves fall and decompose, and their nutrients are returned to the soil. In turn, the plants remove these nutrients from the soil and use them in growth. Note that this is a very simple explanation of how an ecosystem operates.

Chapter 4 explains how energy and nutrients are cycled through an ecosystem.

The world's ecosystems are diverse. They contain species that are directly linked to the abiotic and biotic factors within the ecosystem. To delve further into classifying areas, an ecosystem can contain many different habitats. A habitat is an area or environment within an ecosystem where an individual of a species lives, feeds and reproduces. Habitats are therefore specific for each **population**. A population is a group of individuals belonging to the same species, living in the same habitat at the same time. For example, a rainforest ecosystem has several habitats. The ground level is home to the cassowary, a flightless bird, whereas the canopy level is home to the striped possum. The habitat for the cassowary is different to that of the striped possum despite living in the same ecosystem.

Ecosystem = the interaction between the environment + its community

Community = the different species inhabiting an area at one particular time

Environment = abiotic + biotic components of an area

QUESTION SET 3.1

Remembering

1 Identify the two major biomes in the biosphere.
2 Explain 'biological hotspot'.
3 Define the following terms.
   a Biodiversity
   b Endemic
   c Topography

Understanding

4 Distinguish between:
   a population and community.
   b environment and habitat.
   c biotic and abiotic.
5 Draw a concept map to show the relationship between the following: biosphere, habitat, ecosystem, community, biome, environment, biotic factors, abiotic factors and population.

Classification of ecosystems and environments

Ecologists study the relationships between living things and their surroundings. This study is called **ecology**, a term first used by Ernst Haeckel in 1869. In the early days, ecology was largely descriptive, providing qualitative data based on observational studies. Over time, ecology has become a more exact science by utilising quantitative data measurements and through the development of models and theories that help us better understand relationships. Today, ecologists use both qualitative and quantitative data to classify ecosystems and environments based on their abiotic and biotic components.

Classifying environments

Environments can be classified based on their biotic and/or abiotic factors. Abiotic factors are physical and chemical factors such as temperature, light intensity, texture and pH of the soil, concentration of significant gases in water or air, and the availability of water. Every organism is restricted to a particular area due to **limiting factors**. A limiting factor is an element of the environment that restricts the survival of an organism to a region. The tropical carnivorous pitcher plant *Nepenthes rajah* is native to Malaysia. Specifically it occurs on Mt Kinabalu and the adjacent mountain Mt Tambuyukon in Sabah on Borneo Island.

N. rajah only grows at certain altitudes with a **tolerance range** of 1500–2600 m above sea level. These plants need humid, well-drained, grassy areas that have high levels of magnesium and iron, and low levels of silica in the soil. They are renowned for their remarkable ability to hold around 1 litre of fluid to capture and digest lizards, frogs and invertebrates.

On the edge of these parameters, at altitudes lower than 1500 m, *N. rajah* is limited in its distribution. These areas of the habitat are known as **zones of physiological stress**. The plant can grow but the conditions are not ideal for survival. Outside of the zone of physiological stress is the **zone of intolerance** where the plant cannot survive.

Biotic factors include the presence or absence of other living organisms that affect an organism, such as other members of their own species, competitors, collaborators, **predators**, disease-causing organisms, **parasites** and the availability of mates.

▲ **Figure 3.4**
Nepenthes rajah can tolerate altitudes up to 2600 m.

Unit 4 Biology discusses tolerance range, and the zones of physiological stress and intolerance.

Terrestrial environments

The distribution of **terrestrial environments** such as tundras, deserts, open forests and temperate grasslands is based mainly on climatic variation. Temperature, water, light and wind are the four main elements of climate. Both water and temperature significantly impact on the geographic range of organisms that can live in an environment. For example, the climate of the desert differs considerably to that of a tropical rainforest. Deserts are generally found 30° north or south of the equator where the climatic conditions are drier. Temperatures range widely from below 0°C overnight to above 40°C during the peak of the day. Rain is generally unpredictable and is less than 250 mm annually. Substrate concentration also aids the classification of the environment. Substrate concentration, such as phosphorous and nitrogen, are limiting factors in arid environments. They are considerably lower than the substrate concentrations found in other environments.

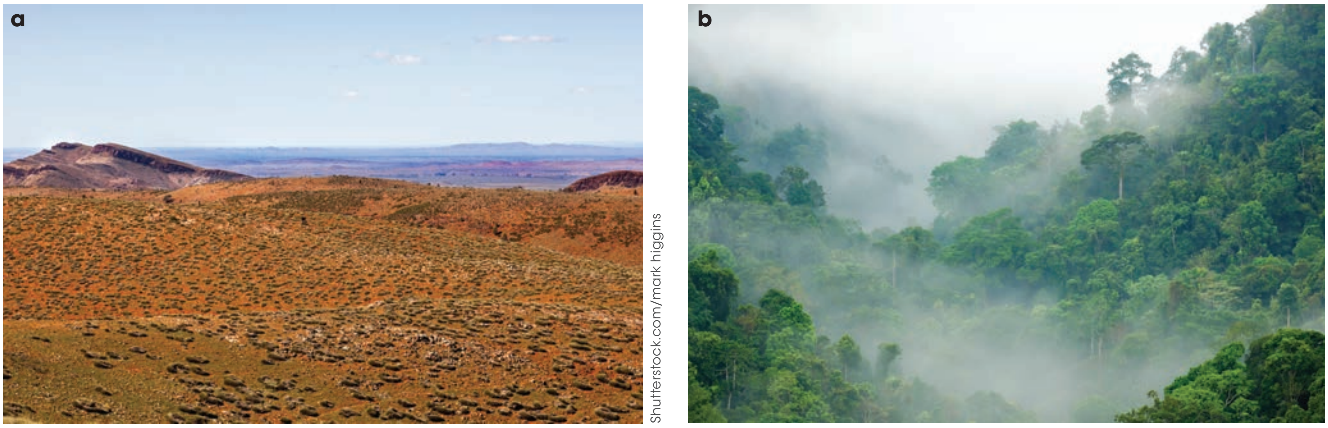
Limited numbers of species are found in an Australian desert. These include small mammals such as the spinifex hopping mouse (*Notomys alexis*) and the numbat (*Myrmecobius fasciatus*), invertebrate herbivores such as grasshoppers and crickets, and mulga trees (*Acacia aneura*). The biodiversity of the desert is low due to the abiotic conditions acting on the region.

In contrast to the arid desert, tropical rainforests are generally found in between the Tropic of Cancer (23.5°N) and the Tropic of Capricorn (23.5°S), but can extend slightly outside these boundaries. They are extremely dense and home to around 50% of all animal and plant life. They also accommodate numerous species of fungi and bacteria.

Temperatures range between 20°C at night to 35°C during the day all year round. Rainfall and humidity are high. Commonly tropical rainforests have between 1500 and 2500 mm of precipitation annually. However, they are also characterised by poor soil due to high levels of nutrient leaching caused by the increased rainfall. Rainforest organisms are supplied with nutrients from the continual decomposition of plant and animal debris, known as **humus**. The rate of this decomposition is a limiting factor to forest growth: the slower the humus is formed, the slower the nutrients are made available to the rainforest organisms, thus reducing the rate at which the organisms can grow. Many gardening enthusiasts will create humus by decomposing food scraps in a compost bin. This additional nutrient-rich material promotes their garden plants to grow and thrive.

When classifying environments it is important to identify the physical and chemical features of the soil. Understanding the features of the soil helps determine which plants will grow best in a particular region. Soil type is determined based on a number of different properties. These include location, depth, texture, colour, porosity, pH, water-carrying capacity and nutrient status.

Figure 3.5 ▼ a) Low rainfall in deserts limits biodiversity; b) High rainfall in tropical forests promotes greater biodiversity.



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EXPERIMENT 3.1

SOIL ANALYSIS

Aim

To classify the soil from a local area by identifying its physical and chemical features

Materials

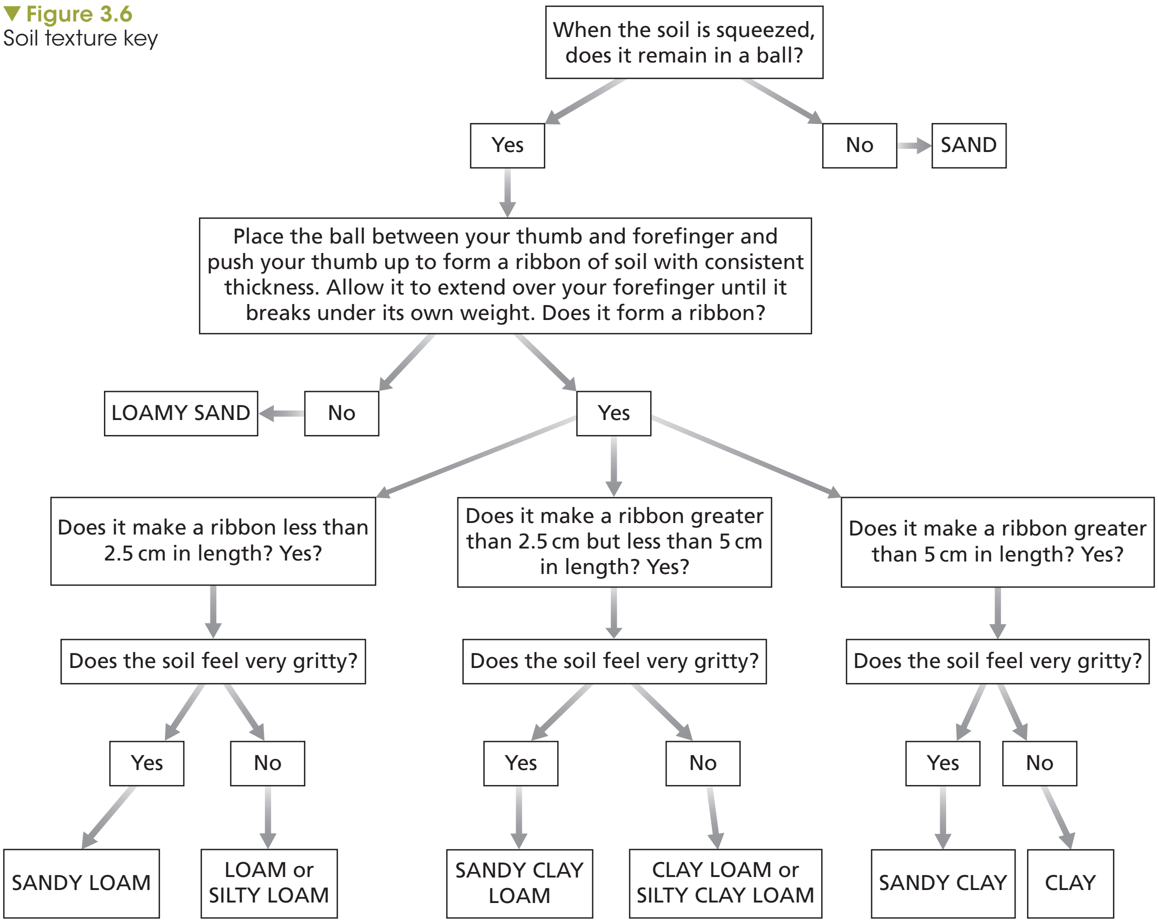
- ruler
- soil texture key (Figure 3.6)
- gloves
- label
- funnel
- filter paper
- 100 mL measuring cylinder
- stopwatch
- 80 mL distilled water
- two 10 mL measuring cylinders
- a tablespoon measure
- 40 g topsoil sample
- 40 g subsoil sample
- 100 mL beaker
- pipette
- balance
- universal indicator and chart

