CHAPTER 6 CHANGES IN ECOSYSTEMS

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

Science Understanding

- Ecological succession involves changes in the populations of species present in a habitat; these changes impact the abiotic and biotic interactions in the community, which in turn influence further changes in the species present and their population size (ACSBL026)
- Ecosystems can change dramatically over time; the fossil record and sedimentary rock characteristics provide evidence of past ecosystems and changes in biotic and abiotic components (ACSBL027)
- Human activities (for example, over-exploitation, habitat destruction, monocultures, pollution) can reduce biodiversity and can impact on the magnitude, duration and speed of ecosystem change (ACSBL028)
- Models of ecosystem interactions (for example, food webs, successional models) can be used to predict the impact of change and are based on interpretation of and extrapolation from sample data (for example, data derived from ecosystem surveying techniques); the reliability of the model is determined by the representativeness of the sampling (ACSBL029)

Figure 6.1 ▲ Riversleigh, Queensland. Once a lush rainforest supporting an enormous array of plants and animals, this fossil site is now part of the driest vegetated continent on Earth.

Riversleigh in Queensland was once a lush rainforest. Today it is part of the driest vegetated continent on Earth. A few million years ago there were no eucalypt trees to provide shade. The landscape was dominated by towering tea trees and pandanus that lined deep river pools where freshwater crocodiles swam and large wombat-like creatures called diprotodonts came to drink.

Today, the temperature soars above 40°C at midday, there is very little wind and everywhere you look it is dry, dusty and seemingly lifeless. Yet within a day, as Earth turns away from the Sun, the temperature drops dramatically. The scrub lands come alive with nocturnal animals such as geckos, small mammals and a rich diversity of insect life. During the rainy season, Riversleigh is exposed to flooding rains transforming the area into an inland freshwater wetland that forms a temporary home for thousands of water birds on their migratory routes.

These daily and seasonal changes are examples of relatively short-term change. Riversleigh, like other ecosystems, is always changing. Ecosystems have changed from what they were millions of years ago and will continue to change annually, seasonally and daily. Ecosystems are dynamic in nature.

Ecosystems can change dramatically over time

In the early 1980s, **palaeontologists** studying the 110-million-year-old rock sequences at Dinosaur Cove in Victoria pieced together evidence of a different land. Australia, Africa and Antarctica didn't exist 110 million years ago (mya). In fact, none of the continents we know today existed at that time; they were all joined together to form a supercontinent called **Pangaea**.

Pangaea initially split into two large landmasses, **Laurasia** to the north and **Gondwana** to the south. The great southern continent of Gondwana contained what was to become the Australian landmass. By 110 mya Gondwana was beginning to break up. South America was separating from Africa and India was beginning its long trek north. This was an important stage in the physical isolation that was to give Australia's biota (plants, animals and other organisms) such distinctive characteristics.

WOW

Endemic plants

More than 80% of our plant and animal species are endemic to Australia. There are seven families of mammals, four of birds and 12 of flowering plants that are unique to Australia. No other country has as many endemic flowering plant families.

Origin of Australia's unique fauna and flora

Mammals lived with the dinosaurs for almost 130 million years as small and unobtrusive members of the ground fauna. The extinction of the dinosaurs finally opened up new niches previously denied to them. In Australia, at about the same time as the dinosaurs became extinct, the last of the Gondwana landmasses were breaking up and by 40 mya Australia had parted company with Antarctica, the last remnant of Gondwana.

For the next 40 million years the Australian landmass had no connection with any other continental landmass. Only in recent geologic time has **continental drift** resulted in northern Australia having some tenuous connection with the Indo-Malaysian archipelago.

This combination of rapid speciation and isolation has meant that Australia's biota has, to a great extent, found independent solutions to environmental challenges. The result is an unusually high degree of **endemic** species; species that occur naturally only in Australia.

