Unique aquatic and terrestrial ecosystems

Each local aquatic or terrestrial ecosystem is unique

Trends in population estimates

2.1

- ***examine trends in population estimates for some plant and animal species within an ecosystem***

Plant population trends

Mangrove species

When studying a tidal **estuary** you are most likely to look at the abundance of mangrove species along a transect line from the sea to inland. If we graphed the results we would see something like that shown in Figure 2.1(a). Mangrove species A is highest in abundance inland, species C is highest closest to the sea, and species B is most abundant in between A and C. Mangrove species C being most abundant closest to the sea appears to be the most tolerant of **saline** conditions, followed by species B, and then the least tolerant of saline conditions is species A.

Trends in population estimates can be seen easily when abundance values have been graphed. Examining trends can lead to inferences about the species and what abiotic or biotic characteristics they are most suited to.

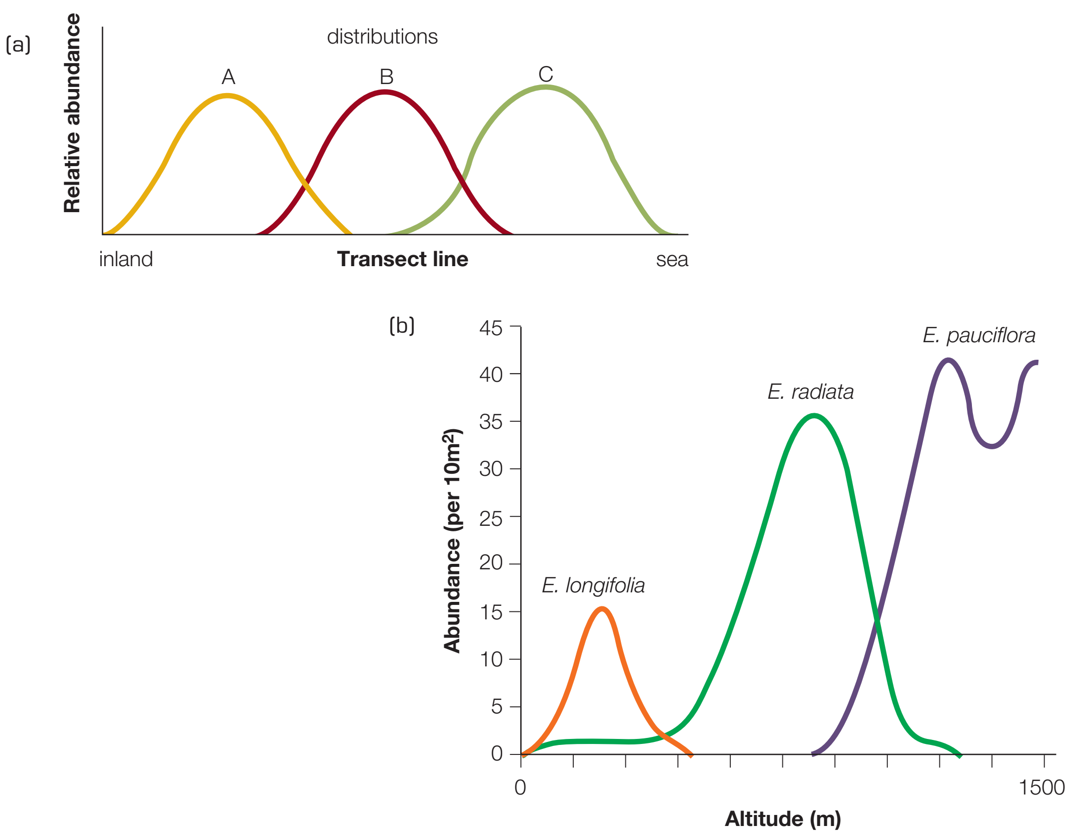


Figure 2.1 Trends in plant population estimates: (a) three mangrove species and distance from the sea; (b) three eucalypt species at different altitudes

Eucalyptus species

Figure 2.1(b) illustrates the abundance of different eucalyptus species at different altitudes in southeast New South Wales. Although the species tend to overlap as altitude increases, each different eucalypt species appears to be more abundant in, and therefore more suited to, a specific altitude range. *Eucalyptus pauciflora* numbers dominate the higher altitudes, while *Eucalyptus longifolia*, even though it has a smaller abundance, still dominates the lowest altitude ranges. *Eucalyptus radiata* appears to be suited to most altitudes; however, it is most abundant in the middle altitude range.

Animal population trends

Grain beetle species

The abundance of two grain beetle species (*Calandra* and *Rhizopertha*) in Figure 2.2(a) show different trends over the period of 180 weeks. Although both species rapidly increase over the first 20 weeks, and drop quickly over the second 20 weeks, *Rhizopertha* continues to drop to a certain abundance level and remains stable over the remaining time period. *Calandra*, however, goes through a series of fluctuations then drops a little during weeks 80 to 140, but then increases again, close to its highest-reached abundance level. This graph infers that *Calandra* appears to survive better than *Rhizopertha* when in competition with each other in this environment. Although we cannot predict what these two species were in competition for (e.g. food, space), we can assume that one species dominates the other in this particular situation through higher species abundance. This, of course, does not mean that the two species cannot successfully exist together in the same environment.

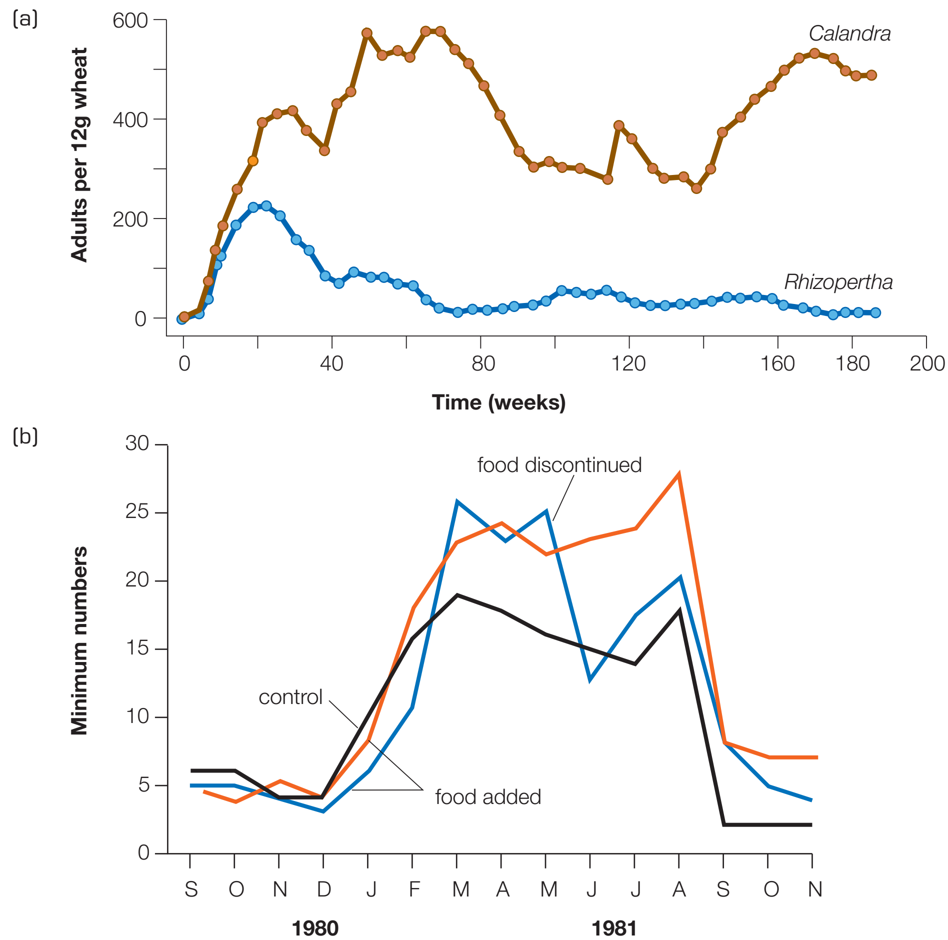


Figure 2.2 Trends in animal population estimates: (a) two grain beetle species in competition; (b) Australian marsupial *Antechinus stuartii* supplemented with food

Australian marsupial species

Figure 2.2(b) illustrates the effect of increasing the food supply for a population of small marsupial carnivores, *Antechinus stuartii* (Fig. 2.3), over 12 months. Supplementary food was provided to two groups of *Antechinus stuartii*; however, the food supply was discontinued in one group along the way. Looking at the graph in Figure 2.2(b), all groups rapidly increase in numbers up to March 1981 and then stabilise for a few months. Each group reaches a peak in August 1981 before rapidly declining in numbers to a point similar to 1980 figures in November 1981. The control group (not supplemented with any food) have not reached as high numbers as the supplemented groups. When food was discontinued for one group a dramatic drop occurred in numbers, but it seemed to recover quickly and increase and return to the same pattern as the other groups. Food appears to play an important part in the abundance of *Antechinus stuartii* and indicates that the abundance of the populations studied was limited by food supply. Otherwise, we would not have seen any increase in species numbers for those supplemented with food.

Knowledge of the response of a species to different environmental factors can be used to make predictions about the potential distribution and abundance of species. You will be using your ability to examine trends in population estimates when analysing your own population estimate graphs collected on your field trip later in this chapter.

Figure 2.3 Australian marsupial *Antechinus stuartii*

Predator and prey populations

2.2

■ ***outline factors that affect numbers in predator and prey populations in the area studied***

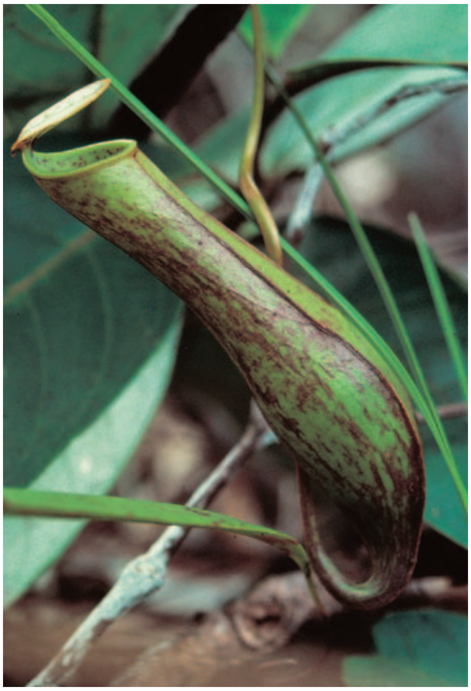
There are two types of interactions between organisms: detrimental and beneficial. **Detrimental interactions** exist when one or more organisms are harmed or disadvantaged from the relationship. **Beneficial interactions** exist when one or more organisms benefit from the relationship. One example of a detrimental interaction is the **predator–prey relationship**.

Predation (predator–prey relationship)

A predator–prey relationship is a feeding relationship where the **predator** (consumer) obtains its food by killing an animal (**prey**), for example spiders eating flies or eagles eating bush rats. Not only are land animals predators, some plants and marine organisms also play this role (see Fig. 2.4).

Predators affect the abundance of their prey. Providing the prey species reproduces as fast as it is predated upon its population will stay at a constant size. For example, if the rabbits in a grassland ecosystem reproduce faster than the foxes that predate them then the rabbit population will increase. In natural communities, the abundance of a predator and its prey can fluctuate through time, with the predator numbers copying those of the prey. When there are large numbers of prey available, the predator population increases in size. As prey are consumed, their numbers decline, leading to a shortage of food for the predators, whose numbers also decline. This pattern is illustrated in Figure 2.5.

(a)



(b)

(c)

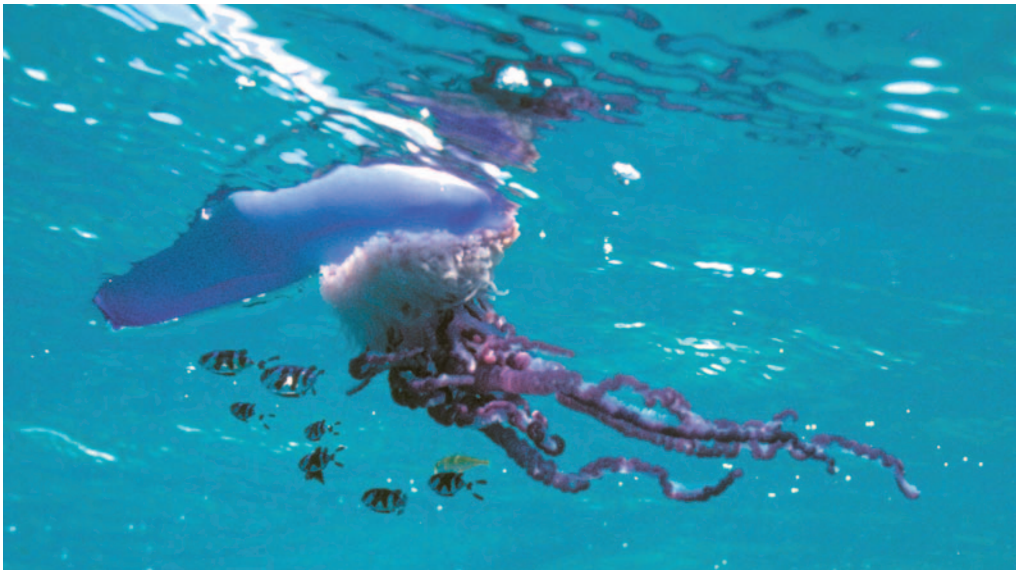


Figure 2.4 Plants and marine animals can be predators: (a) the pitcher plant traps and digests insects in highly modified leaves; (b) a predatory snail feeds on soft coral; (c) the Australian 'blue bottle' with its large blue float captures its prey using long stinging tentacles