What are the risks in doing this experiment?	How can you manage these risks to stay safe?
Soil sample may have biting or stinging invertebrates, or disease-causing microbes present.	Gloves to be worn throughout the experiment and hands washed thoroughly after the experiment has concluded. A simple face mask is recommended.
Universal indicator causes irritation to eyes including stinging, redness, tearing and blurred vision.	Wear safety goggles throughout he experiment and wash eyes immediately if contact has been made.

Procedure

Part A: Soil texture and colour

1 Your teacher will provide you with topsoil and subsoil samples.
2 Use the soil texture key in Figure 3.6 to determine the texture of the two soil samples and their classification.
3 Collect 1 tablespoon of soil. Add a few drops of water at a time until it forms a moist putty.



▼ Figure 3.6
Soil texture key

Part B: Determining the soil pH

1 Using the balance, measure 20 g of topsoil and place it in the beaker.
2 Add 40 mL of distilled water. Stir and allow the soil to settle on the bottom.
3 Once settled, add a few drops of universal indicator.

4 Determine the pH by correlating the colour of the water in the beaker to the corresponding colour in the universal indicator chart.
5 Repeat steps 1–4 for the subsoil.

Part C: Determining the soil porosity

1 Using the balance, measure 20 g of topsoil.
2 Place a piece of folded filter paper into the top of the funnel.
3 Add the soil on top of the filter paper. Place the funnel in a 10 mL measuring cylinder.
4 Measure 20 mL of distilled water in a 100 mL measuring cylinder and pour it on top of the soil.
5 Allow the water to drain for 10 minutes.
6 Record how many millilitres passed through after 10 minutes.
7 Repeat steps 1–6 with the subsoil sample.

Results

1 Create a table to summarise your findings.
2 Describe the features of the topsoil and subsoil. What is their texture classification?
3 Did the pH of the topsoil differ to that of the subsoil? Draw a pH scale, including the usual range for soil (pH 6 to pH 7.5) and the danger zone (below pH 5.5 and above pH 8). Indicate where each sample sits on the pH scale.
4 Define 'porosity' and summarise how porous the soil samples are.

Discussion

1 Did the physical and chemical features differ between the topsoil and subsoil? Account for any differences recorded.
2 Explain how the type of vegetation and its density can affect the composition of the topsoil.
3 Waterlogged soils are generally associated with low levels of oxygen. Justify why this is the case.
4 Using the soil texture key, explain why clay soils are more easily waterlogged than other types of soils.
5 Relate the soil type to the vegetation types found in the same location. Predict whether each soil characteristic (soil texture, colour, pH, porosity) could have an effect on the type of vegetation that can grow there.
6 Suggest how the decomposition rate of plant debris may differ between a rainforest and a desert.

WOW

Arid Australia

The arid areas of Australia have ancient soils that are very infertile. Their phosphorous and nitrogen levels are on average less than 50% lower than other arid areas of the world! Antarctica is the only place drier than Australia. Furthermore, out of all the mammals that have become extinct in the last 200 years, 50% of them are Australian such as the desert rat-kangaroo and the desert bandicoot.

Aquatic environments

Aquatic environments include both marine (saltwater) and freshwater environments. They make up the largest part of the biosphere. The oceans alone cover 71% of Earth's surface. Examples of aquatic environments include moving waters of oceans, bays, **estuaries**, creeks, streams and rivers, and still waters of lakes, ponds and swamps.

The major substrate that defines whether a body of water is marine or fresh is the concentration of sodium chloride (salt). Marine environments are characterised by having a salt concentration of approximately 3%. On the other hand, freshwater environments have a salt concentration of less than 1%. Estuaries have fluctuating salt concentrations. During a high tide, the salt concentration increases to almost equal to that of the ocean and decreases as the point of low tide approaches. As you move up the estuary, the salt concentration almost equals that of fresh water.

Ocean environments are classified according to depth, distance from the shoreline and the way they are formed. The first 200 m of ocean depth is known as the **photic zone**. This is the only part of the water that light can penetrate and accommodate photosynthesising organisms. Approximately 90% of marine life lives in the photic zone. The temperature ranges from approximately 34°C to 10°C. As the depth increases, water temperature decreases. Water between the depths of 200 and 1000 m is known as the mesopelagic zone. Some light penetrates this region, although it is not sufficient for the survival of photosynthetic organisms. Temperatures range between 20°C in warmer areas and 4°C closer to 1000 m. Figure 3.7 shows a summary of the other oceanic zones and the temperature ranges.

As ocean depth increases, organisms also feel the effects of increased pressure. This is another limiting factor of the distribution of marine organisms.

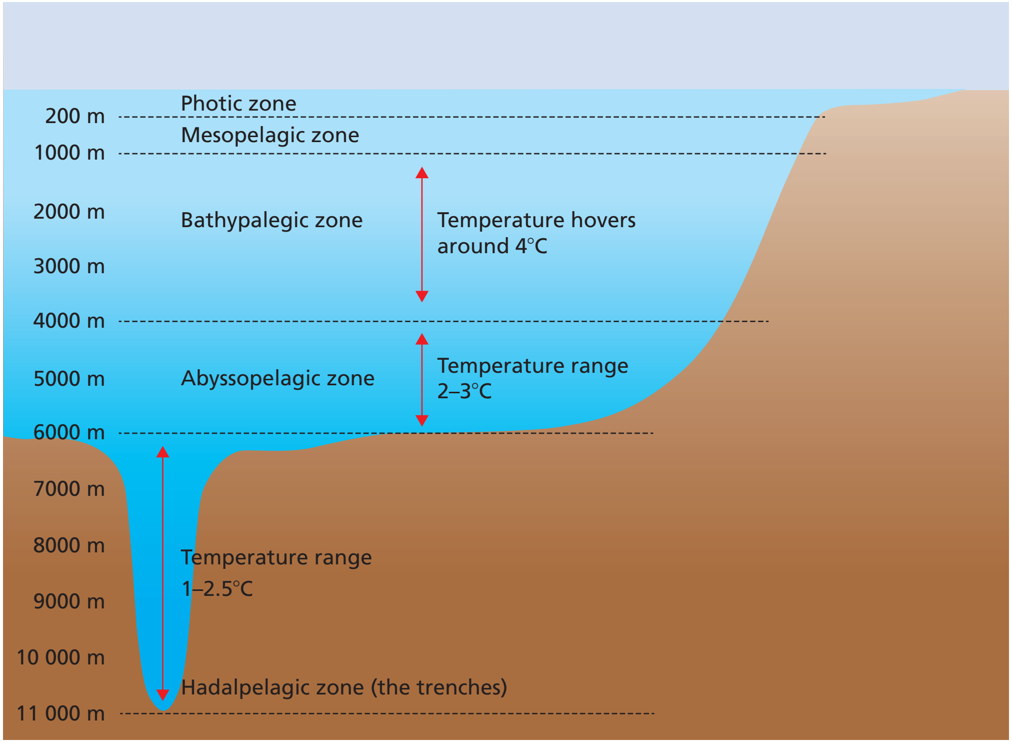


Figure 3.7 As ocean depth increases, water temperature and available light decrease. These factors limit the distribution of organisms. Barely 10% of marine organisms can survive below the photic zone.

Freshwater environments have two subgroups: standing (still) bodies of water and moving bodies of water. Deep lakes are also characterised by depth and can be broken down into photic and aphotic zones. Freshwater environments are also classified according to the production of organic matter. For example, large, deep rivers tend to be nutrient-poor whereas shallow lakes have a tendency to be nutrient-rich but lend themselves to **eutrophication**. Eutrophication is the increased concentration of nutrients, phosphates and nitrates in a waterway that promotes algal bloom. The resulting algal bloom can lead to reduced light penetration and oxygen concentration, causing negative effects on local species living in shallow lakes.

The nutrient composition of rivers, creeks and streams are dependent on the terrain through which they flow. Fallen leaves and the weathering of rocks through fast-moving water substantially increase the concentration of organic and inorganic nutrients.

The distribution of all organisms is restricted by the limiting factors in their environments.

Case study

Marine reserves: detecting the effects of fishing using the Namena Reserve, Fiji

Jordan Goetze, a PhD student at the University of Western Australia, is researching the benefits of Namena Marine Reserve in Fiji.