Mass extinctions

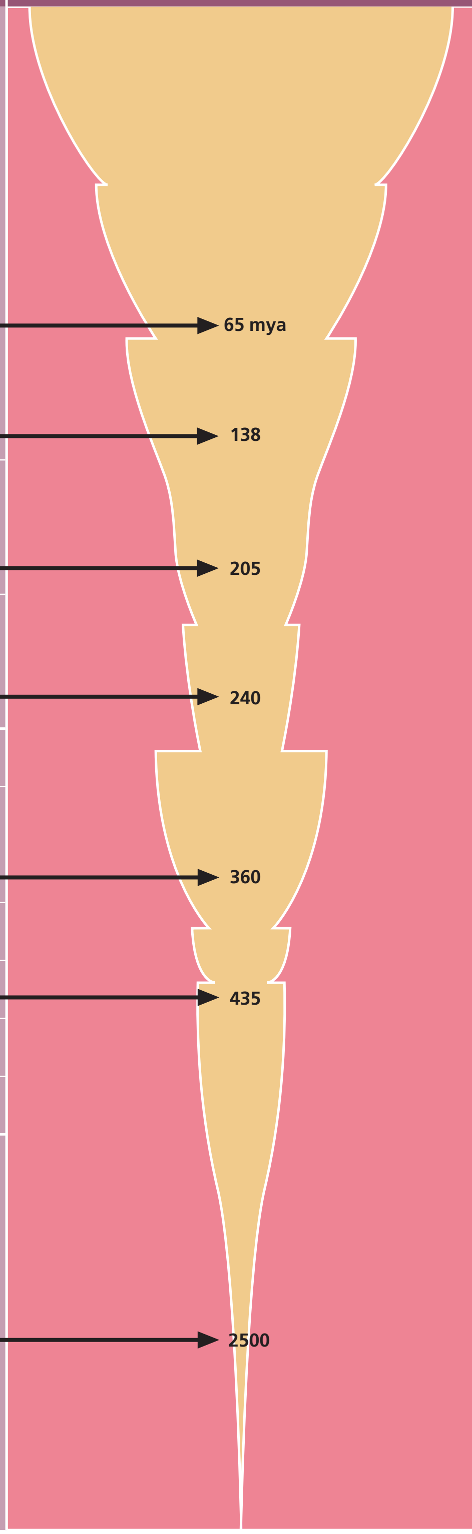
Large numbers of species can disappear in a relatively short time in **mass extinction** events. These are often worldwide and linked to agents such as variations in sea level, salinity and atmospheric oxygen concentration, global climatic change, and catastrophic events such as intense periods of volcanic activity and the impact of asteroids.

Approximately 65 mya the communities of vertebrates were dominated by dinosaurs and other reptiles. In a split second, geologically speaking, the dinosaurs and many other species disappeared in one of the biggest episodes of mass extinction on Earth. Three-quarters of all known life were wiped out at this time.

▼ Figure 6.2
Summary of Earth's major events: continental drift, global diversity, and major geological and biological events.

Era and Eons	Period		Age (millions of years)
Cenozoic	Quaternary	Recent (Holocene)	0.01
		Pleistocene	2.6
	Neogene	Pliocene	
		Miocene	23
	Paleogene	Oligocene	
		Eocene	
		Palaeocene	65
Mesozoic	Cretaceous		146
	Jurassic		208
	Triassic		245
Palaeozoic	Permian		290
	Carboniferous		362
	Devonian		408
	Silurian		439
	Ordovician		510
	Cambrian		570
Pre-Cambrian Eon			1000
			2000
			3000
	Oldest dated terrestrial rocks		4560

Diversity of marine and terrestrial organisms



1.65 mya to present. Major ice ages. Modern humans evolve. Mass extinction of large animals.

65–1.65 mya. Colossal mountain building as continents rupture, drift, collide. Major shifts in climate. First tropical and subtropical conditions extend to polar regions. Woodlands, then grasslands emerge as climate gets cooler, drier. Major radiations of flowering plants, insects, birds, mammals. Origin of earliest human ancestors.

65 mya. Apparent asteroid impact causes mass extinction of all dinosaurs and many marine organisms.

135–65 mya. Pangaea break-up continues and broad inland seas form. Major radiations of marine invertebrates, fish insects and dinosaurs. Origin of angiosperms (flowering plants).

181–135 mya. Pangaea starts to break up. Diverse marine communities. Major radiations of dinosaurs. Conifers dominant.

205 mya. Asteriod impact? Mass extinction of many species in seas, some on land; some dinosaurs, mammals survive.

240–205 mya. Recoveries, radiations of marine invertebrates, fish dinosaurs. Gymnosperms the dominant land plants. Origin of mammals.

240 mya. Mass extinction. Nearly all species on land and in seas perish.

280–240 mya. Pangaea and worldwide ocean forms. Shallow seas squeezed out. Radiations of reptiles, gymnosperms.

360–280 mya. Recurring glaciations. Major radiations of insects, amphibians on land. Spore-bearing plants dominate, gymnosperms present. Origin of reptiles.

370 mya. Mass extinction of many marine invertebrates, most fish.

435–360 mya. Laurasia forms. Glaciations as Gondwana crosses South Pole. Mass extinctions of many marine species. Gondwana drifts north. Vast swamps, fish, vascular plants. Radiation of fish continues. Origin of amphibians.

500–435 mya. Gondwana drifts south. Major radiations of marine invertebrates and early fish.

550–500 mya. Land masses dispersed near equator. Simple marine communities. Origin of animals with hard parts.

700–550 mya. Laurentia breaks up: widespread glaciations.

2500–570 mya. Oxygen accumulating in atmosphere. Origin of protists, fungi, animals.