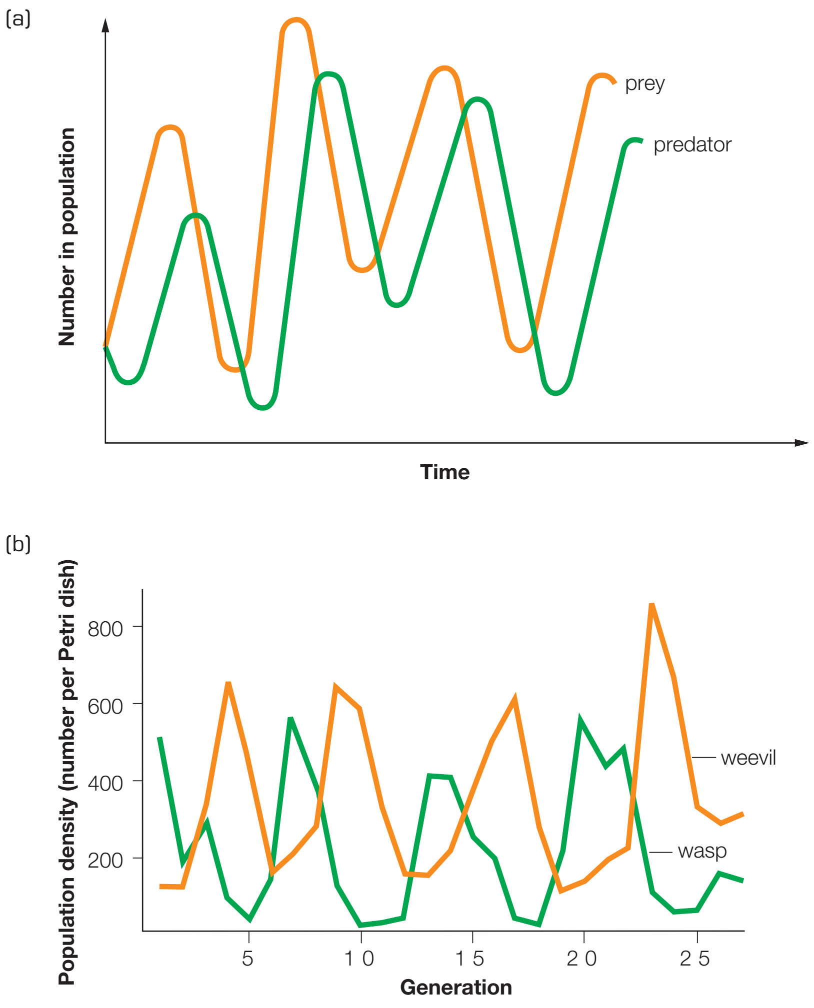


Figure 2.5 (a) The typical pattern found in predator–prey relationships; (b) The number of parasitoid wasps fluctuates in relation to its host the bean weevil

Factors affecting numbers of predator and prey populations

There are a number of different factors that may affect the numbers of predator and prey populations:

- number of predators competing for same prey
- availability of prey's food
- birth rate (depending on the age of reproductive maturity and the number of reproductive episodes per lifetime)
- death rate (increased by exposure to disease)
- number of males and females
- size of ecosystem for supporting the predator and prey numbers
- movement between ecosystems
- number of shelter sites available.

Factors relevant to your chosen study area may not include all of those listed above. For example, in a mangrove ecosystem you may find that the factors affecting numbers in predator and prey populations are directly related to human impact. Use the above examples as a reference when you are conducting the field study of your area and looking for possible factors affecting the numbers of predator and prey populations.

2.3 Allelopathy, parasitism, mutualism and commensalism

- ***identify examples of allelopathy, parasitism, mutualism and commensalism in an ecosystem and the role of organisms in each type of relationship***

Allelopathy

Allelopathy is the production of specific biomolecules by one plant that can be beneficial or detrimental to another plant. This concept suggests that biomolecules (**allelochemicals**) produced by a plant escape into the environment and subsequently influence the growth and development of other surrounding plants. Not all plants have **allelopathic** tendencies, but most plants that do use it to compete with other plants and therefore negatively influence the existence of neighbouring plants. Basically, it is mainly used by plants to keep other plants out of its space. Space is crucial to the survival of plants. The fewer plants around, the more water to absorb from the soil, the more soil to support the roots for plant stability, and the more sunlight available to absorb.

Types of allelopathy

There are a number of different types of allelopathy. In one type, the plant that is protecting its space releases growth-compounds from its roots into the ground. New plants trying to grow near the allelopathic plant absorb those chemicals from the soil inhibiting root/shoot growth or seed germination. Another type of allelopathy involves the release of chemicals that slow or stop the process of respiration or photosynthesis, some may just inhibit nutrient uptake. Plants may also release chemicals that can change the amount of chlorophyll in another plant. The plant cannot then make food with the changed chlorophyll levels and dies.

Allelopathic chemicals can be present in any part of the plant. They can be found in roots, stems, flowers, fruits and leaves.

Examples of allelopathy

- The black walnut plant releases a chemical that inhibits respiration. The chemical is found in all parts of the plant but it is concentrated in the buds and roots. Plants exposed to this chemical exhibit symptoms such as wilting, yellowing of foliage and eventually death.
- Sorghum species (cereal grass) release a chemical in the root exudates that disrupts mitochondrial functions and inhibits photosynthesis. It is currently being researched extensively as a weed suppressant.
- Eucalyptus leaf litter and root exudates are allelopathic for certain soil microbes and plant species (see Fig. 2.6). Some pine trees are also allelopathic. When their needles fall to the ground, they begin to decompose and release acid into the soil. This acid in the soil keeps unwanted plants from growing near the pine tree.

The more that is learnt about allelopathy the more we can find out about healthier alternatives to herbicides. That is, we could prevent unwanted plants or weeds from growing in an area by selecting plants that specifically produce chemicals against them.

Figure 2.6 Eucalyptus leaf litter is allelopathic and doesn't allow other plants to grow near it

Beneficial interactions

Symbiosis is the term used for interactions in which two organisms live together in a close relationship that is beneficial to at least one of them. Symbiosis usually involves providing protection, food, cleaning or transportation.

There are three types of beneficial or **symbiotic interactions**:

- **parasitism**—one species benefits and the other is harmed
- **mutualism**—both species in the relationship benefit from the association
- **commensalism**—one species benefits and the other is unaffected.

Parasitism

Relationships where one species benefits and the other is harmed are **parasitic**.

A **parasite** obtains food and shelter from the host organism. They feed upon the tissues or fluids of the host organism, but do not usually kill it, as this would destroy the parasite's food supply. The parasite is often smaller than their host and they may live on the surface of their host (**ectoparasites**, e.g. ticks, fleas and tinea) or internally (**endoparasites**, e.g. tapeworms) (see Fig. 2.7).

(a)

(b)

(c)

(d)

Figure 2.7 Parasites can be ectoparasites: (a) ticks, (b) fleas, (c) tinea; or endoparasites, (d) tapeworm

Mutualism

Relationships where both species benefit from the association are **mutualistic**.

Reef-building corals have symbiotic algae within their tissues which provide the yellow-brown pigments that give the coral its colour (see Fig. 2.8). The algae live, reproduce and photosynthesise in the host and use the waste products of the host. In turn, the coral uses oxygen and food produced by the algae during photosynthesis to grow, reproduce and form its hard skeleton, which is the basis of the reef. The formation of the Great Barrier Reef depends on this mutualistic relationship. When corals are stressed (i.e. when disturbance turns water murky, or sea temperatures increase) they expel the algae, which in turn causes the corals to starve, leaving white skeletons.

Figure 2.8 Reef-building corals have a mutualistic relationship with algal cells

The relationship between the sea anemone and the anemone fish (or 'clown fish') was once thought to only benefit the anemone fish; however, recent studies have suggested that, in fact, both organisms benefit. The anemone fish is neither stung nor eaten by the anemone. The anemone fish repeatedly brushes against the anemone's tentacles until its own mucous coating inhibits the anemone's sting. The anemone fish is therefore protected from predators by hiding in the anemone's tentacles unharmed. It feeds on the anemone's food scraps. The anemone benefits as the anemone fish cleans its host and lures other animals into the anemone's tentacles (see Fig. 2.9).

Figure 2.9 The mutualistic relationship between the sea anemone and the anemone fish ('clown fish')

The 'ant plant' has a mutualistic relationship with a species of ant. The plant has a swollen base in which there are specialised chambers. The ants form large colonies within these chambers and carry their prey corpses and excreta to parts of the chambers (cemeteries) where the plant is able to absorb the waste nutrients.

Commensalism

Relationships where one species benefits and the other is unaffected are **commensal**.

Epiphytes such as mosses, small ferns and orchids can be seen on tree trunks in moist forests. They appear to benefit from living on the trunk of the host tree by catching rainwater to dissolve nutrients and by being closer to sunlight. Epiphytes do not appear to affect the host tree negatively. The strangler fig commences its life as an epiphyte. The seed germinates from bird droppings on the host tree and the young fig starts to grow. The fig benefits and the host at this stage is not affected. However, the fig grows and extends its roots down into the soil below. It envelops its host and prevents trunk growth (see Fig. 2.10). The relationship changes from commensalism to competition for space.

The barnacle is a crustacean that normally adheres to a fixed surface; however, some barnacles adhere to the surface of whales and turtles. This does not affect the whales or turtles, but benefits the barnacles as they are transported to diverse areas rich in food (plankton).

TR

Extension activity—allelopathy, parasitism, mutualism and commensalism

(a) (b)

Figure 2.10 (a) Young fig starts to grow and extend its roots; (b) Fig envelops its host

2.4 Decomposers in ecosystems

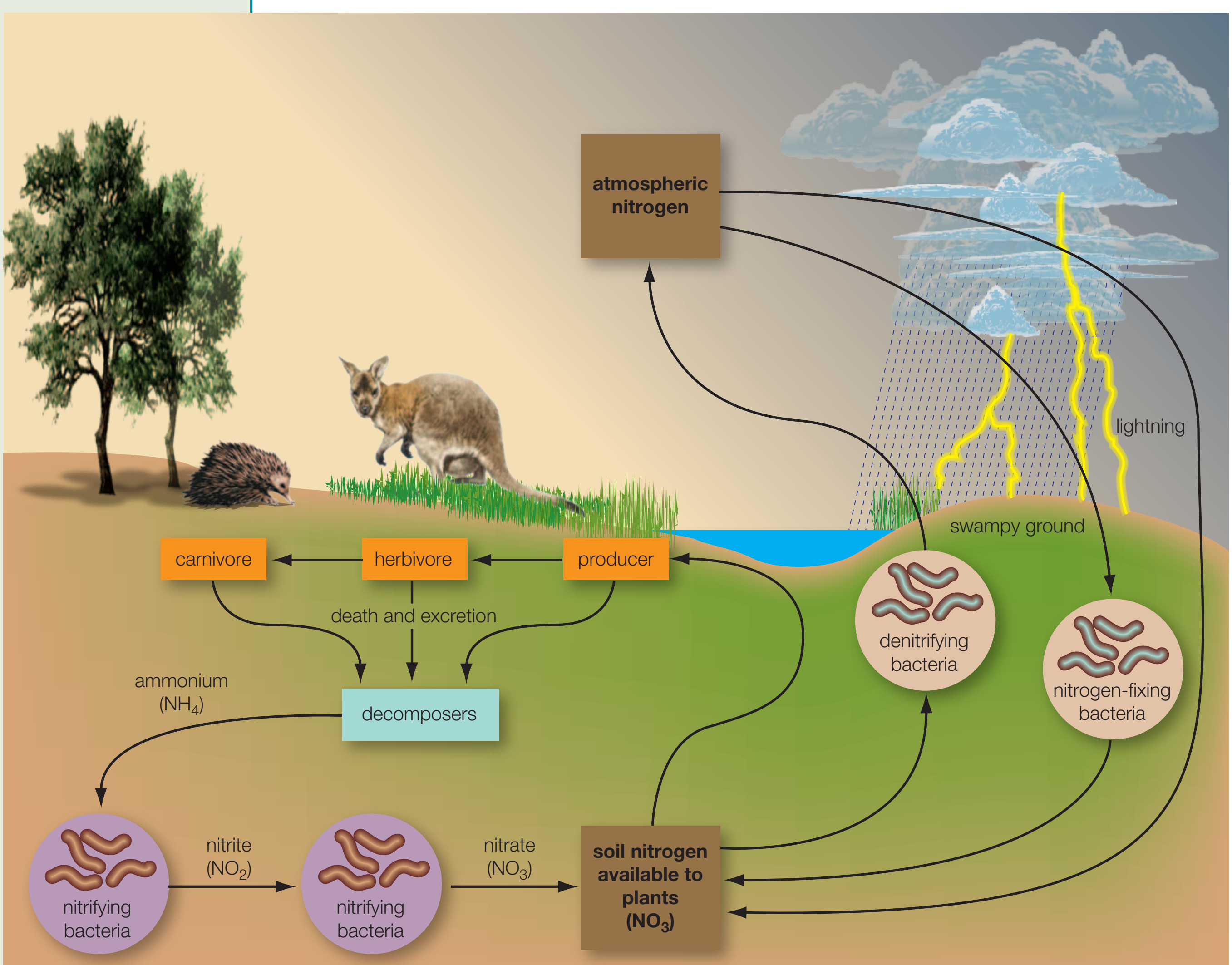
■ ***describe the role of decomposers in ecosystems***

Decomposers use the organic nutrients of dead organisms for energy and break these dead bodies down to inorganic nutrients which can be recycled for use by palnts. Bacteria and fungi in the soil are very important because they return nutrients to the soil when they decompose dead animals and plants. The highly important cycle operating in this process is the nitrogen cycle (see Fig. 2.11). Nitrogen is essential to all living things.