Goetze said that the Namena Reserve was classified as a 'no-take' marine reserve due to the 'reef's position in relation to currents that promote its biodiversity'. The decision was aided by the 'overwhelming wealth of evidence that Marine Reserves can benefit marine biodiversity throughout the world'. Goetze explained that tourism is one of the main reasons Namena Reserve has good compliance to protect its fish stocks. Allowing destructive activities, such as dynamite fishing, cyanide fishing and careless anchoring, limits local biodiversity and makes the area less attractive.

The Namena Reserve is part of a Locally Managed Marine Area Initiative, whereby the local people are responsible for the management of the reserve. This area is a no-take region, which means no fishing or disturbance is allowed but people are encouraged to visit. As Goetze explained, 'the adjacent Namena resort and local communities are vigilant in enforcing the protection [of the reserve] and chasing off poachers'.

Goetze's studies show that the size of reef sharks within the Namena Reserve is larger than those found outside the reserve. They used a non-invasive sampling technique, baited remote underwater video sampling, over a period of three weeks. They noted that the abundance of reef sharks was also higher in the marine reserve compared to adjacent areas, likely due to fishing reducing shark numbers outside the reserve.

As part of Goetze's PhD studies he will also research the effects of artisanal fishing on Fijian Tabu areas. A Tabu area refers to a temporary closure of fishing grounds. Traditionally these areas were closed after the death of a prominent community member, however, conservation and management organisations are looking at expanding this idea. Goetze and his team will collect quantitative field data through baited remote underwater video stations. They will gather data while the Tabu area is closed and again once it re-opens and is fished. This process will be repeated a year later. The information collected will aid the development of a computer model that will help to answer questions regarding the effects of occasional fishing periods. The simulation aims to predict the prolonged effects of intense fishing on the biodiversity and fish stock levels after reopening the Tabu areas.

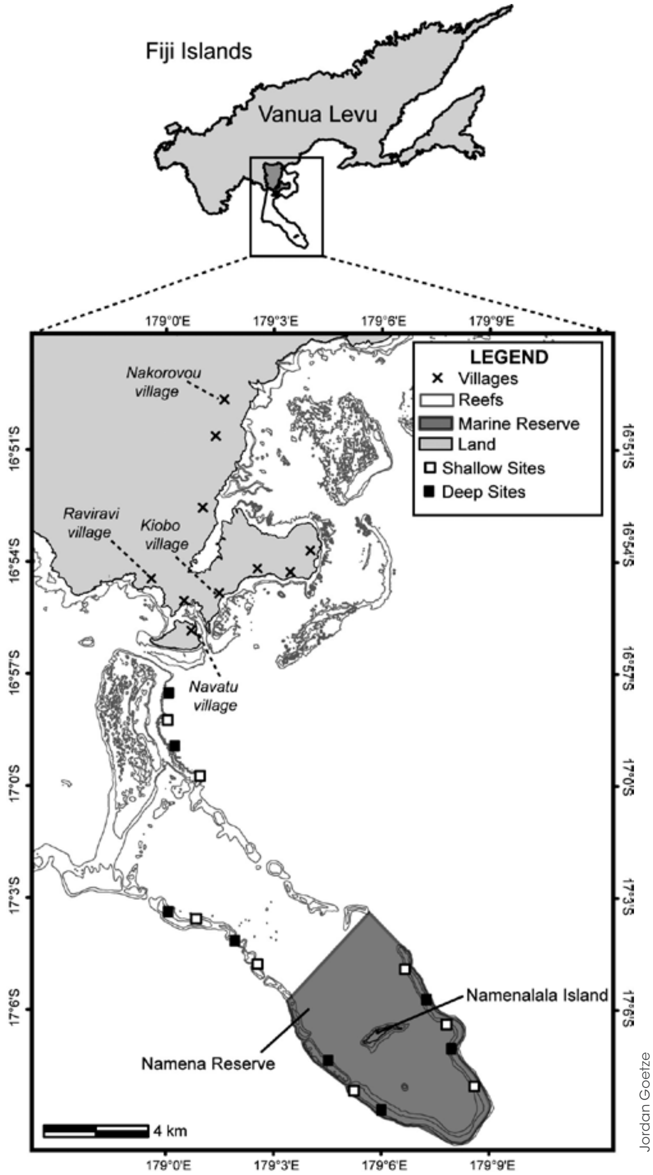


Figure 3.8 ▲
Jordan Goetze's map showing the location of the Namena Marine Reserve, Fiji

Questions

1 Many marine reserves are established with no baseline data on fish stocks. Suggest the implications of this on determining whether a marine reserve is successful.

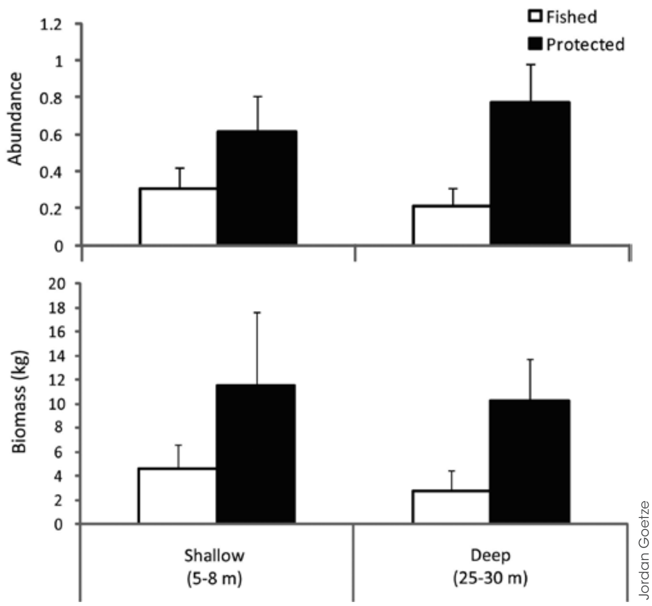
2 a Explain what a Tabu area is.

  b Justify whether you believe these areas should be converted into marine reserves.

3 Suggest some concerns surrounding artisanal fishing for the people and the fish species.

4 Suggest the benefits of using baited remote video stations to collect data.

5 The graph in Figure 3.9 represents Goetze's findings. Use this information and your own research to write a persuasive argument to the government supporting the introduction of more marine reserves to help conserve Australia's marine biodiversity.



▲ Figure 3.9
Jordan Goetze's graphs showing relative abundance and biomass within and outside the Namena Reserve

Classifying ecosystems

Environments and ecosystems are not only classified by their abiotic features as discussed previously, they are also largely classified by their component species and species interactions. Ecosystems are usually named after the most **dominant species** in the community along with its overall distribution. For example, an aquatic environment such as a swamp can also be classified by the dominant species being the mangrove, thus it is known as a mangrove swamp. Other examples of individual ecosystems include mountain ash forest, spinifex grassland and coral reefs.

The distribution of ecosystems depends on factors such as soil type and climate, remembering that the ecosystem is the interaction between the species and these factors. Figure 3.10(a) shows the key climatic groups, which can be compared to Figure 3.10(b) that shows how the major vegetation patterns correspond to differing climates.

Generally speaking, the component species of an ecosystem will be some variety of plant. Vegetation is classified according to:

- the percentage of ground shaded or covered by the tallest layer of vegetation
- the form (tree, shrub or grass) of the tallest layer.

For example, open forests have between 30 and 70% of the ground shaded by trees between 10 and 30 m tall. If the trees are taller, the forest is classified as a tall open forest. If the percentage cover is between 10 and 30%, it is classed as woodland. Table 3.1 shows the ground cover features of the major Australian ecosystems.

Environments can be classified based on their biotic and abiotic features. Ecosystems can also be classified by their biotic or abiotic components, but are often named after their dominant species.

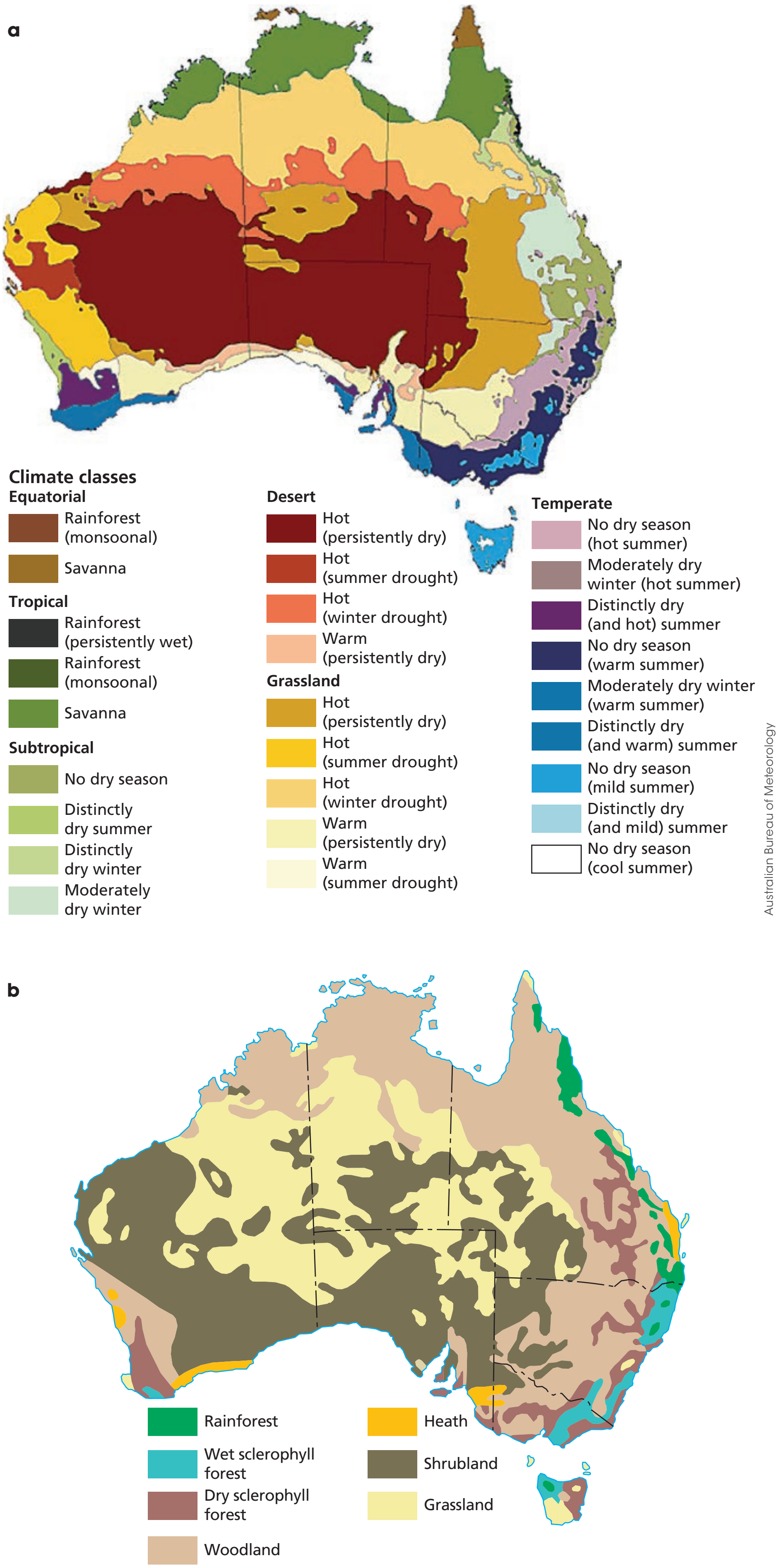


Figure 3.10 ▶ a) Key climate groups in Australia; b) Vegetation patterns in Australia, reflecting the climate groups