4600–2500 mya. Origin of early Earth. Origin of photosynthetic bacteria. Formulation of crust, first atmosphere, and seas. Chemical, molecular evolution leading to origin of life – protocells to anaerobic bacteria.

GEOLOGICAL TIME PERIODS

For more information about what happened during each of the time periods shown in Figure 6.2, visit the Museum Victoria website.

Evidence of changes in past ecosystems

Comparing present biota with those in the fossil record helps us to understand changes in living components of ecosystems over time. Changes in abiotic factors can also be deduced by studying soils, rocks and even ice cores.

Illustration by Dorothy Dunphy in Archer, M., Hand, S. J., Godthelp, H. (1991) Riversleigh. Reed Books Pty Ltd, Sydney.

Figure 6.3 ▶ An artist's impression of Riversleigh as it may have appeared 15 mya based on fossils preserved in the limestone rocks of the area.

How can scientists accurately predict and describe Riversleigh's ecosystem 25–15 million years ago? It is because of the more than 250 sites at Riversleigh that are rich in fossils, many of them well preserved. These sites are supplying a detailed and continuous fossil record of the changes in biota. The extensive biodiversity seen in the fossil record points to a climate very different to today's dry and hot habitat. Sedimentary rocks at the sites also indicate signs of a wetter climate. Scientists are using the characteristics of the grey limestone deposited between 25–15 mya. Early relatives of today's fauna were preserved in the lime-rich sediments of the wetlands that flourished at this time. This layer lies on top of older limestone without the fossil remnants and without sedimentation patterns characteristic of a wet climate.

Figure 6.4 ▼ An ice-drilling site, Antarctica

National Science Foundation, photo by Vasilii Petrenko

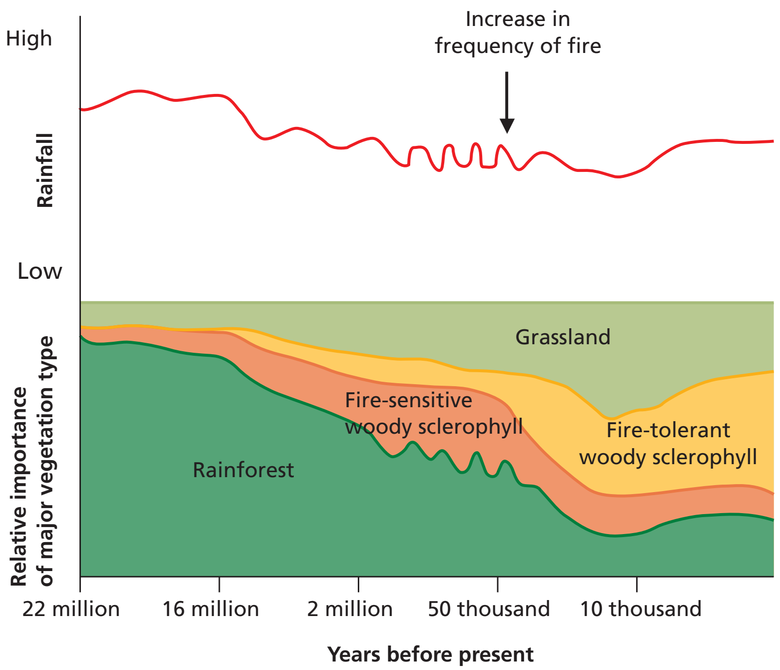
Using ice cores as evidence of change

Drilling down into the ice at the poles and within large glaciers produces cores that have preserved a continuous record of past climatic conditions. Trapped gas bubbles and the presence or absence of traces of organisms reveal information about changes in temperature and relative concentrations of atmospheric gases.

Periods of low global temperatures resulted in ice ages: extended periods of time when glaciation occurred over large sections of the northern hemisphere and when the ice sheets expanded at both poles. Glaciation helped create the deep fertile soils of Europe, but in Australia the story was different. There have been five major ice ages, the last reaching its maximum 15 000–18 000 years ago.

Sea levels dropped and huge expanses of the ocean floor were exposed, providing a land link for species to move between Australia and the islands to the north.

Reduction in global temperatures and lower evaporation rates also affected the water cycle – lower levels of atmospheric water meant lower rainfall. A little more than 15 000 years ago Australia became a desert: windblown, dry and, more than three-quarters of the continent, treeless. Two-thirds was covered in sand dunes and our top soil was heavily wind-eroded.



Source: Archer, M. & Clayton, G. (eds) (2000) *Evolution and Zoogeography of Australasian Vertebrates*. AUSCIPUB Pty Ltd, Sydney.

Figure 6.5 Changes in Australian vegetation over time. With a decrease in rainfall and a cycle of recent ice ages, the vegetation of Australia has changed dramatically over the last 22 million years.