The nitrogen cycle

Atmospheric nitrogen becomes part of living organisms in two ways. Firstly, bacteria in the soil form nitrates from the nitrogen in the air. Secondly, during electrical storms (lightning), nitrogen is combined with oxygen and water to produce an acid that falls to the earth in rainfall and deposits nitrates in the soil. Plants take up the nitrates and convert them to proteins that then travel up the food chain.

Figure 2.11
The nitrogen cycle



When organisms excrete wastes the nitrogen is released back in to the environment. When organisms die and decompose the nitrogen is broken down and converted to ammonia. Plants absorb some of this ammonia; the remainder stays in the soil where bacteria convert it back to nitrates. The nitrates may be stored in humus or are leached from the soil and carried into lakes and streams. Nitrates may also be converted to gaseous nitrogen through a process called denitrification and returned to the atmosphere, continuing the cycle.

Optional website activity. Visit www.biology.ualberta.ca/facilities/multimedia and click on 'Ecology', then animate the nitrogen cycle.

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Website activity

2.5

Trophic interactions between organisms

- ***explain trophic interactions between organisms in an ecosystem using food chains, food webs and pyramids of biomass and energy***

Autotrophs and heterotrophs

Ecological interactions are the exchanges and flows of energy and matter, and these interactions are determined by the ways in which organisms obtain their food. Ecosystems are often described in terms of their **trophic** or feeding relationships. **Autotrophs** or *producers* are organisms that make their own food by converting inorganic molecules to organic compounds (see page 20). The majority of autotrophs are green plants and algae that use sunlight for photosynthesis. A small group of autotrophs that do not carry out photosynthesis are chemosynthetic bacteria.

All other organisms are **heterotrophs** or *consumers*. They must consume other organisms in order to gain the organic molecules they need for life. There are several types of consumer organisms:

- **primary consumers**
  —**herbivores**: organisms that eat plants only (e.g. koala)
- **secondary or tertiary consumers**
  —**carnivores**: organisms that eat animals only (e.g. crocodile)
  —**omnivores**: organisms that eat both plants and animals (e.g. ants).

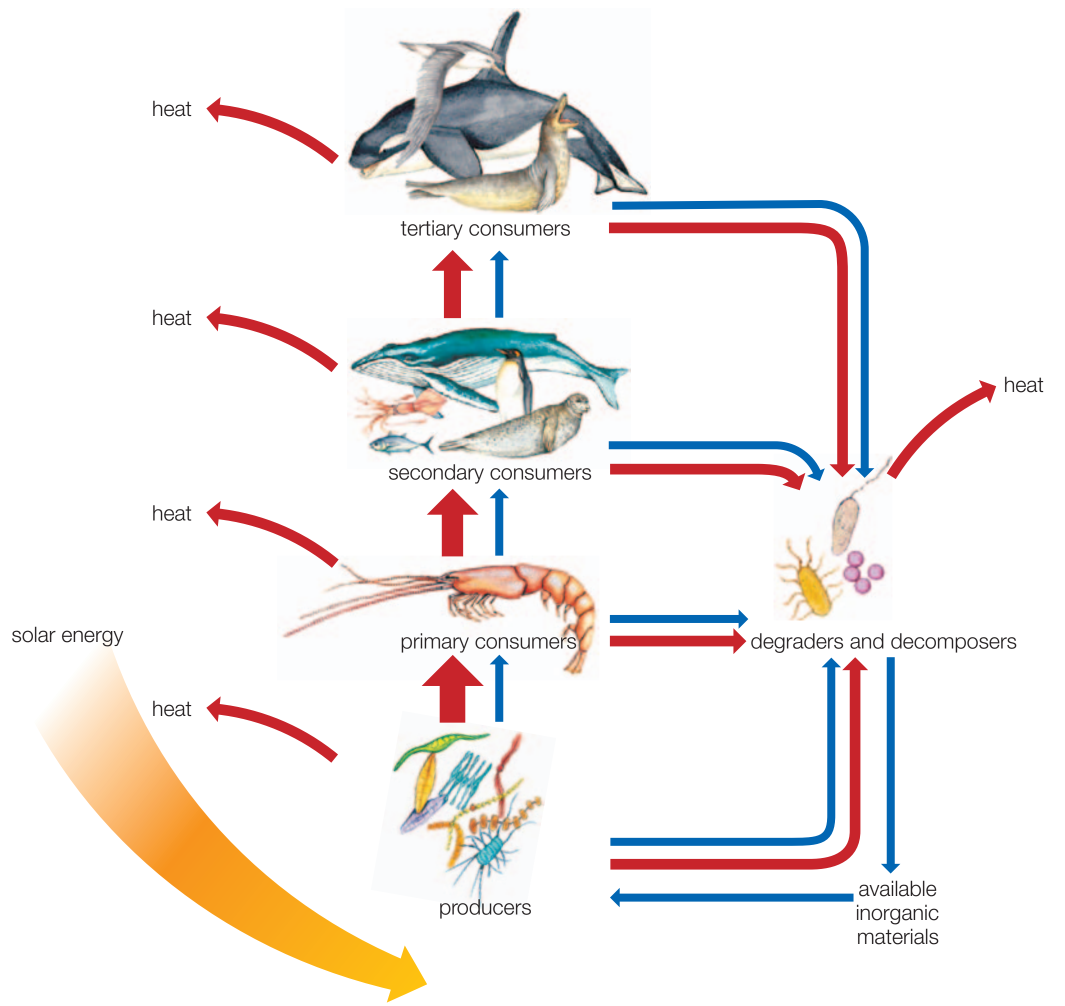
Primary consumers are eaten by secondary consumers, and secondary consumers are eaten by tertiary consumers.

Among the heterotrophs there are also organisms that feed on dead organisms and organic waste from different **trophic (feeding) levels**. These are called **degraders**, which include:

- **scavengers**—animals that eat dead organisms
- **detritivores**—animals that ingest organic litter or detritus (and then digest it)
- decomposers—fungi and bacteria that cause chemical decay of organic matter and absorb the broken-down material.

Of course, some of the consumers may overlap more than one trophic level. Some organisms may even change trophic levels during their life cycles. For example, some insects are **carnivorous** as larvae but become **herbivorous** as adults (e.g. stoneflies). Figure 2.12 illustrates the general characteristics of an ecosystem in a simplified diagram of the flow of energy and materials.

Figure 2.12
A simplified diagram of the flow of energy (red) and materials (blue) through an ecosystem. Although there is a net loss of energy, materials may be recycled



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Worksheet on food chains

SR TR

Worksheet on a food web

Food chains and food webs

Food chains show the energy movement from one living thing to another. They describe the feeding order in which plants or animals eat or are eaten by other animals. A simple food chain is comprised of:

producer ⟶ herbivore ⟶ carnivore

The diagram in Figure 2.13 represents examples of food chains where the energy flows up each trophic level. The trophic level of an organism is its position in a food chain, the sequence of feeding and energy transfer through the environment. Arrows indicate the direction of the flow of energy from one organism to the other.

However, food chains are not isolated in ecosystems; they are more realistically shown as a **food web**. Food webs show complex food interactions in an ecosystem. They are made up of two or more food chains (see Fig. 2.14). Even food webs may not be isolated in ecosystems. Trophic interactions usually take place within a particular habitat however these sometimes overlap.

Ecological pyramids

A patch of eucalypt woodland can support *thousands* of leaf-eating insects but only *hundreds* of insect-eating birds and only *one or two* bird-eating foxes or cats. Food webs such as that shown in Figure 2.14 represent a **pyramid of**

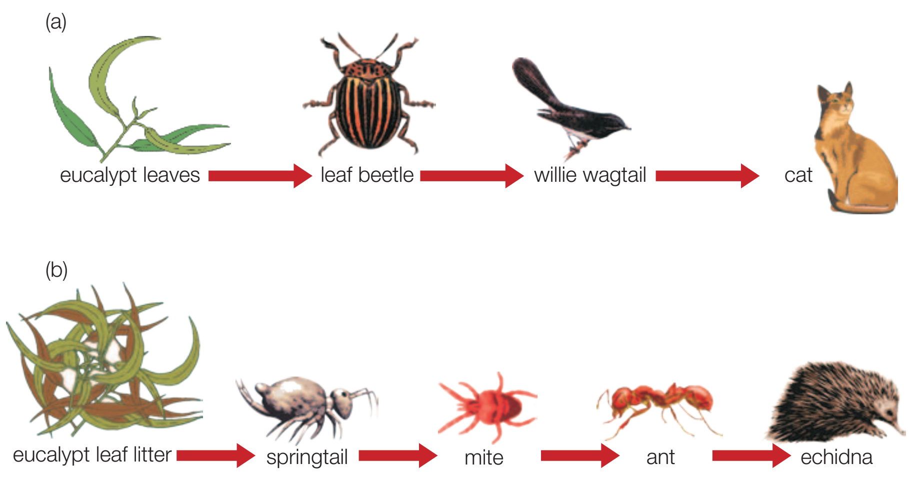


Figure 2.13 Examples of simplified food chains that might occur in eucalypt woodlands: (a) a grazing food chain; (b) a detritus food chain

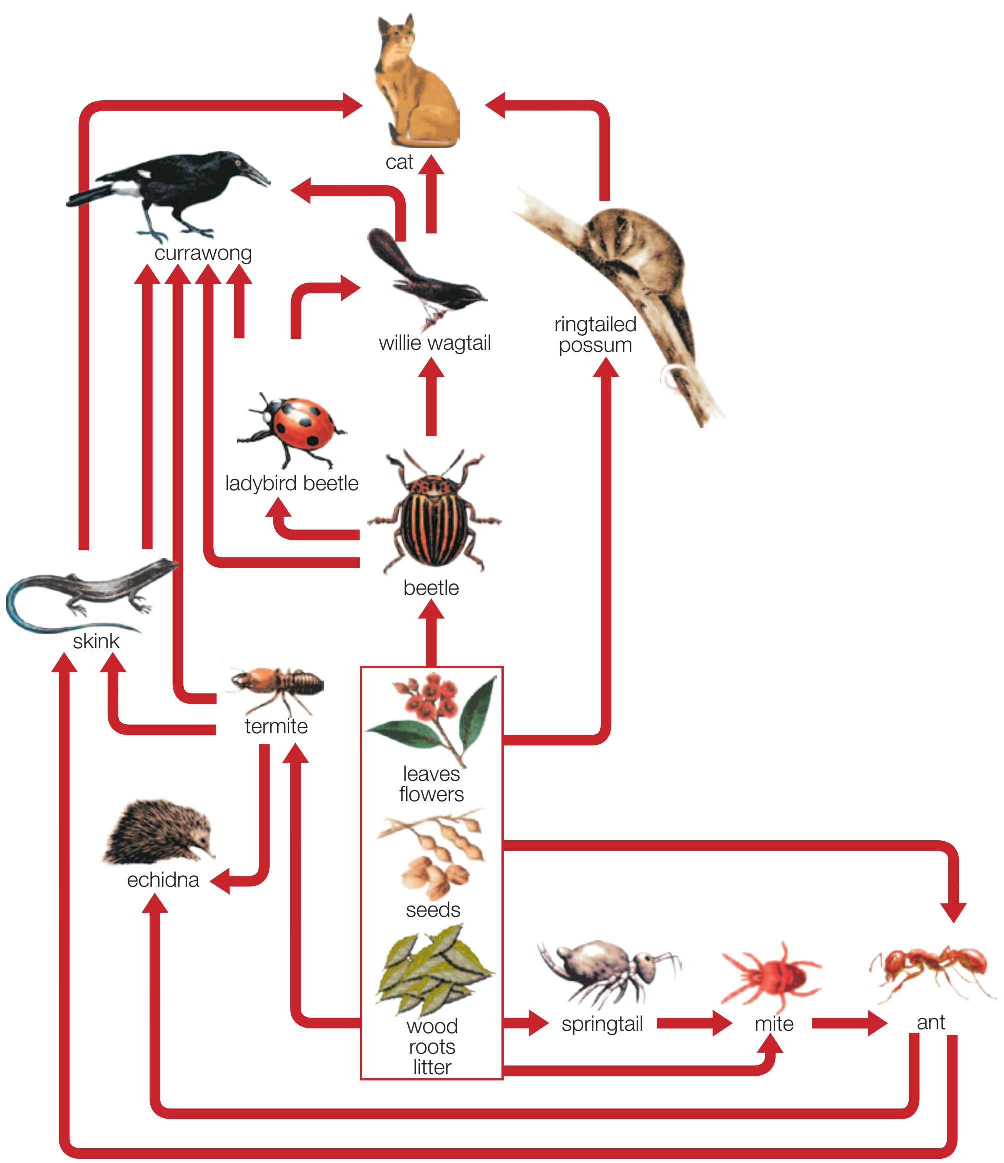


Figure 2.14 A simplified food web, illustrating how food chains from Figure 2.13 may interconnect with other food chains in a eucalypt woodland

numbers. In a pyramid of numbers, large numbers of herbivores (primary consumers) are consumed by smaller numbers of increasingly large carnivores (secondary and tertiary consumers) (see Fig. 2.15).

Pyramids of biomass

The amount of food at any trophic level depends, in part, on its biomass (total amount of living material present at any one time). A **biomass pyramid** shows the amount of biomass through each level of the food chain. At each level, energy (heat) and matter (food and wastes) are lost (90 per cent). Diagrams showing the biomass of trophic levels in an ecosystem are more frequently pyramidal in shape than diagrams of numbers of organisms. However, when an ecosystem is found to be unstable (where biomass from one level cannot support the next) then the biomass pyramid shape moves away from the pyramidal shape (see Fig. 2.16). For example, if only 4 g of eucalypt leaves has to support a 20 g leaf beetle, then the biomass pyramid is unstable; the lower trophic level must have a larger biomass than the higher levels.