Table 3.1 The ground cover features of major Australian ecosystems

Ecosystem	Ground cover
Deserts 	In patches, widely spaced
Grasslands 	In arid regions; typically hummocks and tussocks with a very low cover of <30%
Scrublands 	Foliage cover of 30–70%
Woodlands 	Widely spaced canopy cover of 10–30%; well-developed shrubs and grasses
Alpine 	Low, fairly continuous cover
Open (sclerophyll) forests 	Fairly open canopy cover of 30–70%; good understorey and ground cover
Closed (rainforest) forests 	Dense canopy cover of 70–100%; distinct layers or storeys within forest
Reefs and marshes 	Dense growth

If you travel from one ecosystem to the next, it may be hard to notice where one ecosystem ends and another begins. In neighbouring ecosystems, physical conditions such as soil type and temperature gradually change or merge and the ecosystems overlap. Ecosystems are seldom *closed*. Some of the animals, such as birds, will be part of multiple communities as they move from one area to another. These ecosystems are *open*.

QUESTION SET 3.2

Remembering

1 Identify the different factors used to classify an ecosystem.
2 Define 'eutrophication'.

Understanding

3 Distinguish between an open and a closed ecosystem.
4 Using an example, explain the difference between qualitative and quantitative data.
5 Outline each limiting factor that inhibits the widespread growth of *Nepenthes rajah.*

Ecological niches

Ecosystems across the world are unique and diverse in their own ways. The organisms that inhabit a particular ecosystem are able to survive because of the particular set of biotic and abiotic factors present. The way in which species function within their environment, for example, the time they feed, what they feed on, where they live and when they reproduce, is known as an **ecological niche**. To place this concept into context, Eugene Odum (1913–2002) an American biologist at the University of Georgia, made the analogy that if the species habitat was its home address, then its ecological niche was its habitat along with its profession.

The way a species functions within its environment is known as its ecological niche.

To think of it in another way, the niche of an organism is how it 'fits into' the ecosystem. The niche of the saddle-back tamarin monkey of the Amazonian rainforest, *Saguinus fuscicollis*, includes being **diurnal**, **arboreal**, and feeding on a diet of fruits and insects from the trunks of trees up to a height of 10 m above ground level. They live in groups of two to twelve individuals, in which there is generally only one primary female who will copulate to produce offspring. After a gestation period of around 155 days she gives birth, usually to twins, when food resources are abundant. The emperor tamarin, *Saguinus imperator*, fills a niche whereby they are also diurnal and arboreal. However, they feed not only on fruits and insects, but also green leafy plants, eggs and tree sap between a tree height of 10 and 30 m above ground level. They live in a troop of around two to eight family members and breed between the months of April and July when the dominant female gives birth around 140 days later, generally to twins. It is seen that despite living in the same range, they exhibit a different way of life.

The fundamental versus the realised

An American zoologist, G. E. Hutchinson, distinguished between the **fundamental niche** and the **realised niche**. The fundamental niche (potential niche) is the ideal niche a species would occupy if there were no competitors, predators or parasites. The realised niche (actual niche) is narrower. It results from an organism's inability to exploit the resources of its habitat because of restrictions caused by other organisms. Therefore, a species may not be distributed evenly throughout its potential geographic range.

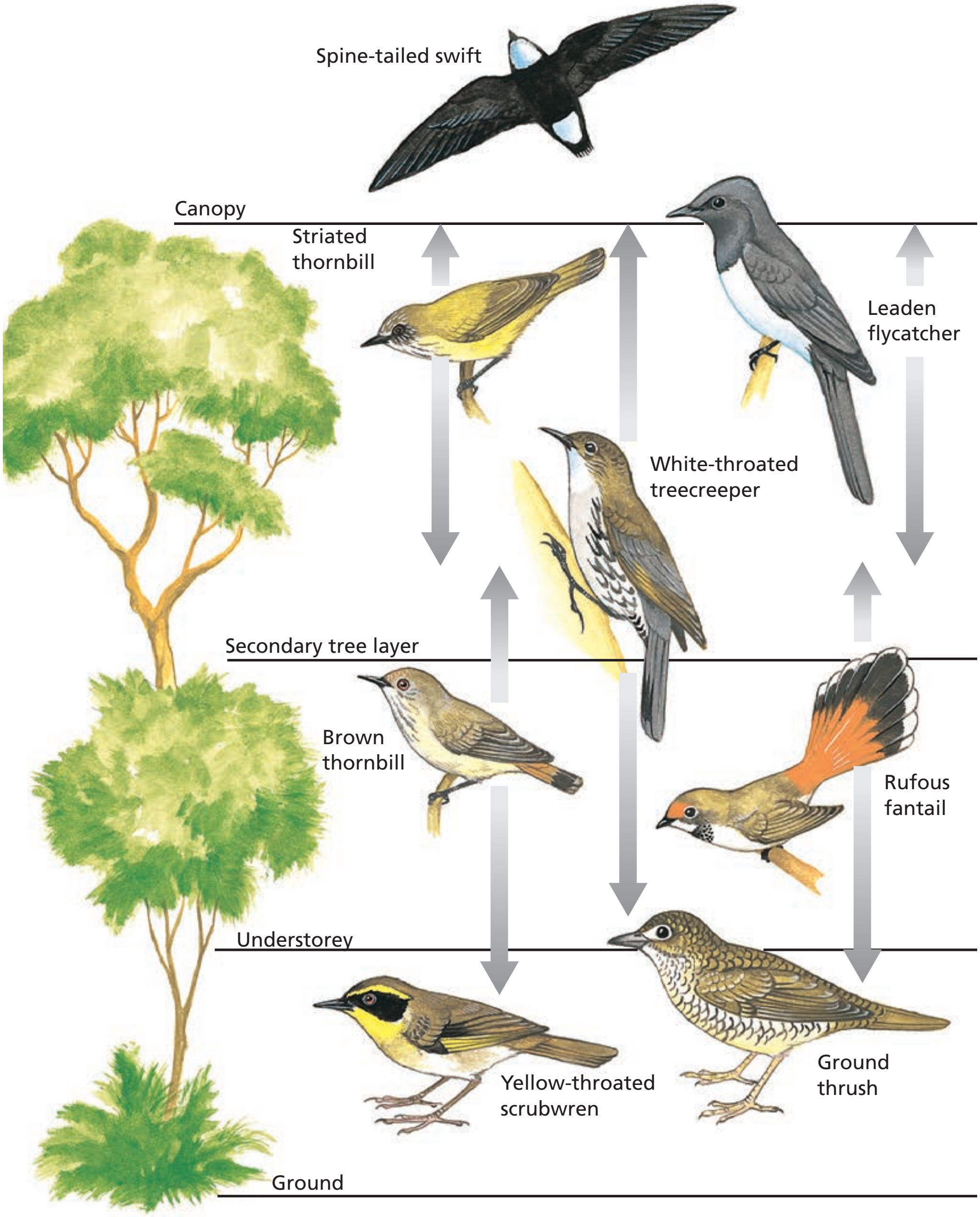
Abiotic factors suitable for the laughing kookaburra *Dacelo novaeguineae* extend virtually all the way down the eastern coast of Australia, from Cape York Peninsula in far north Queensland to the eastern Eyre Peninsula in South Australia, including Tasmania. However, the species is not distributed evenly throughout this geographical range because successful competitors occupy the kookaburra's niche in certain areas.

Resource partitioning

Organisms within an ecosystem cannot feed on the same food sources at the same time. Instead they generally differ in the food source they prefer, their use of space and even the timing of their activities. Different forest birds feed at varying heights above the ground, and some animals feed at night while others feed during the day. Species of shorebirds have different leg lengths and varying beak shapes. This allows them to exploit particular parts of the mud flats and reduce **competition**. This method of using resources is called **resource partitioning**.

NICHES

Watch a video illustrating the difference between an organism's fundamental niche versus their realised niche.