QUESTION SET 6.1

Remembering

1 Describe the relative changes in vegetation types in Australia over the past 22 million years.

Understanding

2 Draw an annotated timeline to show the long-term changes associated with the origin of Australia.

3 Explain how the well-preserved fossils and surrounding sedimentary rock at Riversleigh have been used by scientists to predict the ecosystem of 15 mya.

4 Explain how sampling ice cores can be used to give evidence of climatic change.

Applying

5 Describe the effects of the last ice age on Australia's climate. Suggest how the drop in sea level would have helped to preserve biodiversity.

Ecological succession involves changes in the populations of species

Change is a natural feature of dynamic ecosystems and occurs in different scales. When a tree falls in a forest or wombats dig, small-scale disturbances occur. On a slightly larger scale, one set of living things can change the environment in such a way that conditions no longer suit them but do suit a different set of living things. Communities change progressively over time, with one community being replaced by the next in serial replacement known as **succession**.

Communities change progressively over time, with one community being replaced by the next in the process of succession.

Primary succession

Catastrophic events such as volcanic eruptions, cyclones, earthquakes and tsunamis can cause the development of bare sites with no organisms inhabiting the affected area. This process, called **nudation**, starts a long-term process of change, generally involving three stages. The first stage is known as **primary succession**.

Pioneer plants begin to colonise the area. The particular species of pioneer plants depends on the environmental factors in the habitat, such as whether it is coastal sand dunes, mangroves, or newly formed islands rising from the sea as a result of volcanic activity.

Autotrophic organisms such as lichens are usually the first to become established in harsh, bare surroundings, such as after glacial retreat. Acids secreted by the lichens attack the rocky surface in the process of weathering, allowing windblown dust particles to settle in the cracks.

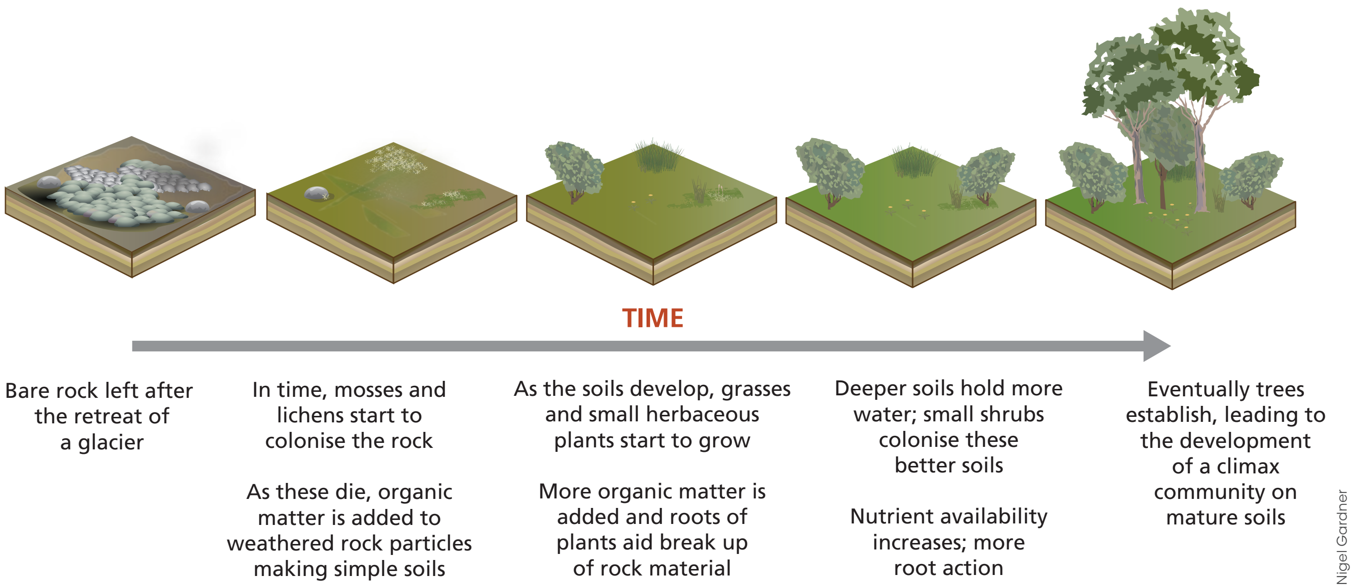


Figure 6.6 ▲ Primary succession following glacial retreat

The shallow soil makes it possible for mosses to become established. When they die, they add nutrients to the soil. Over time, bacteria, fungi and invertebrates are able to form a simple community. At various stages there is enough soil for grasses, ferns and shrubby herbaceous plants to become established; they grow upwards and outwards, shading those below, their roots speeding up the process of weathering.