Pyramids of energy

Not all the energy and material taken in by one trophic group is passed on to the next, and not all organisms at one trophic level are consumed by the next; there are also losses of heat associated with cellular respiration and the elimination of wastes. Thus, there is a net loss of energy and materials as you move up each trophic level. Energy flow indicates the food value of trophic levels more accurately than either numbers or biomass. We can therefore represent this energy flow diagrammatically in **pyramids of energy** flow (see Fig. 2.17). A pyramid of energy is never inverted.

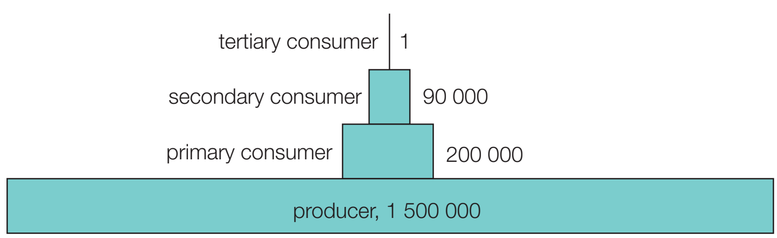


Figure 2.15
Ecological pyramid of numbers (individuals per 0.1 ha)—an oak forest in UK

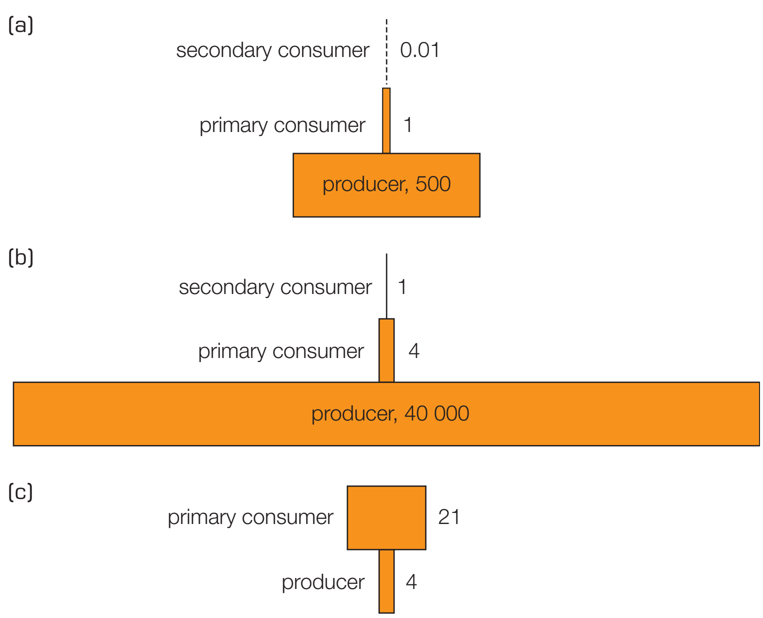


Figure 2.16
Ecosystems as shown through biomass pyramid diagrams—stable ecosystems: (a) a grassy agricultural field in USA, (b) a tropical rainforest in Panama; unstable ecosystem: (c) plankton in the English Channel, North Sea

Some ecologists illustrate ecological pyramids as a stepped shape (as represented in Figs 2.15, 2.16 and 2.17); however, others prefer to simplify it further to a triangular non-stepped shape. The following diagrams summarise the three different types of ecological pyramids illustrated as the simplified, triangular non-stepped shape (see Fig 2.18).

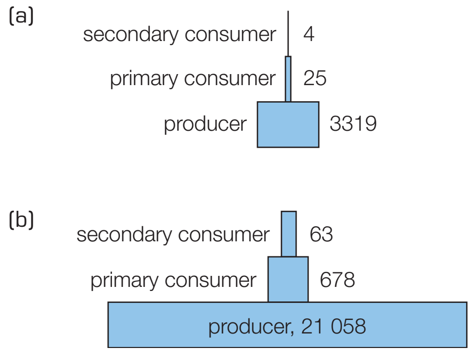


Figure 2.17 Ecological pyramids of energy flow (kJ m^{-2} year): (a) a desert grassland in New Mexico, USA; (b) a prairie in Oklahoma, USA

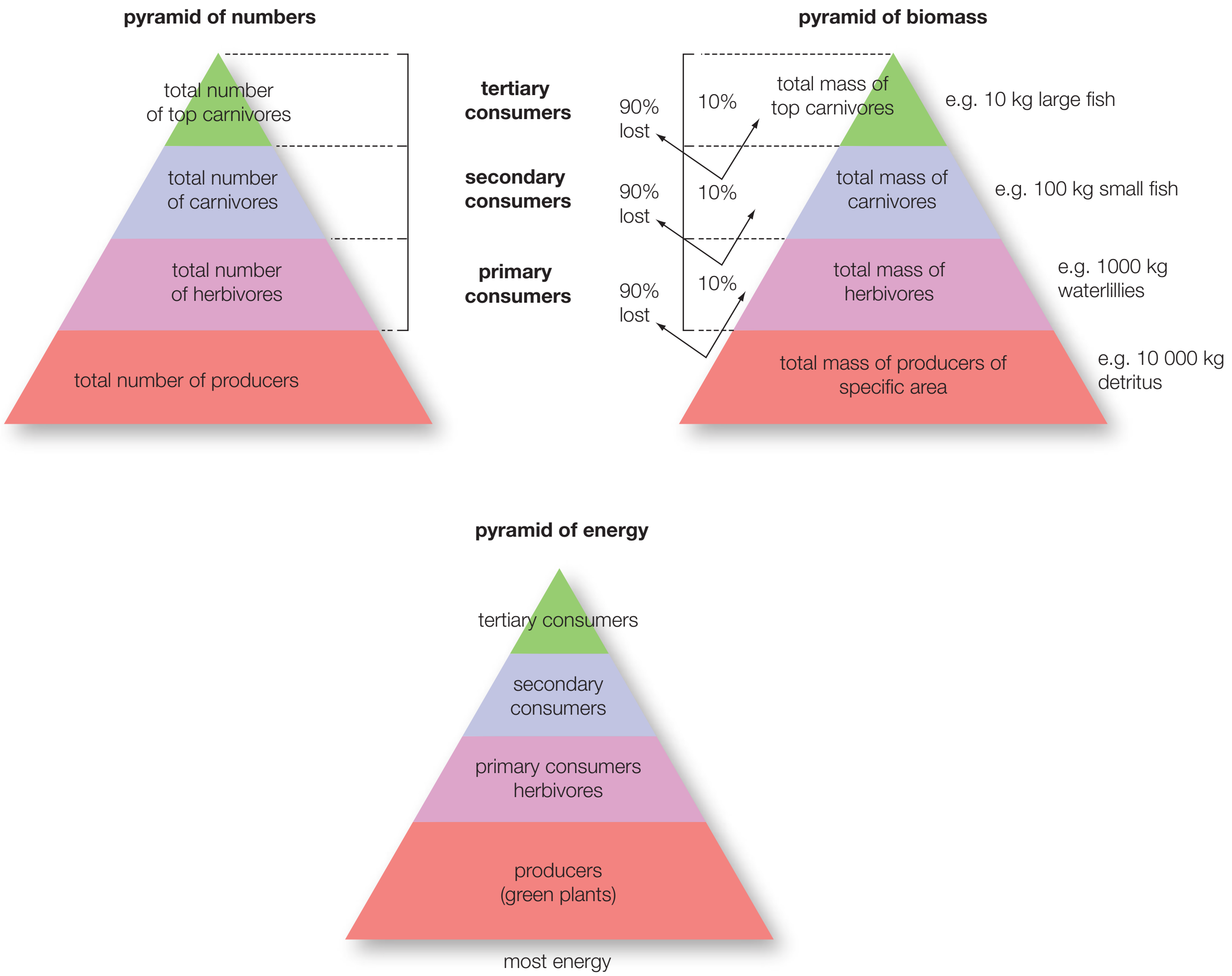


Figure 2.18 A summary of the three types of ecological pyramids

Constructing food chains and food webs

FIRST-HAND AND SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P14

SR TR

For recommended websites to obtain secondary source information

- ***gather information from first-hand and secondary sources to construct food chains and food webs to illustrate the relationships between member species in an ecosystem***

Background information

A food chain is a flowchart that shows the movement of energy from one living thing to another. It illustrates the feeding order or trophic levels. A food web is the combination of more than one food chain, representing the feeding relationships in a habitat or ecosystem.

Energy passing through from different trophic or feeding levels is illustrated by the direction of the arrows. Most food webs can be constructed from their composite food chains; however, most food webs you see illustrated are simplified. This is because most ecosystems have hundreds of organisms intertwined and interacting within the ecosystem. It would be very time consuming to attempt to draw every species in the food web so they are simplified to represent the major trophic levels and feeding relationships that occur.

Part 1: Constructing food chains and food webs from feeding information

Using the data provided in the following table (see Table 2.1), construct six food chains with at least three trophic levels. Once you have completed the food chains then construct one complete food web, start by combining the food chains you have constructed. Check for any organism relationships that you have missed and add these in; be careful with the direction that arrows are placed and that all necessary arrows are included. Note that **detritus** (accumulated debris of dead organisms) forms part of the food web but is not an organism. Use Figures 2.13 and 2.14 as a guide for how your food chains and web should be presented.

Table 2.1 Feeding information for organisms found in a simplified lake ecosystem

Lake organism	Trophic type	Food/prey
Human	■ Consumer —omnivore	■ Trout
Tadpole	■ Consumer —omnivore	■ Algae and zooplankton
Yabbie	■ Consumer —filter feeder —herbivore ■ Scavenger	■ Zooplankton ■ Large water plants ■ Detritus
Platypus	■ Consumer —carnivore	■ Insects, molluscs, worms and small invertebrates
Water bird	■ Consumer —herbivore	■ Large water plants
Silver perch	■ Consumer —omnivore	■ Aquatic insects, crustaceans and molluscs
Pelican	■ Consumer —carnivore	■ Small trout and silver perch
Large water plant	■ Producer	■ Photosynthetic, survives submerged or free-floating
Diving beetle (aquatic insect)	■ Consumer —carnivore	■ Aquatic insect larvae and adult insects blown into the lake
Water flea	■ Consumer —filter feeder	■ Planktonic algae
Trout	■ Consumer —carnivore	■ Zooplankton, yabbies, aquatic insect larvae, insects blown in to lake
Mosquito larva	■ Consumer —filter feeder	■ Planktonic algae
Planktonic alga	Producer	■ Photosynthetic
Kingfisher	■ Consumer —carnivore	■ Small fish, yabbies and tadpoles

Part 2: Constructing food chains and food webs for a chosen ecosystem

Method A: Gather information from first hand sources

From your first-hand experiences during the field trip (taken later in this chapter), you will be required to gather any information on different organisms and their feeding relationships within one particular ecosystem. Carry out Method B to construct food chains and food webs from secondary sources, in preparation for constructing your own from the field trip.

Method B: Gather information from secondary sources

Refer to the investigation on page 18 to recall the way to obtain secondary source information. Read the background information for this task and page 34 under 'Food chains and food webs' to find possible keywords to use in an electronic search. Also use the websites provided on the Student Resource CD. Don't forget to look at a variety of different information sources for this investigation and collate your findings.

Gather information on *one* ecosystem (perhaps use the ecosystem that you may be selecting to visit for your field study later in this chapter) and attempt to create at least three food chains from the data you have. You should be able to then interconnect some of the completed food chains into food webs. If you are not sure of some feeding relationships or have gaps to fill in your food chains or webs, use information from secondary sources to complete the task. You should have at least three food chains and one food web which represent your chosen ecosystem. Arrows should be carefully placed representing the movement of energy. You do not necessarily need diagrams for each organism; using names only is satisfactory.

Analysis questions

Using your food web in Part 1:

1. Identify the longest food chain in your food web.
2. Explain why you think this is called a simplified food web.
3. Identify two producer organisms in your food web.
4. Identify two herbivores and two carnivores in your food web and list what they eat from the food web.
5. Describe the difference between food chains and food webs.

Adaptations

2.6

- ***define the term adaptation and discuss the problems associated with inferring factors of organisms as adaptations for living in a particular habitat***

Adaptations

An **adaptation** is any characteristic that increases an organism's likelihood of survival and reproduction relative to organisms that lack the characteristic. Simply, an adaptation is a feature of an organism that makes it suited to its environment. There are three types of adaptations:

- *structural*—a physical characteristic
- *physiological*—an organism's function or process
- *behavioural*—the way in which an organism acts.

Problems associated with inferring factors of organisms as adaptations for living in a particular habitat

Adaptations are characteristics that an organism has inherited and that make it suited to its environment. An organism does not intentionally look at an environment and work on changing to suit it, nor does it try to produce offspring that have these changes. An adaptation is a result of a change occurring at random when organisms reproduce a new organism.

This random difference just so happens to benefit the organism by making it more suited to the environment it lives in. There are problems associated with inferring that a particular characteristic of an organism is a direct adaptation to its habitat.

Past environments

Characteristics of present-day organisms are a product of millions of years of change; ancestors have received adaptations to survive in different habitats. An organism's current characteristics may have been inherited a long time ago when the organism existed in a different habitat. The organism may still possess that characteristic (or adaptation) but it is now not of any use or related to its survival in its current habitat. Dolphins and whales are well adapted to life in water; however, they possess lungs which are characteristic of land-dwelling animals. If these animals occupied a very different environment to that of their ancestors, then we cannot infer that the lungs are any sort of adaptation to their current environment, but one inherited from a time when they could possibly have been land-dwellers.