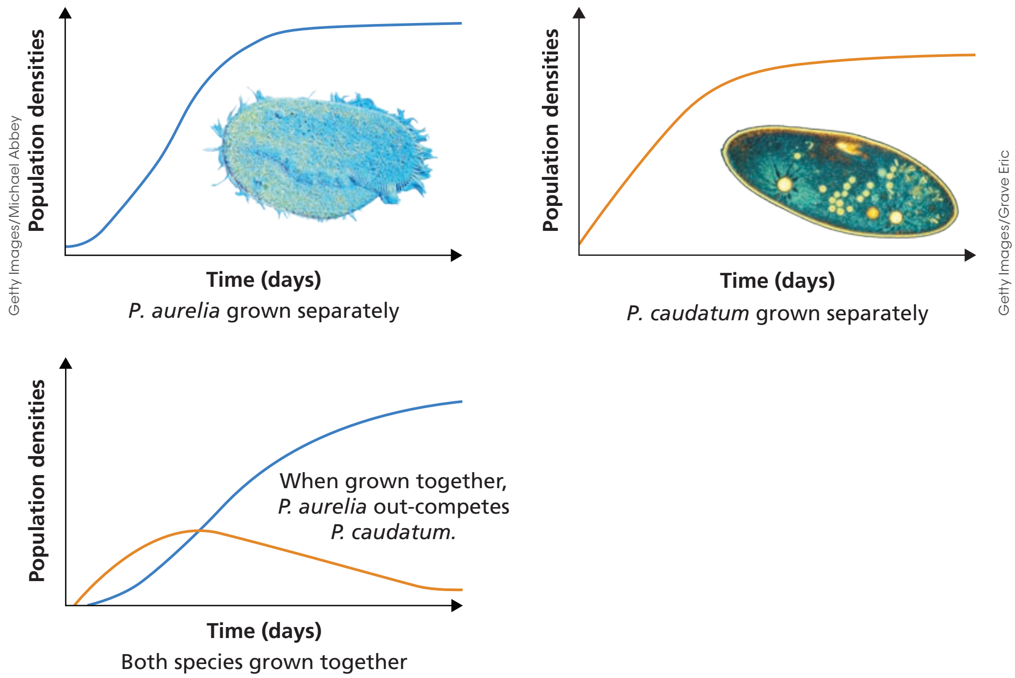


◀ Figure 3.11 Resource partitioning: feeding height diversity of birds in an eastern Australian eucalypt forest

Competitive exclusion principle

A Russian ecologist, G. F. Gause, completed an experiment in 1934 between *Paramecium aurelia* and *Paramecium caudatum*, two closely related species of protists. Gause found that when he grew each species as two separate cultures, with a constant source of food, the population numbers increased exponentially until they reached what is known as a carrying capacity of the culture. However, he found that when the two species were grown in the same culture, *P. aurelia* had a competitive advantage. *P. aurelia* was able to obtain the food more effectively than *P. caudatum* and drove it to extinction. Based on the interpretation of the data collected, Gause concluded that two species so similar, competing for the same resource, cannot coexist in the same community. One will be able to obtain and use the resource more effectively and in turn reproduce more quickly than the other. Further models and experimentation have supported Gause's idea, now known as the **competitive exclusion principle**. However, it is to be noted that two ecologically similar species are able to coexist in the same community if they have one or more considerable differences in their niche.

Figure 3.12 ▶ Data from Gause's experiment with *P. aurelia* and *P. caudatum*



The competitive exclusion principle states that two similar species that compete for a resource cannot coexist.

ACTIVITY 3.1

COMPETITIVE EXCLUSION PRINCIPLE EXPERIMENT: SECOND-HAND DATA ANALYSIS

The competitive exclusion principle postulates that no two species can occupy the same niche in the same environment for an extended period of time. Experiments can be used to test this principle and produce models of this interaction. Models can then be used to make predictions about biodiversity when changes occur within an ecosystem.

A team of scientists investigated Gause's competitive exclusion principle by conducting a field experiment. They studied two **sessile** (fixed or non-moving) species, A and B, introduced onto an intertidal rock face. Over a period of 18 months, population density data was collected within the test quadrats. Table 3.2 is a summary of the data.

▶

Table 3.2 Population density of two species

Time (months)	Population density of species A	Population density of species B
0	5	5
1	12	8
2	17	14
3	36	24
4	55	60
5	50	67
6	43	62
7	45	104
8	50	100
9	38	104
10	25	115
11	30	119
12	16	125
13	18	133
14	21	139
15	14	158
16	8	141
17	0	158
18	0	164

What did you discover?

1 Draw a graph of the tabled data.
2 Which species had the competitive advantage in the first three months?
3 For what period of time can the two species coexist in the same area?
4 Which species had the overall competitive advantage over the 18 months?
5 a Outline what has occurred to species A throughout the 18-month period.
  b Predict the consequences of this scenario on the biodiversity of an ecosystem.
6 If a disease were to affect the reproductive success of species B at 10 months, predict what would happen to the relative abundance of species A and B.
7 a An introduced species, species C, was introduced to the intertidal rock face. It competes for the same resources as species A and B, but has a shorter gestation period than both species. Predict the impact this would have on the relative abundance of all three species.
  b Discuss the impact this scenario would have on the diversity of the ecosystem.
8 Assess the validity of Gause's competitive exclusion principle when applied to this experiment.
9 Design an experiment to measure the impact of species C on the ecosystem.

QUESTION SET 3.3

Remembering

1 Define 'ecological niche' and provide an example.

2 Explain resource partitioning.

Understanding

3 Compare and contrast the fundamental and realised niches of an organism.

4 Summarise how Gause developed his idea of the competitive exclusion principle.

Applying

5 Five different types of warbler species live in a spruce tree: the Cape May warbler, Bay-breasted warbler, Myrtle warbler, Blackburnian warbler and Black-throated green warbler. Explain how the five species can inhabit the same spruce tree and coexist.

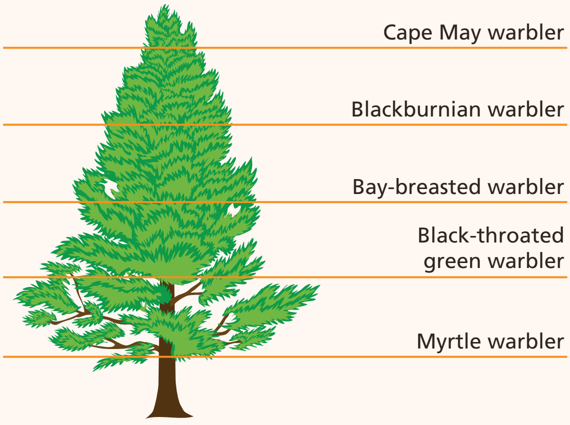


Figure 3.13 ▲
How can five different species of birds inhabit this spruce tree?

Relationships and interactions between living things

Ecosystems and habitats have many different relationships and interactions occurring within them. These relationships impact upon the biodiversity of a region. Some of these interactions can be harmful and others may be beneficial. For example, imagine what a necklace of parasites could do to a carpet python. Or what would happen to a karri forest if the fungus it depends on for survival died? The living world is full of interesting and bizarre examples of relationships between different species.

Every living thing, as well as their environment, is profoundly affected by the presence or absence of other living or non-living things. Organisms of a soil community, for example, are affected by the texture, mineral content and water content of the medium in which they live. However, the properties of the soil itself are affected by the activities of burrowing worms and decomposers. The burrows of the worms allow air and water to reach into the soil and the decomposers increase the fertility of the soils by recycling organic material. A wallaby does not exist on its own. It not only interacts with other wallabies but also with the vegetation it eats, the ticks, mites, flies and other parasites that pester it, and the wedge-tailed eagle or dingo that may attack its young.

Understanding the relationships between organisms and their interactions with each other can help us understand how an ecosystem works. Some interactions can be straightforward but others are extremely complex. It is only by experimentation and painstaking studies of behaviour that scientists can come close to unravelling these relationships.

Competitor or collaborator?

Communities consist of the complex interactions of different populations and the individuals within them. Many are in competition with each other because they require the same resources to fulfil their needs for survival. Competition within and between species is a common feature of all communities. For example, seemingly harmless sea anemones compete for the same food source with others of their species. They can detect slight genetic variations in intruders of the same species. Both rivals discharge a battery of stinging cells, normally used to paralyse and catch **prey**. In the end, one will admit defeat, close up and creep away.

▲ **Figure 3.14**
Different sea anemone species compete for food sources. This is an example of an interspecific relationship.

Getty Images/OSF/Rodger Jackman

Members of some species solve the problem of catching their prey by collaborating with each other as wolves do in hunting for their prey or dolphins when herding schools of fish. These are examples of **intraspecific** interactions: relationships between members of the same species. On the other hand, the **association** that wolves or dolphins have with their respective prey is **interspecific**: a relationship between members of different species.

The way in which one organism competes against or works with another organism to obtain their food helps shape the biodiversity of an ecosystem.

Chapter 4 explains food chains and food webs, and the movement of energy through an ecosystem.

Predator and prey

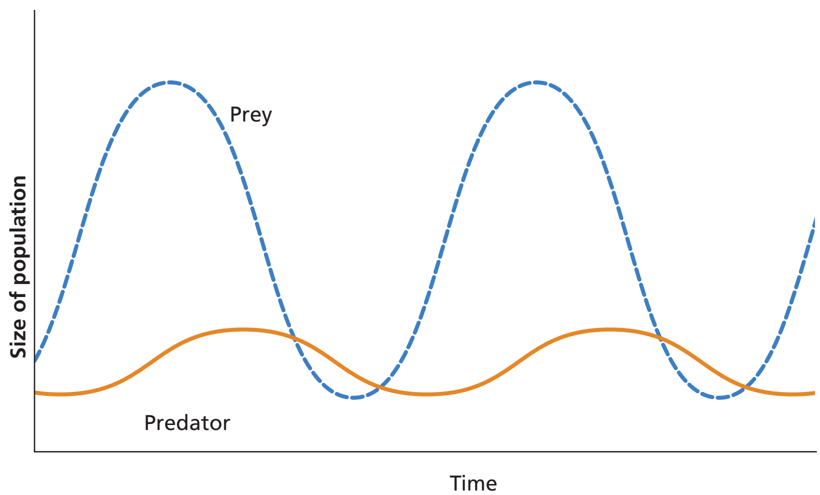
An obvious interaction within every ecosystem is a predator–prey relationship (Figure 3.15). In this relationship one organism, the predator, kills another organism, the prey, or consumes part of it for its food. Although there is usually a preferred prey species, it is unusual for a predator to depend on only one species. It is an advantage for a predator to be a member of a network of food chains. If one prey species becomes in short supply, the predator can turn to others.