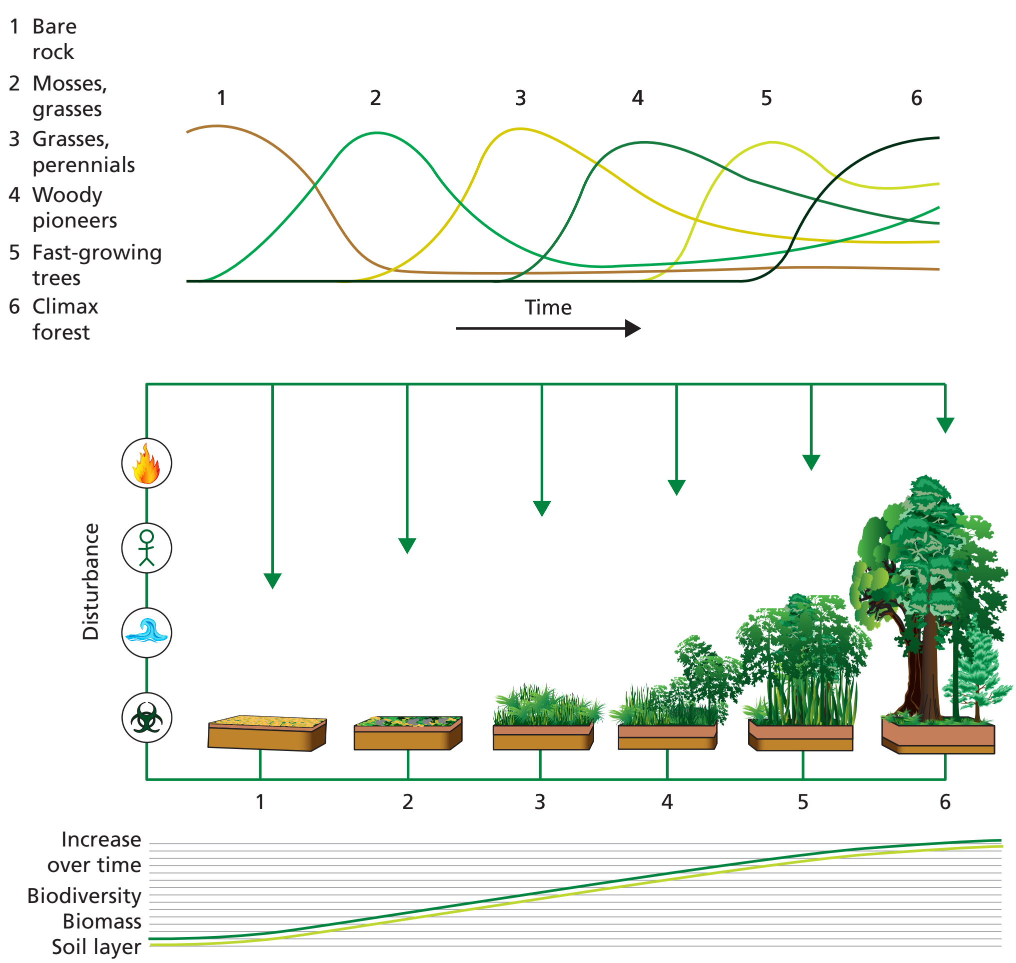
These early colonising plants have characteristics that make them successful: effective seed dispersal, rapid growth, and rapid reproduction. They are generally fast-growing and typical of **r-selected species**. Temporary environments such as pools formed after heavy rain also attract r-selected species. These species are often the first to occupy the unused resources and living space. Their numbers increase rapidly but often decline just as rapidly when more competitive species move in.

See Chapter 4 for more on producers (autotrophs) and their role in ecosystems.

With the establishment of producer organisms (autotrophs), small herbivores such as insects have food and shelter and they become the next link in the food chains. Gradually, a whole new community forms, colonised by immigrants from the surrounding areas. Immigrants survive or stay only if they can obtain the resources that they need for survival.

Secondary succession

Through fire and flood, or through human intervention by logging and land clearing for agriculture, dramatic changes to ecosystems occur. The cycling of matter and the flow of energy are interrupted as the components of the ecosystems are affected. Organisms can recolonise recently disturbed communities via **secondary succession**, regaining equilibrium, although the number and kinds of organisms present may be different from the original ecosystem.



◀ **Figure 6.7**
Forest succession over time in six stages

Climax community

The end of succession is marked by a **climax community**. The old-growth forests of Cooloola National Park in south-east Queensland and the temperate rainforest pockets scattered throughout the east coast of Australia are examples of climax communities. Such communities tend to be made up of slow-growing, long-lived **K-selected species**. These species, living in more stable environments than r-selected species, out-compete the others around them. They are often tall trees such as oaks or large conifers in the northern hemisphere, and trees such as kauri or mountain ash in Australia.

Not all successions reach a climax community. A combination of factors such as fire and selective grazing by herbivores helps to create conditions that allow, for example, grasslands to persist.