Studying the environment

To be able to determine if a characteristic is an adaptation, biologists need to study the organism's environment. It is difficult to relate a characteristic to a specific feature of an organism's environment when we do not know the exact habitats it has lived in over generations.

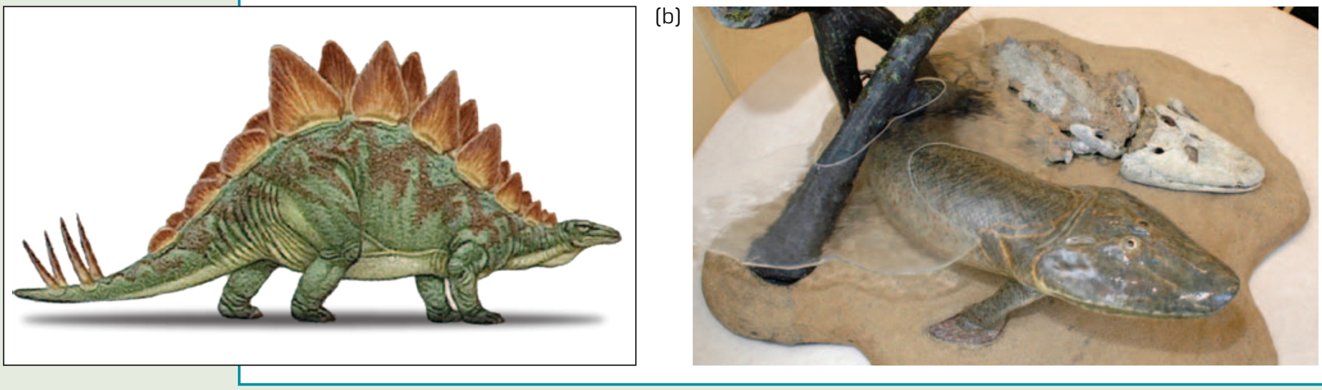
Sometimes adaptations may be obvious (like the stick insect camouflaging itself within its environment) and sometimes not. Some characteristics may have no benefit to the organism in a particular habitat, or are just not adaptations at all. It may be difficult to be certain how one characteristic benefits the organism in a particular environment.

Using fossil evidence

Interpreting the characteristics of organisms from fossil evidence in particular may lead to incorrect assumptions. For example, the extinct organism stegosaurus possessed bony plates along its back (see Fig. 2.19a). Some suggest that this characteristic was an adaptation to its competitive environment and used for defence. Others suggest it was simply used to attract mates, or perhaps even used for thermoregulation. Another more recent example is the 375 million year old fossil, the *Tiktaalik*, discovered in Arctic Canada in April 2006 (see Fig. 2.19b). The research team suggests that it is technically a fish, complete with scales and gills, but it has a flattened head like a crocodile and unusual fins that have sturdy interior bones that may have allowed it to prop itself up. Without knowing the environments it lived in, it is very difficult to suggest that these characteristics are in fact adaptations. So, we must be careful not to assume that all characteristics of organisms are adaptations to their present day habitat or environment.

Figure 2.19: (a) Bony-plated stegosaurus; (b) *Tiktaalik* fossil found in 2006

(a) (b)



Adaptations for survival in Australian ecosystems

2.7

- ***identify some adaptations of living things to factors in their environment***

Australian environments are varied and diverse with some tough conditions for organisms to survive in. The three main abiotic factors that affect survival in Australian ecosystems are water, temperature and sunlight. Australian organisms have adapted to survive harsh conditions such as lack of water, high temperatures and high exposure to sunlight. Some examples of such plant and animal adaptations are described below.

Plant adaptations

Adaptations for dry environments

Xerophytes are plants that have adapted structurally to dry environments by reducing the surface area of their leaves in order to minimise water loss.

For example:

- cactus plants like the Mexican lime cactus have small spiky leaves to reduce the loss of water and shallow, widespread roots to catch surface moisture
- the pigface, found on sand dunes, has fleshy stems which store water (see Fig 2.20a)
- eucalypts have a waxy cuticle on their leaves which reflects heat and light to minimise water loss from evaporation
- cyprus pines have tiny leaves reducing water loss through **transpiration**
- porcupine grasses roll their leaves during the hottest part of the day to allow fewer **stomata** (leaf pores) to be exposed to the dry atmosphere, therefore less water is lost through evaporation
- all spinifex species have tough, pointed and narrow leaves for reducing water loss.

Other plant adaptations

- Sclerophyllous (hard) leaves minimise water loss with a waxy or hairy surface, sunken stomata or greatly-reduced leaves (e.g. desert oak)
- Succulent leaves and stems or fleshy underground tubers store water (e.g. parakeelya)
- Deep-root systems access deep-water supplies or shallow root systems to enable the rapid uptake of moisture when it suddenly becomes available after rainfall
- Desert acacias (wattles) have leaflets that are vertically flattened and oriented towards the ground, reducing the amount of light and hence water loss.

(a)

(b)

Figure 2.20
(a) Pigface with its fleshy stems;
(b) Spinifex grass with pointed narrow leaves to reduce water loss

continued . . .

(c)

(d)

Figure 2.20
(c) Kangaroos lick their forearms to lose heat by evaporation;
(d) Spinifex hopping mouse produces concentrated urine

Animal adaptations

Lack of water

- Kangaroos do not sweat, so they avoid losing water through sweating.
- The bilby hides in burrows to reduce water loss by evaporation; most desert mammals are nocturnal to reduce exposure to daytime temperatures.
- The water-holding frog is a burrowing frog that spends the majority of its life underground. It seals itself in a waterproof cocoon made up of layers of shed skin. Water is stored in the bladder or in pockets under the skin.
- The fat-tailed dunnart (a carnivorous marsupial) does not need to drink water, it obtains it all from its food of invertebrates that it feeds on at night (it is nocturnal). Through the day it shelters in nests of grass or under logs or rocks.
- The desert mouse also does not need to drink as it gains moisture from food (it is currently on the presumed extinct list).
- The spinifex hopping mouse and some desert mammals reduce water loss from excretion by producing highly concentrated urine (see Fig 2.20b).

High temperatures

- Animals are generally small in size to reduce heat gain and loss.
- Kangaroos, such as the rat kangaroos, dilate or swell their blood vessels, bringing them close to the surface of the skin to lose heat more rapidly (called vasodilation).
- The bilby hides in burrows to reduce the temperature of the environment and lives nocturnally (it forages for food at night when it is cooler).
- The bilby has large vascular ears for extra surface area for heat loss.
- Kangaroos lick their forearms to lose heat as the evaporation of saliva draws heat from the surface (see Fig. 2.20c).

High exposure to sunlight

- Lizards constrict their bodies to reduce surface area exposed to the sun.
- Some lizards have a pale external colour to reflect sunlight, therefore reducing heat absorption.
- Kangaroos sit in the shade during the day to avoid the heat absorption from the sun (see Fig 2.20d).

Three types of adaptations

As you can see from the above adaptation examples, there is a large variety in adaptations for just one type of environment (arid), and of that variety of adaptations there are just three types: structural, physiological and behavioural. In order to understand the difference between the three adaptation types, examples are described below:

- structural—plants that have long, narrow leaf structure in order to reduce water in a desert environment
- physiological—animals that dilate or swell their blood vessels, bringing them close to the surface of the skin to lose heat more rapidly in a high-temperature environment (vasodilation)
- behavioural—animals that burrow under the ground to avoid the sun in a desert environment.

2.8 Adaptations from the local ecosystem

- ***identify and describe in detail adaptations of a plant and an animal from the local ecosystem***

The local ecosystems that may be found near Australian schools can vary quite considerably. The abiotic factors of the surrounding environment play a large part in determining the ecosystems that may exist in the area.

Some detailed examples of plant and animal adaptations found in common Australian ecosystems are described below. Later in this chapter, students are required to observe specific plant and animal adaptations from an ecosystem they selected for conducting a field study.

Mangrove forest (wetland)

Plant adaptations—mangroves

Mangroves use their roots, leaves and reproductive methods in order to survive in a harsh, changing intertidal environment of low-oxygen (and soft) soils and saline conditions (see Fig. 2.21).

Roots

Mangroves live in shifting environments where tides and floods constantly move the mud in which they live, destabilising the trees. Some mangrove species have pneumatophores (aerial roots) which are filled with spongy tissue and small holes that provide structural support and transfer oxygen from the air to the roots trapped below the ground in low-oxygen soil. The roots are also adapted to prevent the intake of a high amount of salt from the water.

Leaves

Some types of mangroves have leaves with glands that excrete salt. Grey mangroves can tolerate the storage of large amounts of salt in their leaves which are later dropped when the amount of salt gets too high. Mangroves can restrict the opening of their stomata, pores in the leaves responsible for regulating the exchange of gases and water during photosynthesis. This conserves fresh water within the leaves which is vital for survival in a saline environment. Mangroves are also able to reduce the leaf surface exposure to the hot sun by turning leaves side-on. This reduces excess water loss through evaporation.

TR

Mangrove adaptations—field trip material

Figure 2.21 Mangrove adaptations: (a) pneumatophores (aerial roots); (b) leaves release salt; (c) seeds germinate before dropping from the parent tree, roots establish once they land in mud

Seeds

Some mangrove species are **viviparous**, meaning they retain their seeds until they have germinated (shoot). When dropped into the water from the parent tree, the seed is able to remain dormant (some surviving after a year at sea) until it finds soil when it is immediately ready to put out roots. Other mangrove species produce seeds that float, so the tide assists in the dispersal, avoiding the overcrowding of young plants.

(a)

(b)

(c)

Animal adaptations—mangrove crabs

Mangrove crabs burrow into the soft mud to gain protection from both dehydration and predators. They use the water in their burrows to keep their gills moist and keep away from the hot sun.

Figure 2.22 A male fiddler crab can be distinguished by its single large claw

Examples of mangrove crab species

The male fiddler crab has a distinctive single large claw (see Fig. 2.22). It burrows in the intertidal zone and as the tides recedes it comes out to feed on algae, microbes and organic matter. Sometimes it may drag leaf litter into its burrow to be eaten.

The red crab is nocturnal, leaving its burrow at night to feed on fallen mangrove leaves. The burrow leaves a large distinctive hole in the soft mud under trees at the back of the mangroves.

Competing for resources

2.9

- ***describe and explain the short-term and long-term consequences on the ecosystem of species competing for resources***

Competition

When in competition two organisms use one or more resources in common, such as food, shelter and mates. The competition is so the organism can acquire a limited factor in the environment. For example, plants compete for factors such as water, light, carbon dioxide and minerals. Organisms may compete with members of their own species or members of another species. Competition between members of the same species is called **intraspecific competition** (see Fig. 2.23). Competition between members of different species is called **interspecific competition** (see Fig. 2.24). Usually interspecific competition is less intense than intraspecific competition. This is most likely due to members of the same species having far more resource needs in common to compete for.

L. C. Birch, a zoologist from the University of Sydney ('The meanings of competition', *American Naturalist*, 1957), defined two types of competition: **resource competition**, where organisms utilise a resource that is in short supply; and **interference competition**, where organisms harm each other while obtaining a resource, even if that is not in limited supply.

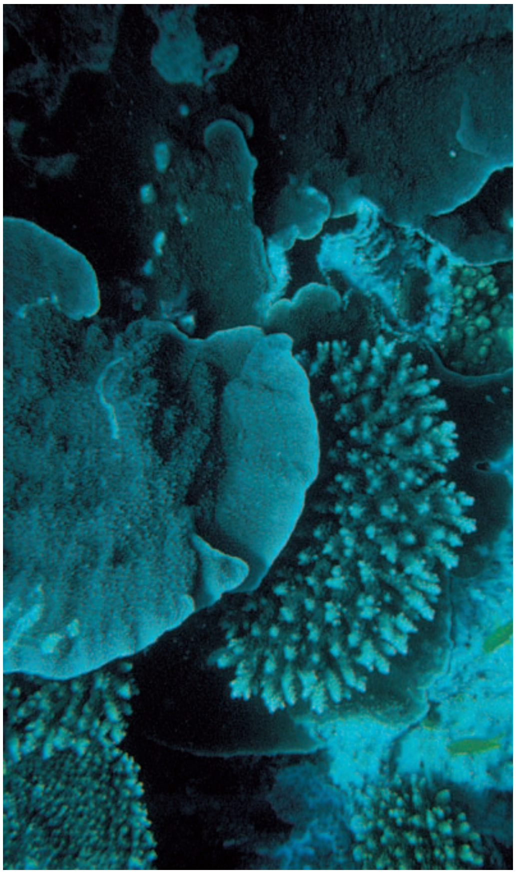


Figure 2.23 Coral on the Great Barrier Reef—one species shades its neighbour as they compete for light

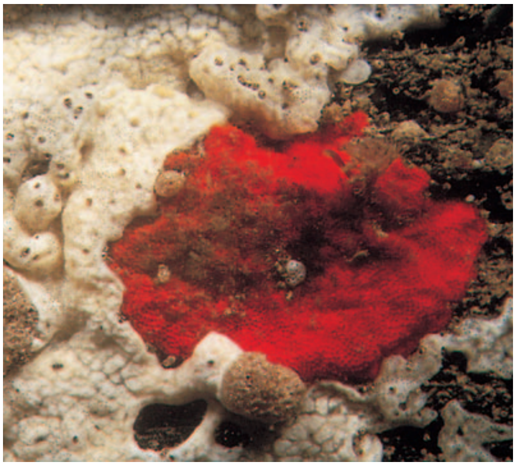


Figure 2.24 Two species in the subtidal zone of a southeastern Australian seashore aggressively compete for space—the white ascidian species is enveloping the red bryozoan species and will eventually overgrow and kill it

Plants

Individuals compete for a range of resources. Plants compete with other nearby plants for soil nutrients, water and space or for access to sunlight. Some plants are better able to compete than others in certain parts of ecosystems. These species exclude their competitors from that part of the ecosystem. As discussed earlier (see page 28) some plants secrete allopathic chemicals into the soil to inhibit the growth of or kill other nearby plants.