Chapter 5 discusses more about predator–prey population cycles.

The dynamic relationship that exists between predator and prey is usually balanced, but sometimes conditions can change and upset this balance. Under favourable conditions, with increasing availability of prey, the number of predators can increase, although it usually still remains less than that of the prey. During a period of adverse conditions, the prey population can decrease. When this occurs, there is increased intraspecific competition in the predator population. Predators turn to alternative prey species and the effect on them can be severe, though it does allow the original prey population to grow again.

Predation of any sort affects the prey population in an ecosystem. Predation includes animals preying on plants, plants preying on animals, such as the Venus flytrap or pitcher plants, or simply animals preying on other animals. For example, **seed predators** have a large effect on the plant population and their distribution throughout an ecosystem. These animals only feed on the seeds of plants, causing the seeds to become unviable or damaged as they pass through the digestive system of the predator. Another example of the effect of predation on the biodiversity of an ecosystem is the release of nutrients into the soil caused by decomposing animal carcasses left behind by predators, which allows for micro-organisms to survive in the ecosystem.

▼ **Figure 3.15**
The predator–prey relationship



ABALONE UNDER THREAT

Watch how the Victorian Department of Environment and Primary Industries is using biosecurity measures to control the herpes-like viral infection of abalone.

The issue with disease

The interaction between a disease-causing organism and the **host** is another interaction that can affect the biodiversity of an ecosystem. For example, the myxomatosis virus causes a disease that affects rabbits. In Australia, this virus is deliberately used to reduce the rabbit population to allow for native animal populations to increase. In this case, the disease allows the biodiversity of the Australian ecosystem to be higher because without the virus the rabbits become overpopulated and outcompete the native animals for resources. On the other hand, disease can also decrease the biodiversity of an ecosystem. Chlamydia is a disease impacting upon the populations of koalas across Australia. It affects the reproductive tract of the koala resulting in the failure to produce offspring. This in turn leads to the loss of koala numbers and genetic diversity from particular ecosystems.

QUESTION SET 3.4

Remembering

1 Using an example, explain 'collaboration'.

2 Explain how disease affects the biodiversity of a region.

Understanding

3 Using examples, compare interspecific and intraspecific relationships.

4 Identify and explain the distinctive feature of a predator–prey relationship.

Applying

5 Using an example, explain how the predator–prey relationship shapes the biodiversity of an ecosystem.

SYMBIOSIS

Refresh your understanding of symbiosis by watching the video.

Symbiotic relationships

Symbiosis is the general term used to describe the relationship in which individuals of two or more different species live together and in which at least one of the species benefits. There are three main types:

1 **parasitism**: one species benefits at the expense of the other

2 **mutualism**: both species in the relationship benefit and neither is harmed

3 **commensalism**: one species benefits and the other neither benefits nor is harmed.

These relationships help shape the biodiversity of a region.

Parasitism

Most species, including humans, harbour parasites in every conceivable part of their body. A parasite is an organism (such as a bacterium, virus, fungi, worm or arthropod) that lives on or in another organism, known as the host. The parasites are extraordinarily well-adapted, with regards to their life cycle, structure and physiology, to find their host and survive the hazards of being dependent on them. The hosts themselves have **coevolved** strategies for surviving the effects of their unwelcome invaders.

Their presence or absence in an ecosystem is yet another factor that shapes the unique diversity of the region. The way in which the parasite interacts with the host organism determines whether either one survives. For example, native mistletoe is a parasitic plant that uses eucalypt trees as hosts. The mistletoe plant is transferred from one tree to another by the mistletoe bird, spreading it throughout the eucalypt ecosystem. The presence of this parasitic plant in turn can reduce the diversity of the ecosystem by killing numerous varieties of eucalypts.

David M. Watson

© NHPA/Photoshot

Alamy/BotanyFocus

▲ Figure 3.16
The mistletoe plant is spread by mistletoe birds that eat the berries and defecate the sticky seeds onto branches.

Mutualism

Not all relationships cause harm to a species. There are differing levels of mutualism, from a rather loose association in which the partners seem to gain little from each other, to associations that are so intimate that the two partners can be regarded as a single organism. These organisms work together and share the same ecosystem and even the same habitat. The relationship between the pistol shrimp and the goby fish is an example of a mutualistic relationship. The shrimp is able to dig a burrow to live in but it is relatively blind and cannot detect approaching predators. The goby fish uses the burrow for protection from predators and, in return, it acts as the 'eyes' for the shrimp. During the day the shrimp maintains continual contact with the goby's tail, which the goby will flick several times if a predator approaches and the two must retreat into the burrow. During the night they rest and share the burrow as partners.

Pollinators are essential for many flowering plants to reproduce. Like grasses, some plants can be pollinated by wind. Flowering plants, however, generally rely on insects, birds, small mammals and even reptiles to transfer pollen from one plant to another. This is another example of mutualism; the pollinator benefits from feeding on the nectar while the plant benefits by being pollinated.

Generalist pollinators pollinate a range of different plant species, whereas specialists will only pollinate the kind of plant with which they have coevolved. In these partnerships, both members depend on each other so much that if one disappears, the other would not survive. The plants would be sterile without a pollinator and the pollinator would starve without the plant as its food source.

PISTOL SHRIMP AND GOBY FISH

Visit the weblink to see how the pistol shrimp and goby fish work together.

Alamy/Dave Watts

▲ Figure 3.17
These pygmy possums, while collecting nectar from eucalypt blossom, are also acting as pollinators.

WOW

The Canberra spider orchid

The critically endangered Canberra spider orchid, *Caladenia actensis*, is on the brink of extinction. Population numbers are extremely low and the plant only exists in two locations, Mount Ainslie (30 plants) and Mount Majura (220 plants) in the Australian Capital Territory. The orchid relies on the thynnid wasp species to pollinate it. The orchid has coevolved to resemble the wasp, fooling it into attempting to mate with it and pollinating the orchid in the process of doing so.

Friends of Mt Majura, Waltraud Pix

▶ Figure 3.18
The rare spider orchid, *Caladenia actensis*

Seed dispersers are also intrinsic to ecosystem biodiversity. These organisms include mammals and birds that eat fruits and seeds for nutrition. When the animal defecates, it deposits the seeds in a new location where it can germinate and grow. Seed dispersers are distinct from seed predators in that the seeds do not get damaged in the animal's digestive system and therefore remain viable for germination. The symbiotic relationship between the seed disperser and the plant is another example of mutualism because both organisms benefit from the interaction. The cassowary, *Casuarius unappendiculatus,* is a seed disperser who plays a critical role in the Queensland rainforest ecosystem. They feed on fruits and berries, and can disperse seeds up to a kilometre away from where they were consumed. Studies have shown that the rare rainforest tree, *Ryparosa kurrangii*, found in the Daintree forest, had a better germination rate after it had been passed through the gut of the cassowary. The cassowary is one of the only **frugivores** (fruit-eating animal) that can consume the *R. kurrangii*'s large fruit and seed. Without this intrinsic relationship, the *R. kurrangii* may struggle to germinate and become even rarer.

In the absence of these pivotal relationships, many species would become threatened or extinct because they cannot survive by themselves. Plants would not reproduce without the pollinators and in turn the pollinators would not have a food source. Without seed dispersers, some plants would not germinate and could become extinct. Diverse ecosystems would not be built.

Intimate relationships

The utmost intimate association is achieved when one of the organisms lives inside the cells of the other. Many coral polyps, jellyfish, clams and sea slugs have algae living in their tissues. The algae need nitrates and phosphates for their metabolism. These are made available in the waste material of their animal partner. The animal partner is careful to ensure that its algae are always adequately exposed to light, because they benefit from the organic compounds produced by algal photosynthesis.

Some sea slugs from the Great Barrier Reef actually stimulate the colonies of algae to reproduce. The sea slugs grow out tentacles along their sides and the algae become squatters. The sea slugs come to rely entirely on the food produced by the algal colonies. However, this does not explain how the algae entered the sea slugs in the first place. The algae were present in the coral the slugs fed on, and they passed from the slug's gut into their tentacles.

Commensalism

Commensalism is a one-sided interaction between species. Only one of the two organisms involved, the commensal, benefits from the interaction. The other organism in this case does not benefit, but it is not harmed. Some relationships are easy to identify as commensal, such as the relationship between the remora fish and the shark. The remora gets a free ride, and possibly free leftovers, by attaching the suction pad it has on the back of its head to the shark. The shark is otherwise unaffected.

Figure 3.19 ▼ The commensal relationship between the cattle egret and a zebra

Alamy/Gallo Images

Another example of a commensal relationship occurs between the cattle egret and livestock. This migratory bird is particularly widespread across the world, originating from Africa, Europe and Asia. The cattle egret is generally found foraging for food next to large livestock. The livestock disturb insects in the grass that the egret then feeds upon. It has been known that the egret will sit on the back of the beast to have a better vantage point to spot insects. Also noted is that the egret has a much higher foraging success rate when feeding near livestock. In this relationship, the bird is the commensal and the livestock are undisturbed and unharmed by the bird feeding near it.

Epiphytes are climbing plants, such as lianas, which use trees to support them as they reach for light. Their seeds germinate on the forest floor and the rapidly growing shoots spread out. If they reach a vertical surface, they take hold of it. Other seeds, such as those of orchids, are wafted high up to the branches and take hold there. In both of these instances, the tree offers support without apparently gaining anything in return and without being harmed in any way.

WOW

Life support

Some of the most common epiphytes in forests are the bromeliads. They germinate high up in the tree canopy and anchor themselves tightly by wrapping their roots around a branch. The leaves grow in such a way that they channel rain water and form a miniature pond, which becomes a habitat to an assortment of small animals. Dragonflies and mosquitoes lay their eggs here, tiny frogs pass through their life cycles here, and slugs, worms, beetles and small reptiles also form part of the community. Even birds come to visit and drink from the 'pond', leaving their droppings for the insect larvae to feed upon and grow.

The bromeliad benefits from this arrangement by being able to extract nutrients from the decaying organic matter in the 'pond', which would otherwise not be available. This relationship between the bromeliad and the organisms in the pond is therefore mutualistic, but what of the relationship between the bromeliad and the tree?