Natural disturbances can lead to succession events

There are many instances of natural disturbances, such as erupting volcanoes, massive flooding, hurricanes, tornadoes, tsunamis and landslides that change the biotic and abiotic interactions in a community. Depending on the severity, type and extent of the disturbances, primary or secondary succession will follow.

Corbis/Ocean

▲ **Figure 6.8**
The rainforests of south-east Queensland are an example of a climax community.

Figure 6.9 ▶ The once-widespread grasslands of western Victoria contained a) kangaroo grass, b) spear grass, c) everlasting daisies and d) blue pincushion. Here, forest communities have given way to grasslands.

AUSCAPE/Wayne Lawler

Getty Images/Jason Edwards

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Lochman Transparencies/Marie Lochman

Tsunami

The devastating effect of the tsunami generated by plate movements in the Indonesian oceanic region on 26 December 2004 is a recent reminder of the extent of devastation that can be caused by natural phenomena. Many thousands of people were killed as the waters sped across the hundreds of kilometres of coastline around the perimeter of the oceans, damaging or destroying everything in its path.

Checking for recovery after the tsunami, a team of scientists surveyed the region's coral reefs looking at 60 sites along 800 kilometres of Aceh coastline. They documented high densities of 'baby corals' and rapid growth in areas that were severely impacted by the tsunami. The researchers attribute the recovery to natural colonisation by resilient coral species, along with the reduction of destructive fishing practices by local communities. Scientists recommended re-establishing natural coastal vegetation, such as mangroves, as that might reduce the impact of tsunamis in the future.

© Becca Skinner

Figure 6.10 ▲ Seven years after the tsunami, Wan, who owns this Banda Aceh rice field in Indonesia, holds a picture of this same tsunami-affected area taken in 2005. Secondary succession is responsible for the current thriving biological community.

Fire

The immediate effects of fire on the biota of a community include loss of vegetation, reduction of leaf litter and a decrease in animal numbers. The degree to which this changes the populations of species present in a habitat depends on the kind of fire (canopy, understorey or both), and its intensity and scope.

Fire also impacts the abiotic interactions in a community. Ash from the fire creates nutrient-rich soil. The new open spaces offer maximum light availability, but also remain vulnerable to the effects of the hot, drying Sun or pelting rain. The heat of the fire leads to biotic changes as species of bottlebrushes, hakeas, some acacias and eucalypts regenerate from fire-released seeds. Fire damage stimulates regrowth in other species and it has been found that smoke particles signal growth in others.

The proliferation of new growth in a post-fire community attracts many mobile species such as wallabies, birds, small mammals and insects. The new growth sustains animals such as wombats and echidnas that may have survived the fire in underground burrows.

Fire is rapid and dramatic, but even though ecosystems change, they can potentially re-establish over many years.

Figure 6.11
a) The colonising plant hairy blanket leaf, *Bedfordia arborescens,* commonly grows in the post-fire temperate rainforests of eastern Australia as though it were growing in a natural plantation.
b) *Bedfordia arborescens* has masses of daisy-like flowers complete with woolly structures to catch air currents and ensure widespread dispersal of seed over a considerable distance.

Natural disturbances are followed by succession.

Fire regimes

Long-term changes in an ecosystem can result from sequences of fires known as a **fire regime**. Fire regimes are determined by:

- the season in which fires occur
- the intensity of the fires
- most importantly, how frequently the fires occur.

The First Australians regularly burned sections of the bush to aid hunting and stimulate new growth of plants for food. Fire-stick farming greatly increased the frequency of fires in many parts of Australia and gave rise to a pattern of vegetation that became dependent on regular burning. This human intervention disrupted regular succession patterns to maintain a grassland state. This is an example of **deflected succession**.

Plants with underground tubers and other adaptations for surviving fire became more common in these fire-dominated environments. Some were edible, such as yam daisies and

Figure 6.12
Fire-stick farming was used by the First Australians to clear areas of land as an aid for hunting.

many types of terrestrial orchids, and formed part of the staple diet for Aboriginal and Torres Strait Islander peoples.

The controlled fire regimes of these past practices are no longer widespread. In many areas of Australia now, the once fire-tolerant landscapes are being buried alive by a spreading invasion of African grasses such as gamba, para, mission and buffel grasses. Vast areas of woodland in the north and centre of the continent are at risk. These introduced grasses build up huge fuel loads, causing fires of an intensity and timing that native trees, shrubs and grasses cannot withstand. Eucalypts, acacias and shrubs that make up the unique Australian landscape normally thrive in the natural fires of lower intensity and frequency, but do not survive these. **Refuges** where Australian native plants and animals survive in intense drought are burnt out, too. If these go, then there is nothing to recolonise the landscape. The Australian woodland will be replaced by grassland, an African grassland.