Animals

Animals compete for a number of different resources within an ecosystem. Animals may compete for mates from the same species. Animals also compete with the same and other species for:

- food
- shelter or hiding places to avoid predators
- shelter or hiding places in defence of territory or young
- shelter for nest sites.

Animals possess various defence mechanisms which may be used in intraspecific and/or interspecific competition. Some can attack intruders using teeth, claws, stingers and/or chemical means. Some use camouflage to hide such as the flower spider (see Fig. 2.25), while others use **mimicry** to resemble dangerous or unpalatable species (see Fig. 2.26). Noxious or unpalatable species, such as some frogs and butterflies, actually advertise that fact with warning colouration such as spots or stripes in bright colours (see Fig. 2.27).

Figure 2.25 The flower spider (*Thomisus spectabilis*) hides through the use of camouflage

Figure 2.26 The blue poison arrow frog

Figure 2.27 (a) The Australian frog *Pseudophryne corroborree* is distinctly coloured gold with black stripes; (b) The monarch butterfly advertises its unpalatability by warning colouration

(a)

(b)

Effect of competition on populations

Organisms in competition will affect population numbers due to the impact on reproduction and survival rates. Population fluctuations can be directly linked to the competing species and their resource. Figure 2.28 illustrates the fluctuations in abundance that may occur in species competing for a resource. If the resource is a common food source, for example, as food sources become more readily available the abundance of both species increases (see Fig. 2.28: 1967–1968). As food sources decrease so may the abundance of both competing species (see Fig. 2.28: 1968–1969).

In some cases, some species may be better competitors than others. In the 1950s, Birch conducted an experiment observing the population sizes of two species of grain beetles. When the species were sharing the same environment, one species was always driven to very low numbers or became extinct (see Fig. 2.2a). Individuals of the less successful species were out-competed for food by individuals of the species that eventually replaced it. Interestingly, Birch was able to reverse this outcome simply by adjusting one aspect of the beetles' environment, temperature.

Consequences of competition on the ecosystem

Short-term consequences

When two species compete for a resource, the short-term effect is a decrease in population numbers. In most instances, one species is more successful than the other and so one species finds that their population numbers have dropped more significantly than the other (due to an increase in deaths and a decrease in reproduction rates). Depending on the continued success of this one species over the other, this trend may continue. However, depending on the supply of the resource they are competing for, the ability of the 'losing' species to adapt by occupying a different niche, or other environmental factors (i.e. temperature), this trend may change (or even reverse as Birch demonstrated).

Long-term consequences

If the trend of one species successfully out-competing another species continues, the long periods of decreased reproduction rates and increased deaths will eventually lead to the elimination of the 'losing' species in that area, and on the larger scale to possible extinction.

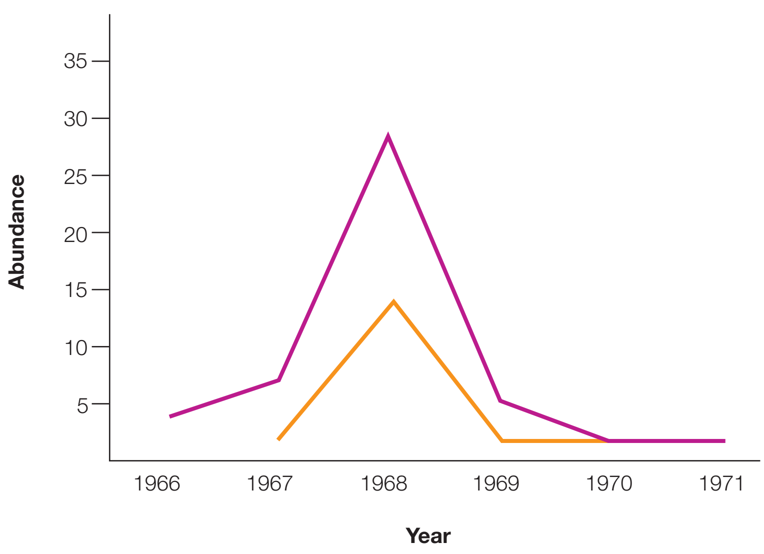


Figure 2.28 Fluctuations in populations of the long-haired rat (*Rattus vilosissimus*) and the spinifex hopping mouse (*Notomys alexis*)

TR

Extension activity

2.10 The impact of humans

■ ***identify the impact of humans in the ecosystem studied***

SR TR

Student activity—human impact

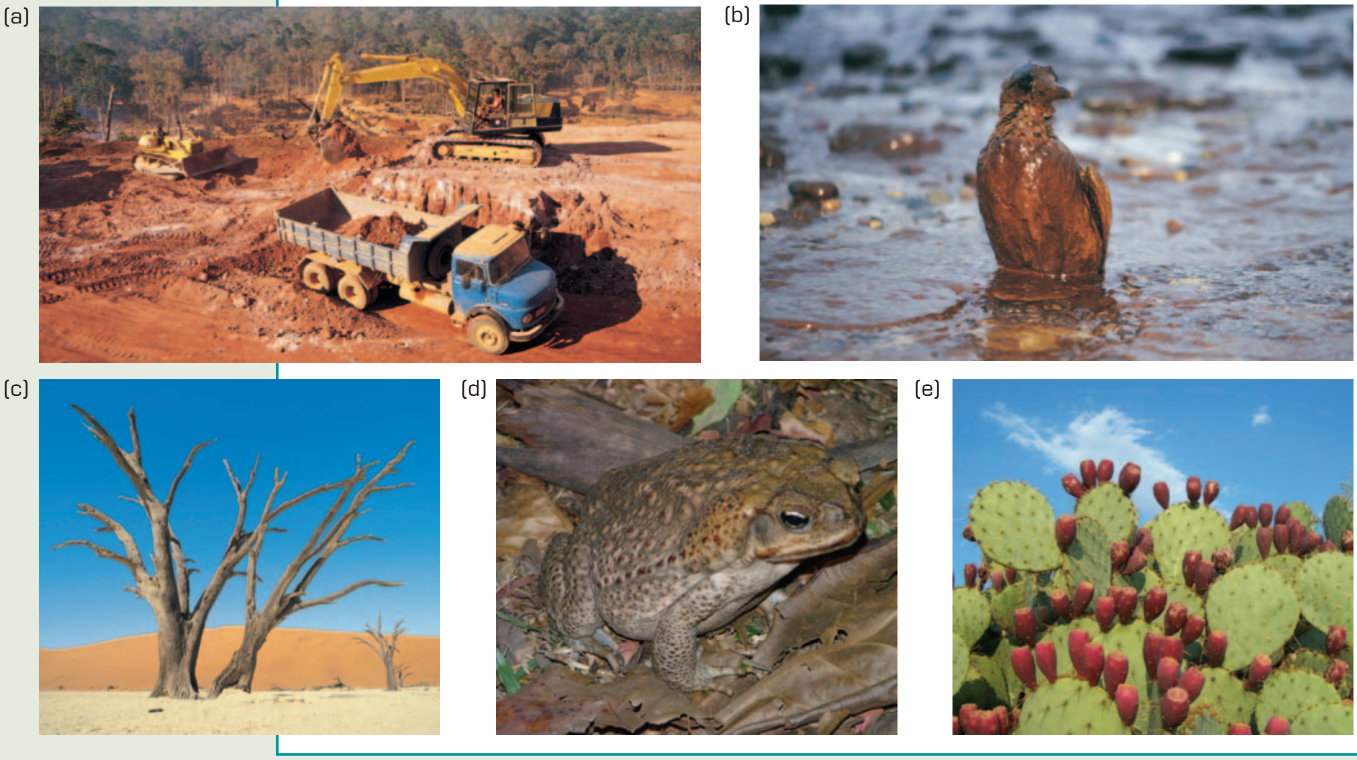
There are three broad types of ecosystems that vary in impact by humans: urban, rural and natural ecosystems. Of course in this chapter we have only been discussing natural ecosystems; however, the human impact on urban and rural ecosystems is significant. The ecosystem that you choose to study may be influenced by urban or rural development alone or perhaps even both. You may observe small pieces of evidence such as rubbish or erosion from walkers which have a small impact on the environment, but it may be distracting you from a larger impact that is not easily observed. Some or many of the examples of human impact below may exist in your ecosystem. You may not be able to see the impact directly; however, evidence of it may be easily observed when visiting the site. Further research into the area studied may provide examples that you have not been able to source directly from the site.

Examples of human impact

(See Fig. 2.29.)

- Land clearance and habitat fragmentation (e.g. clearing of large areas of ecosystems)
- Slash and burn agriculture (e.g. clearing with burning)
- Integrated pest management (e.g. use of pesticides, biological controls)
- Land and water degradation (e.g. poor waste management, dams, irrigation runoff, roads, mining)
- Erosion (e.g. livestock, clearing/ ploughing, roads, housing development)
- Soil acidification (e.g. chemical runoff into soil water)
- Soil and water salinity (e.g. irrigation runoff)
- Polluting the atmosphere (e.g. industrial gases, vehicle emissions)
- Introduced species (e.g. fox, rabbit, cane toad, lantana, Paterson's curse, prickly pear).

Figure 2.29 Examples of human impact: (a) land clearing; (b) oil pollution; (c) salinity; (d) cane toad (*Bufo marinus*); (e) prickly pear (*Opuntia*)



Application of a biological control and its affect on society and the environment

Table 2.2 describes an example of an application of biology, a biological control using cane toads, and its affect on society and the environment.

Using the same table format practise applying PFA P4 to another example such as the prickly pear (see Fig. 2.29e).

PFA
P4

Table 2.2 Application of biology affecting society and the environment

Example	Historical background	How increases in our understanding in biology have led to the development of useful technologies	Relevance, usefulness and the applicability of biological concepts and principles, and the affect on Australian society and the environment	Contribution made to Australian society
Cane toad (*Bufo marinus*) (see Fig. 2.29d)	Cane toads have been present in Australia for nearly 70 years. They were introduced to Queensland in 1935, when approximately 100 individuals were imported from Hawaii in an attempt to control cane beetles. The larvae of French's cane beetle and the greyback cane beetle (*Dermolepida albohirtum*) eat the roots of sugar cane and kill or stunt the plants; they are pests of the sugar cane industry.	Biologists discovered a way of avoiding the use of chemicals (pesticides) to eradicate pests through the use of biological controls. A biological control involves the use of natural predators to decrease a prey population. This particular application of a biological intervention, where the cane toad was thought to be a natural predator of the cane beetle, aimed to reduce the population of cane beetles in sugar cane crops.	Within six months of introducing the 100 cane toads, over 60 000 young toads had been produced. Having no natural enemies, the cane toad became a predator of Australia's native small mammals and thrived in its new environment, spreading rapidly to other areas of Australia (the Northern Territory and New South Wales). They are now a major threat to native animals on the far north coast of New South Wales. Estimated rates of spread vary from between 1 to 5 km per year in northern New South Wales to approximately 60 km per year in the Northern Territory. The cane toad produces in its glands a toxic poison which is detrimental to most animals when exposed to it. It can cause death in small animals (e.g. domestic cats). This has been commonly described as one of Australia's major biological disasters. Not only has it had a major adverse impact on the environment but also on the community—the cost of eradication, attempts at control, and the long-term damage to native species populations.	The failure of this biological application has increased our understanding of the potential dangers of implementing biological controls without extensive prior research into possible interactions with native populations. It has contributed to our understanding for future use of biological controls in Australia.

TR

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SR TR

Student worksheet—introduced species

Threatened species

The nationally endangered Baw Baw frog (*Philoria frosti*) (see Fig. 2.30) is only found in a small area comprising 135 square kilometres on the Baw Baw Plateau in the Central Highlands of Victoria. This native frog requires a special habitat, breeding in wet areas of subalpine heathland, montane wet forest and cool temperate rainforests. It lays a small clutch of unpigmented eggs within natural cavities under dense vegetation, soil, rocks or logs. In the non-breeding season the frogs move away from wet breeding habitats, sheltering in terrestrial habitats beneath dense vegetation, roots, logs, rocks and leaf litter. These non-breeding sites provide protection from extreme weather conditions. The species has suffered a significant decline in population numbers over the past 15 years, particularly from high-elevation habitats. Likely reasons for the frog's decline include the introduction of an exotic fungus and climatic change. Timber harvesting activities may also threaten remaining populations of the frog due to effects such as habitat destruction and fragmentation or pollution.

Biodiversity

Biodiversity refers to the variety of all forms of life, the diversity of the characteristics they contain and the ecosystems of which they are components. Characteristic diversity within a species is what allows populations to adapt to changes in the environment.

Globally, species are rapidly becoming extinct at the rate of 1000 to 10 000 times the natural rate and it has been estimated that 20 per cent of all species are likely to become extinct in the next 30 years. In Australia, 80 per cent of species are unique to Australia. Over 1150 plant species are endangered and about 145 species of birds, reptiles and mammals are endangered. In total, 27 Australian mammals have become extinct since European settlement. Many mammals were from arid areas but their populations were decimated by altered fire regimes and introduced species. It is predicted that if there is not a rapid change in patterns of land use then up to 50 per cent of bird species in Australia will become extinct within 100 years.

Most of the types of human impact listed above directly affect the biodiversity that exists in Australian ecosystems.