Auscape/Rob Williams

▲ **Figure 3.20**
A frog in a bromeliad pond

QUESTION SET 3.5

Remembering

1 Define the following terms.
- a Symbiosis
- b Predation
- c Parasitism
- d Mutualism
- e Commensalism

Understanding

2 Using an example, outline why it is essential to have pollinators and seed dispersers in an ecosystem.

3 Using the symbols + (beneficial), − (harmful) and 0 (unaffected), create a table that summarises the three symbiotic interactions.

4 Using an example for each symbiotic relationship, explain how each one shapes biodiversity.

Applying

5 Compare the interaction between seed predators and plants with the interaction between seed dispersers and plants.

Coexistence: the power of a keystone species

An interesting aspect of predation is that in some cases it can affect the **coexistence** of a number of other species. The purple sea star, *Pisaster ochraceus*, is a natural predator of mussels in the intertidal zones of Pacific Ocean seashores. When researcher Robert Paine removed purple sea stars from this environment, it resulted in the expansion of the population of resident mussels. The mussels displaced the other sessile organisms, such as barnacles and limpets, as they spread. The diversity of species in the area decreased from 15–20 invertebrates and algae to below 5 over the period of 3 years. When the sea stars were returned, the mussels were again preyed upon and the barnacles, limpets and other species were able to re-occupy the space. The predator, *P. ochraceus*, allowed the coexistence of other species with the same requirements for food and space.

The purple sea star species is known as a **keystone species**. These species are seen to have a large influence over lower trophic levels. A keystone species prevents any one of the organisms in the lower trophic levels from monopolising food resources and space. Instead, they allow for richer biodiversity within a restricted area.

The idea of a keystone species was developed by Robert Paine based on his removal experiments in the intertidal areas of western North America. Since this initial study, many scientist have collected data to help support Paine's theory. Many ecologists believe that keystone species should be specific recipients of the efforts to amplify biodiversity. Over time, policy recommendations have been made in the bid for biodiversity conservation. Conservation of a single keystone species should be the central point for the management strategies of an entire community. Scientists have also put forward arguments that keystone species are essential in the re-establishment of ecological structure and sustainability. However, it is the opinion of some that the definition of a keystone species is not yet refined enough to form the basis of conservation efforts. They also speculate that this process could be detrimental to species that are not considered key to species richness, yet are indicators of habitat health.

A keystone species prevents organisms from lower trophic levels from monopolising food resources and space.

Alamy/William Ragosta

Figure 3.21 ▶ *Pisaster ochraceus*, the purple sea star

Scientific literacy: Rainforest Rescue campaign

Following is a text extract from the Rainforest Rescue 'Save the Cassowary' campaign.

Rainforest Rescue Save the Cassowary campaign

We need your help NOW to save the Endangered Southern Cassowary

One of the most ancient of all creatures to inhabit the Wet Tropics of Queensland is the Endangered Southern Cassowary. As a 'keystone species' the Cassowary's role is pivotal in preserving the rainforest and its unique plants and animals. Yet it's estimated that fewer than 1000 birds remain.

The Southern Cassowary has been the Wet Tropics' 'rainforest gardener' for virtually its entire existence, and is the major seed disperser of around 150 plant species. Around 70 to 100 of these plants depend entirely on the Cassowary to disperse their seeds, maintaining the rainforest's rich biodiversity.

With so few birds left in the wild, we must act now to help save the Endangered Southern Cassowary. If it becomes extinct, we stand to lose not just one of Australia's most iconic animal species, but also the Wet Tropics – including the magnificient Daintree Rainforest – as we know it.

Your donation will help to protect and restore critical Cassowary habitat, assist with conservation efforts and help care for injured and orphaned Cassowaries.

The greatest threat to Cassowaries is us ... people. Rapid urban development in parts of the Wet Tropics has either destroyed or fragmented much of their habitat. An adult Cassowary needs 250 hectares in which to forage for food and breed. The disruption of their habitat forces them to travel further – exposing them to threats like dog attacks and road fatalities.

Thanks to Rainforest Rescue supporters, we are taking positive action to help save the Southern Cassowary. This includes the purchase and protection of 22 properties classified as 'essential' Cassowary habitat, and the planting of 43 756 trees in the Daintree Rainforest and at Mission Beach to create Cassowary corridors, and provide extra food and shelter.

Your gift will enable us to continue this vital work to protect and restore critical Cassowary habitat within Queensland's Wet Tropics. Please donate now.

Rainforest Rescue Save the Cassowary campaign, photo © Jeff Larsen

Urban development has led to increased mortality from car strikes with 147 recorded deaths since 1992.

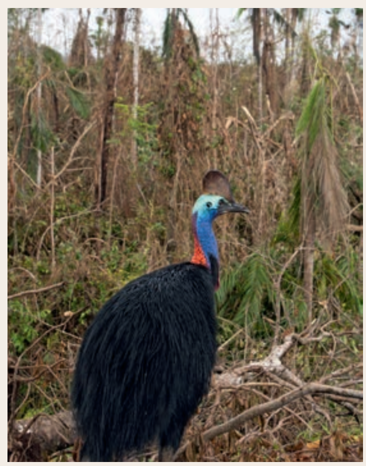
Mission Beach, south of Townsville, is home to Australia's greatest density of Southern Cassowaries. Yet, due to a combination of rapid development and extreme weather events, like Cyclone Yasi, as few as 40 to 50 birds remain.

In 2011, thousands of hectares of prime Cassowary habitat was severely damaged by Cyclone Yasi. In the first 12 months after the Cyclone 25 Cassowaries were reported to have died – 13 of them hit by cars as they were forced to leave their devastated habitat in search of food.

That's why we are negotiating with the Queensland government to co-manage the Garner's Beach Cassowary Rehabilitation Centre near Mission Beach. This is the only facility that rescues, rehabilitates and releases injured and orphaned Cassowaries back into the wild.

Your support is vital to carrying out these types of long-term projects that will help to ensure its survival:

- $50 could provide food for one adult Cassowary for a week
- $250 could help with the planting and maintenance of 25 native rainforest trees to help restore or create Cassowary corridors
- $750 could cover the care of an injured or orphaned Cassowary over an 18-month period
- $1000 could contribute to the protection of 200 square metres of Cassowary habitat



© Liz Gallie

Cassowary habitat destroyed by Cyclone Yasi in February 2011

Questions

1 Identify the threats to Cassowary numbers according to this website extract.

2 List examples of persuasive language used in this extract. Describe the general tone.

3 Assess whether or not you found this to be factual and credible. Discuss your views with examples.

4 Scientifically, using this information, propose the most effective way to manage the threats to the Cassowary and help restore the population. Evaluate the distribution of money for long-term projects by this group.

QUESTION SET 3.6

Remembering

1 Define 'coexistence' and 'keystone species'.

Understanding

2 Explain why a keystone species increases an ecosystem's biodiversity.

3 Many ecosystems are classified by the dominant species present in the system. Compare and contrast the difference between a keystone species and a dominant species.

Applying

4 The Yellowstone cutthroat trout is a keystone species in Yellowstone National Park, US. Apply your understanding of a keystone species to explain Figure 3.22 and why it is essential to conserve population numbers of the Yellowstone cutthroat trout.

Figure 3.22 ▲
Yellowstone cutthroat trout as a keystone species

CHAPTER SUMMARY

- The biosphere can be broken up into major aquatic and terrestrial biomes.
- Each biome is comprised of numerous ecosystems, which are comprised of a number of habitats.
- An ecosystem is considered to be the interaction between the living organisms in the community and their environment.
- The environment is the set of biotic and abiotic factors of a particular area.
- Each organism has a particular role within the ecosystem known as the organism's ecological niche.
- An organism has a fundamental niche that it could potentially inhabit when no predators are involved, and a realised niche that they do inhabit due to competition from other organisms.
- The competitive exclusion principle stipulates that no two species can occupy the same niche for an extended period of time.
- Resource partitioning allows for multiple species to coexist in the one area without detriment to their relative abundance.
- Predation, disease, and symbiotic relationships and interactions affect the biodiversity of an ecosystem.
- Symbiotic relationships and interactions include parasitism, mutualism and commensalism.
- A keystone species is a species of relatively low abundance in a higher trophic level that allows the coexistence of a number of lower trophic level organisms in a particular area.
- Biodiversity can be affected in a negative way if the keystone species is removed.
- Biodiversity of an ecosystem is the result of the presence or absence of abiotic and biotic factors, and the interactions and relationships between these factors.