QUESTION SET 6.2

Remembering

1 Distinguish between primary and secondary succession.

2 Describe factors that may prevent succession from reaching a climax community.

3 Identify evidence to show that succession events have been occurring in Indonesia following the tsunami on 26 December 2004.

Understanding

4 Draw an annotated timeline to show the sequence of stages in primary succession.

5 Predict the stages of succession where the majority of species are:

  a r-selected species.

  b K-selected species.

6 Relate the characteristic features of r-selected species and K-selected species to the stages of succession they are most likely to be found in.

7 Explain how fire affects succession.

Human activities can reduce biodiversity

Until a few tens of thousands of years ago, humans were just one species among countless others. Today, there are few areas in the world that have not been influenced by our activities. Within a relatively short span of time our activities have been changing the character of the land, ocean, atmosphere, and even the genetic character of species. We now have the population size, technology and cultural inclination to use up energy and modify the environment at rapid rates.

Maintaining our standard of living is important, but the effects of this need to be evaluated against overall sustainability of global ecosystems. It is ecosystems that maintain all life, including ours, on our planet. The variety of organisms, such as the genes they carry and the populations and ecosystems of which they are a part, is a measure of biodiversity. This also includes the ways in which the various components of biological diversity work together to sustain the biosphere. Maintaining a high level of biodiversity is a key to survival.

Australia's biodiversity is unique and globally significant, but humans have impacted significantly on its natural environment. Australia is recognised as one of only 17 'megadiverse' countries, with ecosystems of exceptional variety and uniqueness. This group of megadiverse countries covers less than 10% of the global surface, but supports more than 70% of Earth's biological diversity. It is this very biodiversity that is attracting attention from those who would exploit it, whether through illegal trading of unusual collector items, searching for natural chemical compounds or attempting to control ownership of native fauna and flora and their products.

Scientific literacy: Study challenges Indigenous burn control

A research paper published in 2011 in the journal *Quaternary Science Reviews* questioned whether Indigenous Australians did indeed use fire to control vegetation in Australia. The research team studied charcoal records from 223 sites across Australasia dating back 70 000 years and found that Indigenous Australians may not have used fire as frequently and extensively as once thought. The findings show that Indigenous Australians used fire on a local scale around campsites, but that, overall, fire activity did not greatly increase when the First Australians arrived about 50 000 years ago. Instead, fire activity increased with the arrival of European colonists after 1788.

The research shows high bushfire activity from about 70 000 to 28 000 years ago, then a decrease until about 18 000 years ago. This was followed by another increase – a pattern consistent with shifts between warm and cool climatic conditions and the last glacial maximum. This may suggest that the prevalence of fire in Australasia reflects climate.

This new idea not only challenges beliefs about the activities of the original inhabitants of Australia, but also has implications for the theories that grass-eating species such as the kangaroo increased in numbers because fire-stick farming changed the landscape to that of a savannah, and that ecological disturbance caused by fire-stick farming may have contributed to the extinction of Australian megafauna.

According to lead researcher Scott Mooney, the idea that Aboriginal and Torres Strait Islander people were using fire to control large areas of the continent may be based on observations made by early explorers and settlers.

Questions

1. Summarise the evidence used to argue that Indigenous Australians did not carry out widespread burning of the landscape.
2. Discuss why any reason for the extinction of Australian megafauna can only be theory and not fact.
3. Suggest what other factors could have killed Australia's megafauna.
4. Using the information given, justify the idea that bushfire activity is related to the climate.
5. Comment on the validity of accepting observations by early explorers and settlers. Discuss how scientific evidence forms a more accurate basis for theory formation.

Australia's first human inhabitants

Aboriginal and Torres Strait Islander peoples came from the north through South-East Asia at a time when the sea level was lower than it is today. By at least 20 000 years ago, they had travelled through much of Australia's inland waterways and desert areas, and inhabited coastal areas and their hinterland. The First Australians were predominantly hunter-gatherers, obtaining their requirements from the land and water and adapting to the various climates and resources available. Like all humans, they exploited their environment to improve their own wellbeing, modifying their particular environment in the process.

Throughout much of Australia they changed a regime of fire induced by lightning to fire induced by humans to manage and sustain the productivity of the land. In the process, the distribution and abundance of different species of plants changed to ones that became more fire-tolerant. This in turn produced changes in wildlife.

The demise of Australia's **megafauna** between 10 000 and 20 000 years ago has been attributed to continuous hunting and exploitation by First Australians, but this is still open to scientific debate. Extinct megafauna include the *Diprotodon*, a giant wombat-like marsupial, and other large creatures such as a 6 m-long goanna and a 7 m-long python. Climate change and use of fire are likely to have been contributing and interrelated factors to the demise. Hunting megafauna would have removed the natural fertiliser of soils, estimated at 100 kg per adult per day, disturbing the cycling of matter between the living and non-living components of ecosystems and reducing the fertility of the soils, resulting in soils in which more fire-tolerant plants were able to grow. Climate change and fire would have changed the habitat and affected vegetation. Broad-leaved plants that were integral to cycling of water would have decreased, resulting in less rain and a more arid environment. Competition for resources would have been so severe that populations of the various megafauna would have become unsustainable.