Figure 2.30 Baw Baw frog (*Philoria frosti*)—a threatened species

Conservation of biodiversity

Organisms and their roles are essential for ecosystem survival. Species interactions are complex and the loss of key species can have a substantial impact on ecosystems. Should one species disappear others which depend on it for food or shelter may struggle to survive, setting in motion a domino effect within that environment. For example, cassowaries are birds that have an important role in eating rainforest fruit so that rainforest tree species can be dispersed (see Fig. 1.6e on page 241). Cassowaries are threatened due to rainforest clearing and introduced species. This means that, if cassowaries disappear, some rainforest plant species will lack a medium for seed dispersal and struggle to survive.

Reasons for conserving biodiversity are:

- for bioresources such as food, fibre, medicines, timber etc. Australia has only identified 15 per cent of all its animals and plants. The potential of any undiscovered bioresources is significant. For example, ants possess specialised glands for producing antibiotics to reduce disease in their colonies. These discoveries hold great potential for therapeutic use
- humans enjoy the beauty of the natural environment and countries like to conserve their heritage to be passed down to future generations
- ethically all species have a right to exist just as humans do
- ecosystems underpin many of our natural resources and provide services such as clean water, healthy soil and pollination for crops.

SR TR

Classroom activity—endangered and introduced species

Field study of a local ecosystem

FIRST-HAND INVESTIGATION

BIOLOGY SKILLS

P11.1; P11.3
P12
P13
P14.1

Background

Choose a terrestrial or aquatic ecosystem that is convenient and easy to get to. This ecosystem may range from a woodland, rainforest, mangrove area or rock platform. Take extra care when studying tidal, or wave-exposed areas. The type of ecosystem chosen will affect the sort of equipment and resources needed to undertake the field study. To complete all of the data collection it is more efficient to work in small groups. Once the group is selected each group member should equally share the workload by dividing up the roles. Students are responsible for carrying out their own background research on the chosen ecosystem, and creating their own graphs after data collection. Follow-up work back in the classroom will be necessary. All the data from your group needs to be collated and distributed amongst the group members ready for individual presentation and analysis of the data. Materials usually needed for this type of field study are a map of the area, field guides of the area if available, lined and blank paper for taking notes and data collection, a clipboard or folder, pencils and pens, pre-drawn plots and tables for completion, field study task information, and equipment for specific data collection.

Take care while in the field study area. Bring sunscreen, a hat, insect repellent and wear long sleeves to avoid insect bites.

Minimise environmental damage by collecting data in the field and returning to the lab to conduct chemical tests (e.g. pH and salinity tests). Also choose where you walk carefully and replace rocks or anything you disturb to minimise the physical damage and impact on the ecosystem.

Figure 2.31 Students embarking on a rock platform field study near Sydney

Part 1: Preparation prior to field trip (refer to checklist on page 57, Table 2.5)

- ***choose equipment or resources and undertake a field study of a local terrestrial or aquatic ecosystem to identify data sources and:***
  —identify data sources and gather data by:
  –tabulation of data collected in the study
  –calculation of mean values with ranges
  —graphing changes with time in the measured abiotic data

TR

Risk assessment sheet

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A. Measuring abiotic factors

—measure abiotic variables in the ecosystem being studied using appropriate instruments and relate this data to the distribution of organisms

Once you have selected the aquatic or terrestrial ecosystem that you will study use Table 1.3 provided on page 6 to determine what possible abiotic tests you may need to conduct and list the equipment needed to carry this out in the field. Think about why you choose particular types of equipment over others. Write up the method you will need to follow to complete these tests when out in the field. If you have data loggers and sensors for each type of test then it will be much easier and quicker to collect data. However, data loggers and their probes/sensors are not essential for carrying out the field study data collection. Simple equipment from the lab is just as effective in obtaining data for this study. Streamwatch kits may also be useful.

Construct tables ready for entering data once out in the field. You must include a number of time measurements, the range (lowest to highest value) and mean values (average over a set time period). Choose time intervals depending upon time available at the site. Some suggestions are provided in Table 2.3.

Draft a graph to scale ready to plot points after data collection. Use time as the horizontal axis and each abiotic measurement scale as the vertical axis. Plot all zones for each abiotic factor on the one graph. Think of a title for each graph and label all axes with a name and units of measurement (see Fig. 2.32 on page 54).

Table 2.3 Measuring abiotic factors

Abiotic factor	Equipment used and units	Time measurements (0, 30 and 60 min)	Zone 1	Zone 2	Zone 3	Trend across zones
Air temperature	Thermometer (°C) or a data logger and sensor	1st (0 min—initial reading)				
		2nd (after 30 min)				
		3rd (after 60 min)				
		Range				
		Mean				
Soil temperature	Thermometer (°C) or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Water temperature	Thermometer (°C) or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Humidity	Hygrometer or a wet and dry bulb thermometer (°C) comparison	1st				
		2nd				
		3rd				
		Range				
		Mean				

Abiotic factor	Equipment used and units	Time measurements (0, 30 and 60 min)	Zone 1	Zone 2	Zone 3	Trend across zones
Air pressure	Barometer (hPa)	1st				
		2nd				
		3rd				
		Range				
		Mean				
Wind speed	Wind speed meter (ms^{-1} or an impression scale 1–5)	1st				
		2nd				
		3rd				
		Range				
		Mean				
Light intensity	Light meter (lux or an impression scale 1–5) or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Soil pH	Universal indicator or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Water pH	Universal indicator or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Soil salinity	Silver nitrate (test for chlorides), hydrochloric acid (test for carbonates), barium chloride (test for sulfates) or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				
Water salinity	Silver nitrate (test for chlorides), hydrochloric acid (test for carbonates), barium chloride (test for sulfates) or a data logger and sensor	1st				
		2nd				
		3rd				
		Range				
		Mean				

B. Estimating abundance and distribution

—estimate the size of a plant population and an animal population in the ecosystem using transects and/or random quadrats

Choose the plant and animal species that you will be attempting to estimate both the population size and distribution of (you may need to do some prior research or get assistance from your teacher).

Population size (abundance)

Using the information provided in Section 1.5 (page 13) select which technique you are going to use to estimate the size of the chosen plant and animal population in your ecosystem (e.g. random quadrats). Once the technique has been chosen list the equipment required to carry this out in the field and write up the method.

Construct transect and/or quadrat plots and tables ready for data collection out in the field. Use the information below as an example.

Plant population size

If you choose to use quadrats for estimating population size ensure that they are randomly placed in each zone and the size of each quadrat is recorded (e.g. 1 m^2). Use a key to indicate different species. Determine how many quadrats you will record for each zone. You may only have time for one or two. Draw up a table to include the number of quadrat recordings you will make with space allocated for the mean, range and total values (see Table 2.4). You will also need a rough estimate of the size of the area you have chosen.

Animal population size

Depending upon the ecosystem you have chosen you may be able to use quadrats again to estimate the abundance of sedentary or slow-moving animals such as barnacles on a rock platform. However, if you have chosen other methods it will involve prior preparation (discuss this with your teacher) and the use of the mark–release–recapture formula to assist in the calculation of abundance.

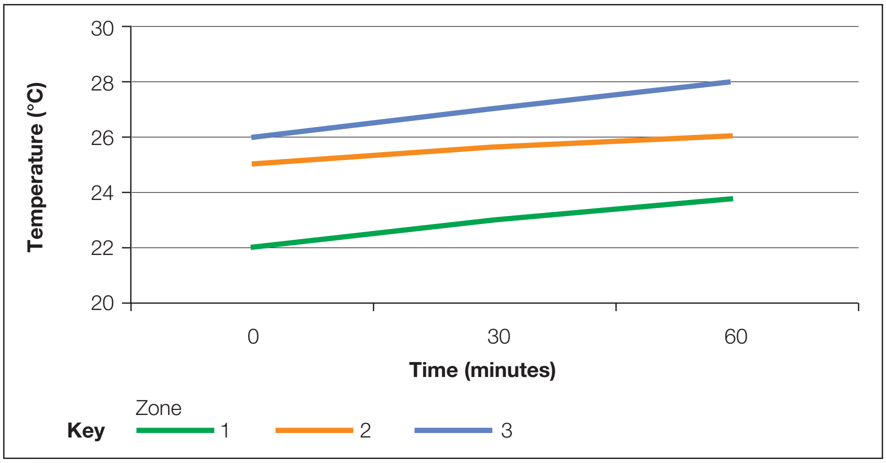


Figure 2.32 Temperature change over 60 minutes in the three zones of a mangrove ecosystem

Table 2.4 Population size calculation table

	Plant Percentage cover/counts	Animal Percentage cover/counts
Zone 1 quadrat		
Zone 2 quadrat		
Zone 3 quadrat		
Zone 4 quadrat		
Trend across zones		
Mean value		
Range across zones		
Size of area (m^2)		
Total area abundance estimate (mean × size of area in m^2)		

Species distribution

—collect, analyse and present data to describe the distribution of the plant and animal species whose abundance has been estimated

Using the information provided in Section 1.4, select technique for describing the distribution of your chosen plant and animal species. Now list the equipment and resources needed to carry this out in the field and write up the method.

Construct the chosen plots (profile sketch or transect) that you will be using to record the distribution of a plant and animal species.

Suggestions

- *Profile sketch* (see Fig. 2.33)—complete the profile sketch across all of the zones. Carefully choose a key for the species and indicate the scale used (e.g. 1 cm = 1 m).
- *Transect* (see Fig. 2.34)—mark the transect line with string, or preferably measuring tape, to pass through a representative area of the ecosystem (include all possible zones). Draw the organisms present in the 1 m width of the marked transect line across all of the zones. Carefully choose a key for the species and indicate the scale used (e.g. 1 cm = 1 m).

C. Trophic interactions

- ***outline factors that affect numbers in predator and prey populations in the area studied***
- ***gather information from first-hand and secondary sources to construct food chains and food webs to illustrate the relationships between member species in an ecosystem***
  —describe two trophic interactions found between organisms in the area studied

Students will need to revise the material on trophic interactions (see Section 2.5 pages 33–9 and Section 2.2 pages 25–7) to make sure that they understand the different types of feeding relationships (in particular predator–prey relationships) and how to construct food chains and webs from feeding information. It is recommended that students research possible organisms and food webs that may exist in their chosen type of ecosystem. This will assist in providing feeding relationship information that may not be easily be sourced during data collection at the study site.

D. Adaptations

- ***identify and describe in detail adaptations of a plant and an animal from the local ecosystem***

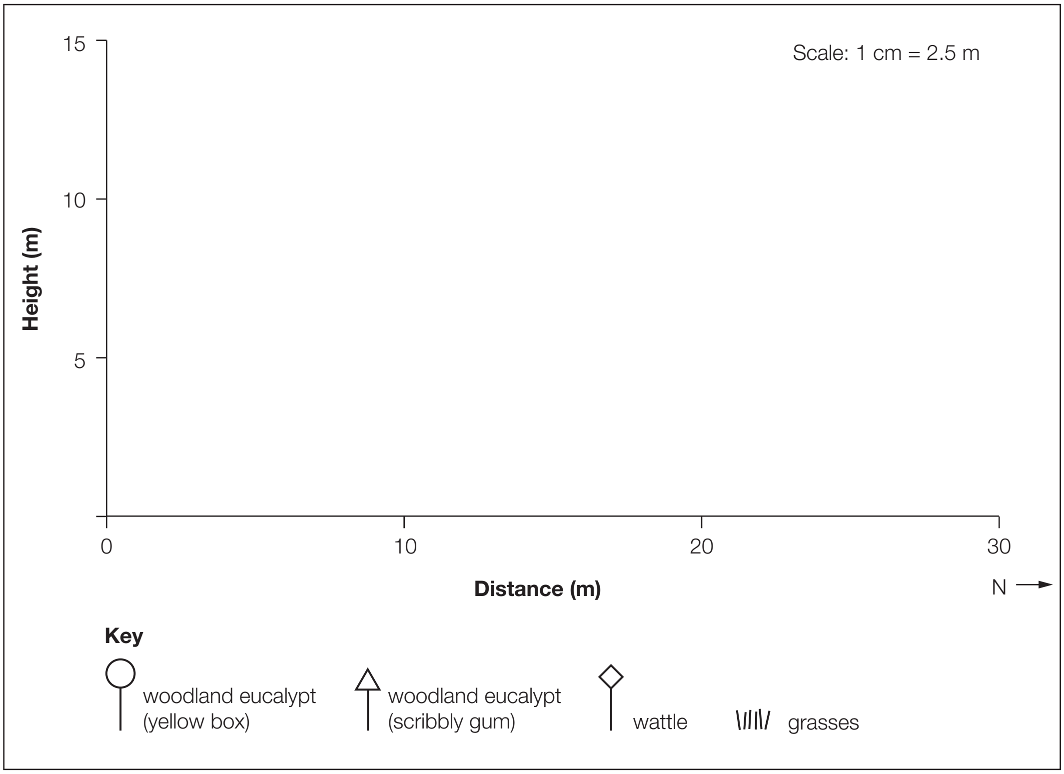
Prior research will assist students in looking at the types of adaptations that may exist in their chosen ecosystem (see Sections 2.7 and 2.8 pages 41–4). With this in mind, students may find it easier to identify and describe in detail the adaptations of a named plant and animal once out at the field study site.