CHAPTER GLOSSARY

abiotic the non-living components of an ecosystem

arboreal living in trees

association a relationship or interaction between two or more species

aquatic environment a water environment, such as an ocean, lake, river, stream or swamp

biodiversity the full range of different living things in a particular area or region; it can be described at various levels, including the range of different species, genetic diversity, or the diversity of ecosystems present in a larger area

biome the main category of an ecosystem across a large geographical area

biosphere the sum of all ecosystems across the world

biotic the living components of an ecosystem

coevolve the evolution of adaptive features in two different species that have placed selective pressures on each other

coexistence different species living together peacefully

commensalism a symbiotic relationship whereby one species benefits and the other is unaffected

community the sum of the different species inhabiting a particular habitat at one time

competition the struggle between two or more species for resources to fulfil their need for survival

competitive exclusion principle the theory that no two species can occupy the same niche for an extended period of time

diurnal describes animals that are most active during the daylight hours

dominant species the most common or abundant species in a particular ecosystem

ecological niche an organism's habitat and the way an organism fulfils its role in the ecosystem

ecologist a scientist who studies the relationships between living things and their surroundings

ecology a branch of biology that explores the relationships between living things and their surroundings

ecosystem a self-sustaining unit consisting of the interactions between the community and the environment

endemic a species that is native to a particular geographic region, and not introduced

environment abiotic and biotic factors of an area

epiphyte a type of climbing plant, such as lianas, which uses trees as support as they reach for light

estuary the transitional region where fresh water from a river meets with salt water from the ocean

eutrophication an increase in the concentration of nutrients, phosphates and nitrates in a waterway that promotes algal bloom

frugivore a fruit-eating animal

fundamental niche the potential region an organism could inhabit if there were no competitors, predators or parasites

habitat an area or environment where an individual or species lives within an ecosystem

host an organism that another organism lives on or in

humus the dark brown organic matter in soil, derived from decomposed plant and animal remains (detritus)

interspecific interactions or relationships between members of different species

intraspecific interactions or relationships between members of the same species

keystone species a species of relatively low abundance that is seen to have a large influence over lower trophic levels to allow the coexistence of these species in a particular area

limiting factor an element of the environment that restricts the survival of an organism to a region

mutualism a symbiotic relationship whereby both species in the relationship benefit from each other

parasite an organism, such as a bacterium, virus, fungi, worm or arthropod, that lives on or in another organism and causes death

parasitism a symbiotic relationship whereby one species benefits to the detriment of the other

photic zone a region of water that light can penetrate to allow photosynthesis to occur

pollinator an organism that is able to transfer pollen from one flower to another

population a group of individuals belonging to the same species living in a particular area at the same time

predator an organism that hunts another organism for its food

prey an organism that is hunted by another organism for food

realised niche the actual niche a species inhabits

resource partitioning the use of resources that allows a number of species to coexist in an ecosystem

seed disperser an organism that feeds on fruits and seeds for nutrition and, when the animal defecates, it deposits the seeds in a new location where they can germinate and grow

seed predator an organism that feeds on seeds and generally acts as a seed disperser

sessile a fixed or non-moving species

symbiosis the relationship between individuals of two or more species that interact together whereby at least one organisms benefits from the relationship

terrestrial environment a land environment such as tundra, desert or rainforest

tolerance range a set of abiotic conditions in which an organism, cell or enzyme functions at its optimal

topography the composition of the natural and man-made features of an area

zone of intolerance a set of abiotic conditions in which an organism, cell or enzyme cannot function

zone of physiological stress a set of abiotic conditions in which an organism, cell or enzyme finds it difficult to function

CHAPTER REVIEW QUESTIONS

Remembering

1 Summarise how terrestrial and aquatic environments are classified.
2 Compare a terrestrial environment and an aquatic environment in terms of the following abiotic factors: pressure, temperature and gas availability.
3 Explain the difference between a competitor and a collaborator.

Understanding

4 Compare the following terms.
  a biosphere to biome
  b environment to ecosystem
  c ecosystem to habitat
  d population to community
  e habitat to environment
  f ecological niche to ecosystem
5 Explain the role of a keystone species in an ecosystem.
6 Outline how symbiotic relationships increase the biodiversity of an ecosystem.

Applying

7 Copy and complete the table below, which summarises the relationships and interactions between living species.

Relationship or interaction	Description	Example
	Different species living together and sharing the same resources	
Commensalism		
	Rivalry between species for particular resources	
Mutualism		
	Transfers pollen between flowers	
	An animal that kills for food	
Keystone species		
Seed disperser		

8 a Using the information given in this chapter and an atlas, predict the ecosystems that are labelled A–D on Figure 3.23.
  b Identify the rainfall and temperature ranges that would be experienced in each area.
9 Suggest what would occur to the biodiversity of an ecosystem if a new species was introduced.

Figure 3.23 ▼

10 Copy and complete Table 3.3 to compare the abiotic features used to classify different terrestrial and aquatic environments.

Table 3.3 Abiotic features of various environments

Abiotic feature	Terrestrial environment: desert	Terrestrial environment: rainforest	Aquatic environment: marine	Aquatic environment: lake
Pressure variation				
Temperature variation				
Nutrient concentration				
Salinity				
Oxygen availability				
Water availability				

Analysing

11 Use Figure 3.24 to answer the following questions.

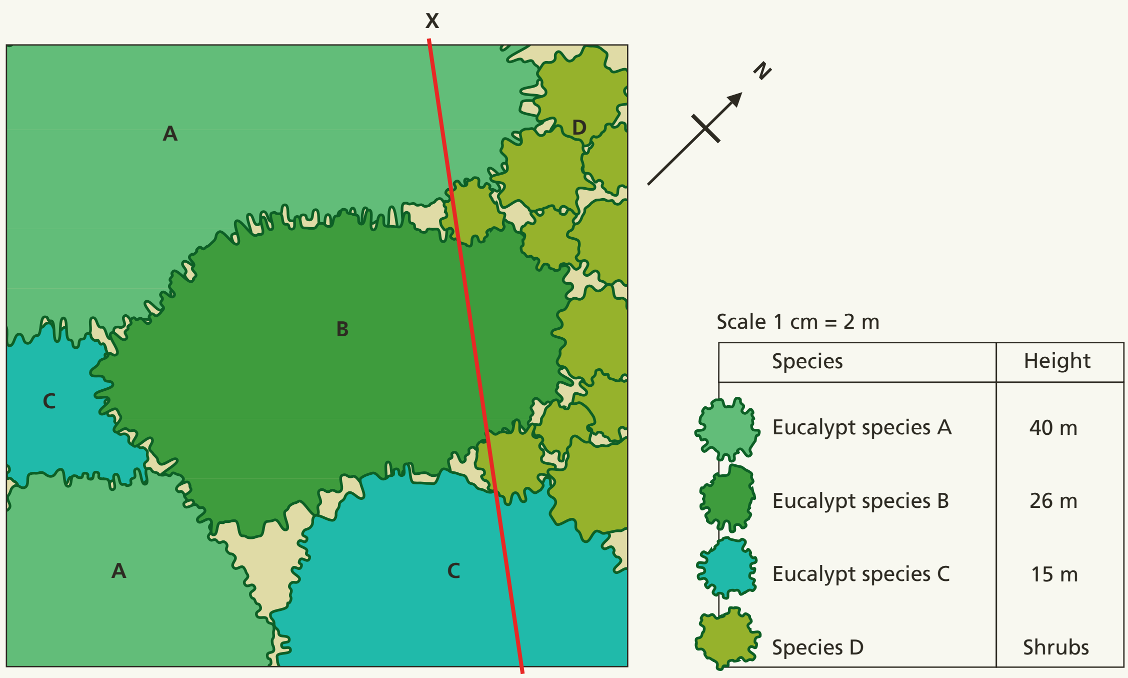
a Identify the dominant species.

b Calculate the percentage coverage of the dominant species.

c Based on the information obtained from this plot, identify the classification of this environment.

d Explain the limitations of using only one sample plot.

e Suggest reasons for the difference in species distribution.



▲ **Figure 3.24**
Surface map (aerial view) of sample plot

12 Elephant dung contains a great deal of fibrous matter, including seeds. Some of their plant food species have evolved to produce seeds that have a coating of rind to protect them from an elephant's digestive juices. Unless the seeds have passed through the elephant's digestive system first, they are unable to germinate. Analyse and explain the relationship described and use a visual medium for communicating your analysis.

13 a For each of the following organisms, make a table or draw a relational diagram (e.g. concept map) of what you consider are the four most important abiotic factors and the four main biotic factors that influence them.
   i A sea anemone in a rock pool
   ii A tree in a paddock
   iii An insect larva in the soil
   b Explain in what way each factor affects each organism. Add your answers to the table or annotate your relational diagram.

14 Use Figure 3.25 to answer the following questions.
   a List the temperature range and precipitation range for the ecosystems listed.
   b Which ecosystem has the largest temperature range?
   c Which ecosystem has the largest precipitation range?
   d Using the Internet, provide an example of each ecosystem.

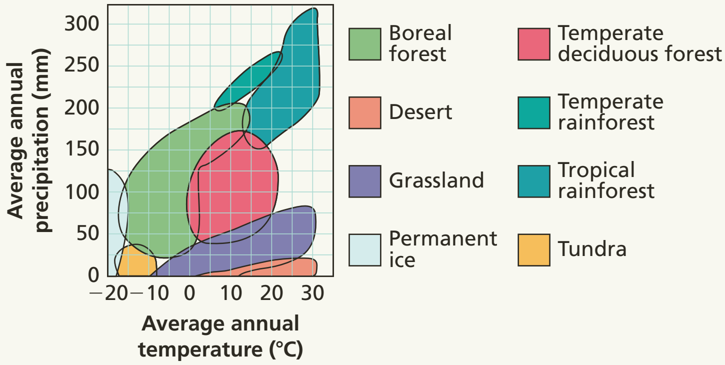


Figure 3.25 ▲
Climograph for some major ecosystems of North America

15 Populations become separated and fragmented due to a number of factors, such as urbanisation and deforestation. Explain how population fragmentation is detrimental to the genetic diversity of a species and their existence.

16 a Explain, using an example, why a prey population is usually larger than a predator population.
   b Suggest a reason that a prey population may be smaller than the predator population.

17 Explain 'dynamic relationship' with regards to predator and prey.

Evaluating

18 Evaluate this statement: 'Ecosystems are diverse and composed of varied habitats'.

19 Joseph Connell conducted an experiment to determine the fundamental and realised niches of two different species of barnacle, the *Balanus balanoides* and *Chthamalus stellatus*. The two barnacles inhabited the same rock face but the *C. stellatus* was found on higher rocks and the *B. balanoides* were found on the lower rocks. During his experiment, Connell discovered that the *B. balanoides* could only live on the lower rocks as exposure to air during low tide would cause the barnacle to dry out and die (known as desiccation). When the *B. balanoides* were removed from the rock, the *C. stellatus* could inhabit the entire area.
   a Draw a diagram that shows the realised and fundamental niches of *B. balanoides* and *C. stellatus*.
   b Using the theory of competitive exclusion, explain why *C. stellatus* does not inhabit the entire rock.

Creating

20 Using the terms from the glossary, create a graphical organiser such as a concept map to summarise your understanding of the chapter.

21 Summarise why the world has organisms living in a range of habitats from the tops of the mountains to the troughs that lie several kilometres under the ocean.

Reflecting

22 Justify this statement: 'The world is a more diverse place because of the relationships found within ecosystems'.