E. Human impact

- ***identify the impact of humans in the ecosystem studied***

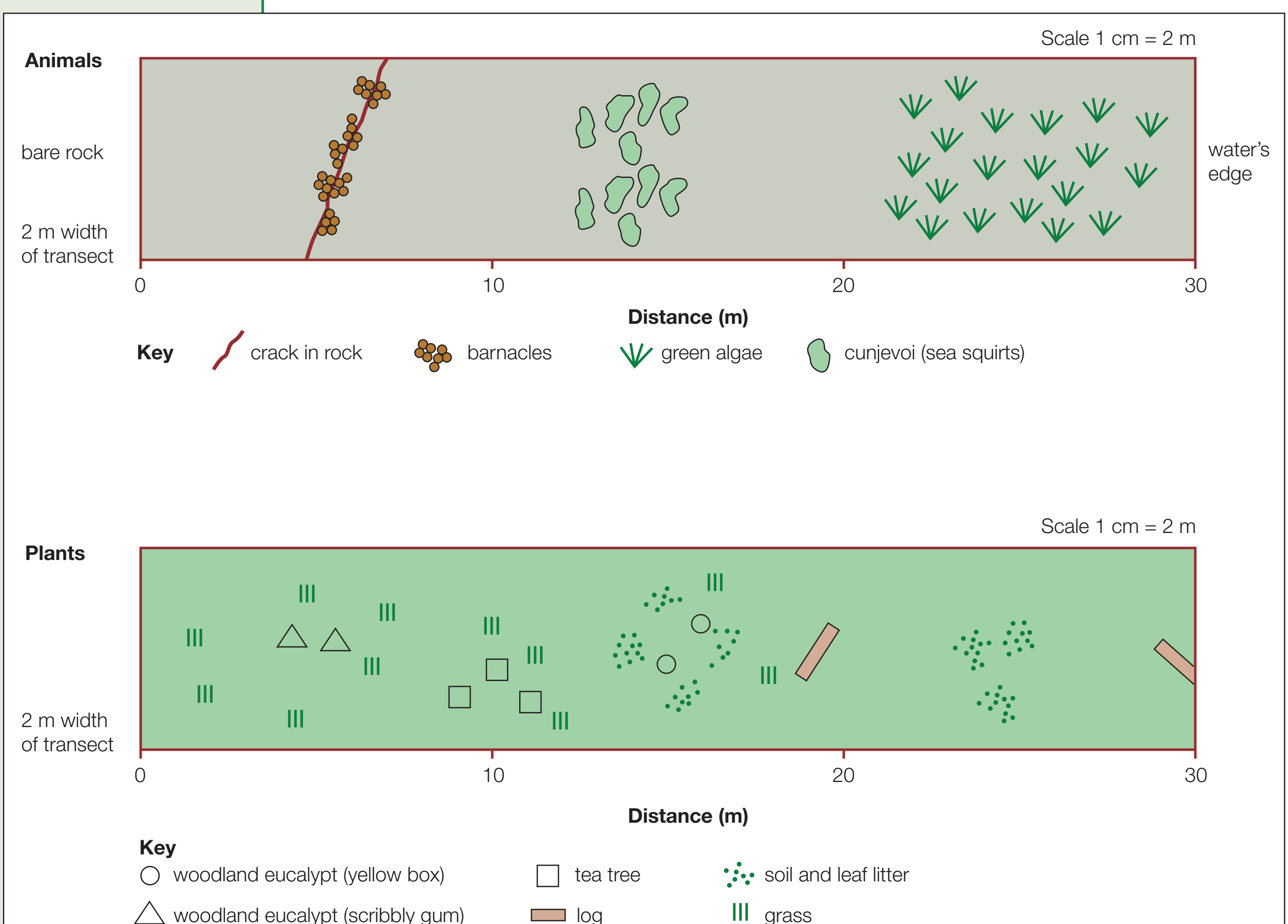
A revision of examples of human impact and the need to look for evidence showing their occurrence (see page 48) will be of assistance. Preparing a list of possible evidence indicating human impact will assist you in knowing what to look for once out at the site. Prior research into the chosen study site may indicate more hidden but large-scale human impact factors, such as nearby industry. It may also provide the history of the area, examples of previous human impact and any changes occurring in recent years.

Figure 2.33 A blank profile sketch ready to use for your chosen ecosystem



A blank profile sketch

Figure 2.34 An example of transect plots



Checklist prior to data collection in the field

You should now have completed the following tasks prior to data collection in the field:

Part 1	Task	Check ✔
General information	■ Name of ecosystem chosen for field study ■ Map of the chosen area ■ Optional field guides to the area	
Method	■ Method written for conducting abiotic tests (including equipment used and units of measurement)	
Data collection preparation		
A. Measuring abiotic factors	■ Table constructed for measuring abiotic factors (including mean values and ranges) ■ Graphs drafted to scale using correct axes fully labelled and titles	
B. Estimating abundance	■ Method written including techniques chosen to estimate the size of the chosen plant and animal population and equipment required ■ Construct transect and/or quadrat plots and tables ready for data collection	
B. Estimating distribution	■ Method written including techniques chosen to measure distribution of the chosen plant and animal population and equipment required ■ Construct transect and/or profile sketches ready for data collection	
C. Trophic interactions	■ Revise Section 2.5 and the construction of food chains and webs ■ Research feeding relationships and food webs in your type of ecosystem	
D. Adaptations	■ Research the types of adaptations and examples that may occur in your type of ecosystem	
E. Human impact	■ Prepare a list of evidence that may indicate human impact to look for at the site ■ Research the actual chosen site and its exposure to recent human impact	

Table 2.5 Checklist for tasks to do prior to field trip

Table 2.5

Note: This is a rough guide in attempting to be as prepared as possible prior to visiting the field study site. If you are unable to complete all of the above tasks in preparation for the field trip much of this can be attempted by sourcing the information while on site. However, you must be aware of the time constraints during the actual site visit and be very organised in order to complete all data collection at the time. Remember, you may not get the chance to return to the site afterwards.

Part 2: Data collection out in the field

Once you have arrived at your field study site write a short description of the area (i.e. weather conditions, slope, aspect). Mark on your map of the area the position of the field study site. Study groups should make effective use of time by sharing the collection of data.

A. Measuring abiotic factors

Once you have marked out the site and determined the zones, start collecting abiotic data and completing your tables. Remember that these measurements are to be repeated a number of times at set time intervals while at the site. In between measurements other tasks can be completed such as estimating abundance and distribution. If you have time, plot a graph for each abiotic characteristic you measured showing the abiotic factor on the vertical axis (y-axis) and the time along the horizontal axis (x-axis). Time measurements for the different zones are to be plotted on the one graph. You will need to provide a key to identify each zone (see Fig. 2.32). Each axis must be to scale, fully labelled and the graph title must be provided. You may choose to hand draw each graph using graph paper or it can be easily plotted using Microsoft Excel, data loggers or other graphing programs.

B. Estimating abundance and distribution

Start collecting your abundance and distribution data for a plant and animal population.

Note: You may need to re-do some of your plots if messy or incomplete when back in the classroom. Present to scale (with a key for organisms) when drawing a quadrat, profile sketch or transect.

Throughout your data collection, note any observations or evidence of animals in the area (this obviously requires you to move and work quietly during data collection). After data collection, complete Table 2.6 for animal and plant species observed in the area. You may need to use relevant field guides for the area to identify some species. You may ask your teacher for assistance or write a brief description (or take a photograph) to use for identification when back in the classroom.

Table 2.6: Animal and plant species in the area

Animal species	Plant species

Mangrove adaptations—field study material

C. Trophic interactions

Select two examples of organisms interacting in a feeding relationship and complete Table 2.7 below. Select at least one predator–prey relationship.

Factors that affect numbers in predator and prey populations in the area

Use the lists of organisms and relationships that you have completed in Tables 2.6 and 2.7 to outline at least three factors that may affect the numbers of predators and preys in your area. Refer to page 27: 'Factors affecting numbers of predator and prey populations' for examples.

Food chains and web

Using your list of animal and plant species in the area, construct at least three possible food chains (include three organisms or trophic levels in each).

Using the food chains you have just completed, construct a simplified food web for the ecosystem you studied. Be careful to place all arrows correctly. You may need to conduct further research of secondary sources to complete this task.

D. Adaptations

Give two examples of plants and two examples of animals from any zone that show specific adaptation to your ecosystem. Outline the problem and how they appear to have adapted to it.

E. Human impact

Identify any evidence of human impact in the area (at least three) and describe the possible long-term effects of each of these on the ecosystem. Describe possible solutions for two of these problems.

Checklist at field study site

Before you leave your field study site, use the checklist (see Table 2.8) to ensure that all tasks have been completed.

Table 2.7 Organisms in feeding relationships

Organism 1	Organism 2	Description of trophic (feeding) interaction
E.g. Kookaburra	*Worm*	*Predator-prey relationship: carnivore kookaburra consumes the worm*

Table 2.8 Field study site checklist

Part 2	**Task**	**Check ✔**
General information	■ General description of the area ■ Mark area studied on site map ■ List members of group sharing data collection	
Data collection		
A. Measuring abiotic factors	■ Complete abiotic factors table (and graphs if time permits)	
B. Estimating abundance and distribution	■ Measure chosen plant and animal population size by conducting transect and/or quadrats plots ■ Measure distribution of the chosen plant and animal population by conducting transect and/or profile sketches	
C. Trophic interactions	■ Complete list of plant and animals species observed in your area ■ Describe two trophic interactions between organisms in your area ■ Outline three factors that may affect the numbers of predators and preys in your area ■ Construct three food chains (including at least three organisms) from your area ■ Construct a simple food web for organisms in your area	
D. Adaptations	■ Give two examples of plants and two examples of animals that show specific adaptation to your ecosystem	
E. Human impact	■ Identify evidence of human impact (at least three) in the area and describe the possible long-term effects of each of these on the area. Describe possible solutions for two of these problems	

TR

Table 2.8

Part 3: Back in the classroom—data analysis and report presentation

- ***examine trends in population estimates for some plant and animal species within an ecosystem***
- ***process and analyse information and present a report of the investigation of an ecosystem in which the purpose is introduced, the methods described and the results shown graphically and use available evidence to discuss their relevance***
  —collect, analyse and present data to describe the distribution of the plant and animal species whose abundance has been estimated
  —identify data sources and gather, present and analyse data by:
    –tabulation of data collected in the study
    –calculation of mean values with ranges
    –graphic changes with time in the measured abiotic data
    –evaluating variability in measurements made during scientific investigations

TR

Sample field study assessment task

Background

After each group has completed the data collection from the field study, and students have processed, presented and analysed data, each student must work individually in writing a report.

Process and analyse information

Process and analyse the information from the field study data collection so that it is ready to present in report format. You need to have completed all tasks from your field study (Parts 1 and 2) in order to complete this report.

Present a report of the investigation of an ecosystem

Part 3 is basically a presentation of your findings from Parts 1 and 2, looking at trends found and their relevance. Using scientific writing and format, write a scientific report for your investigation of your chosen ecosystem. Start with the subheadings of:

Aim

- Give a clear description of the aims of the field study.

Method

- Give a brief description of the methods used during the investigation.
- Use subheadings for method sections (e.g. measuring abiotic factors).

Results

- Write a concise paragraph describing the general characteristics of the area.
- Provide a map of the area with the position of your study area marked on it.
- Provide a clear and accurate profile sketch and/or transect drawn to scale with a key for identifying symbols.
- Provide clear and accurate tables of results from population size estimates using quadrats and abiotic measurements. Check that all mean value calculations have been fully completed, including the range.
- Plot a graph for each abiotic characteristic you measured showing any variation between zones.
- Provide a description of two trophic interactions found between organisms in the ecosystem.
- Outline factors that may affect the numbers of predators and prey in your area
- Draw three food chains from your ecosystem and a food web you have devised from all information collected on organisms in the area. Ensure that arrows are drawn in the right direction and clearly placed between all organism feeding interactions.
- Give two examples of plants and two examples of animals from any zone that show specific adaptation to your ecosystem. Outline the problem and how they appear to have adapted to it.
- Identify evidence for two examples of human impact in the area and the possible long-term effects.

Discussion/conclusion (discussion of trends found in results and their relevance)

- Describe trends occurring in each of the abiotic factors across the three zones.
- Describe what your data tells us about the distribution of the plant and animal species in your area.
- Discuss the possible relevance of abiotic factors in contributing to the population size of the plant and animal species you estimated and the distribution of these across the study area.
- Discuss how some organisms in your area have adapted to the conditions of the environment.
- Make two recommendations as solutions to identified problems of human impact on the area.
- Explain how these solutions may maintain the natural balance of the abundance and distribution of species in your ecosystem.

Analysis questions

■ *evaluating variability in measurements made during scientific investigations*

1. Do your abiotic measurements vary significantly over time? Look at your range of values and mean value.
2. (a) Are your group measurements the same as other groups?
   (b) Could this be due to other abiotic or biotic changes or do you think the trend is a valid one?
3. Was human error possibly involved? Discuss.
4. Were the instruments accurate and calibrated carefully?
5. Did you choose the most accurate equipment and method for the measurements you conducted?
6. Suggest how your methods could be adjusted to increase accuracy.

http://members.optusnet.com.au/-janewest000/Mangrove/home.htm
A virtual field trip of mangroves

SR TR

Websites with extension activities

REVISION QUESTIONS

1. Outline the factors that affect numbers in predator–prey populations in an area.
2. Identify one example of allelopathy, parasitism, mutualism and commensalism in an ecosystem and briefly describe the role of organisms in each type of relationship.
3. Describe the role of decomposers in ecosystems.
4. Identify the difference between food chains, food webs and pyramids of numbers, biomass and energy. Draw an example of each.
5. Define the term *adaptation* and discuss the problems associated with inferring characteristics of organisms as adaptations for living in a particular habitat.
6. Identify two named plants and two named animals with adaptations to factors in their environment.
7. Identify and describe in detail adaptations of a named plant and a named animal from the local ecosystem you studied.
8. Describe and explain the short-term and long-term consequences on the ecosystem of species competing for resources.
9. Identify the three impacts of humans in the ecosystem you studied.
10. Describe how you measured three different abiotic features in the ecosystem you studied using appropriate instruments and discuss how these factors may determine the distribution of organisms.

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Answers for revision questions