Case study

Indigenous ecological knowledge: the Gunditj Mirring Partnership Project

The Budj Bim landscape in south-west Victoria is a traditional homeland of the Gunditjmara people. Budj Bim ('High Head') is part of the 'Eccles' volcanic landform. The volcanic explosion forming Mt Eccles is estimated to have occurred 27 000 to 30 000 years ago and was witnessed by the Gunditjmara people.

It created a complex landscape of stony rises, wetlands, swamps and adjacent low-lying land prone to flooding, and an excellent habitat for an abundance of flora and fauna that became readily available resources for the Gunditjmara.

The Gunditj Mirring Partnership Project has produced a nine-volume literature review recording traditional and contemporary Gunditjmara land management practices, some refined over thousands of years. The sharing and use of this resource will offer valuable insights for the protection and management of the environment today and in the future.

The partnership project is designed as a way of continuing the traditional land ownership strategies, as well as their contemporary techniques, as part of a broader view that Indigenous communities have the potential to provide new and unique viewpoints on land management.

The information gathered is being collated and implemented into an extension program that will aim to test and trial land management methods. Sites on land owned and managed by Aboriginal and Torres Strait Islander peoples will be involved in trials of certain practices, such as

- controlled seasonal burning to encourage species for food and fibre
- strategic grazing to protect culturally significant sites through the reduction of exotic species
- revegetation near waterways to protect and maintain fishing places
- seed collection at sustainable levels
- mapping of plants used for food or medicine.

The team is also in the process of compiling a 'toolkit' of the knowledge, which will be applied to an extension program engaging with area farmers who are interested in working alongside Indigenous community members to undertake on-ground works on their properties as part of the partnership.

Questions

1 Describe how the Mt Eccles volcanic explosion would have caused changes in the local ecosystem and how this benefited the Gunditjmara people.
2 Outline what the Gunditj Mirring Partnership Project literature review produced and what the expected outcome is.
3 Select two of the trials described in the extension program. Explain how each of these will help to increase biodiversity.
4 Explain how non-Indigenous farmers in the area will benefit from the partnership.

WOW

The Anthropocene epoch

A growing number of scientists think we have entered a new geological epoch that reflects the many geologically significant conditions and processes profoundly altered by human activities. Anthropocene ('anthropo' = human, 'cene' = geologic time) is a new term, originally proposed in 2000 by Nobel Prize winning scientist Paul Crutzen. To justify the identification of a new geological epoch there must be demonstrated evidence of global change that can be distinguished using geological indicators.

Evidence most commonly used is the rise in greenhouse gases, rising global temperatures and sea level increases. Increases in soil erosion, sediment transport, deforestation and extinctions of species caused by hunting, agriculture and widespread destruction of natural habitats are other key indicators.

European settlement

Whatever the impact of Aboriginal and Torres Strait Islander peoples on the environment across Australia, they continued to survive and lived sustainably for tens of thousands of years. The effects of European modification of the landscape were much less subtle. As they colonised more and more land, Europeans tried to impose their agricultural practices on a country that did not have the soil, water or climatic stability for it. European settlers had no understanding of fire as a management tool, nor did they appreciate how well-adapted animals and plants could be used as food. The introduction of devastating diseases and their attitude towards the custodians of the land ensured the destruction of Aboriginal and Torres Strait Islander peoples almost to extinction.

Collection: Powerhouse Museum, Sydney. Photo: Charles H. Kerry, Tyrrell Collection

▲ **Figure 6.13** Australia's early settlers tried to impose their foreign agricultural practices on a country that could not cope with them, irreparably damaging the landscape.

Burning the bush by fire-stick farming produced extensive grasslands. Grasslands became the dominant vegetation community throughout many areas of Australia and were embraced with delight by the early settlers. This was not to last. By as early as 1853, a settler by the name of John Robertson wrote to Governor La Trobe of his concerns about the impacts sheep were having on the landscape. He noted that some plants had begun to disappear, clay (denuded) hills were slipping, springs of salt water were appearing and erosion from rainfall was becoming evident.

Clearly, the rate of change to the environment after European colonisation had increased dramatically. Worldwide, the effect of human activity is marked. Destruction of land habitats, changes to the atmosphere and water, the stripping of vegetation and the exploitation of wildlife have all contributed to the extinction of thousands of species. The equilibrium of ecosystems and the biosphere as a whole has been upset, irreparably in places, in what has come to be described as the sixth extinction.

QUESTION SET 6.3

Remembering

1 Australia is recognised as a megadiverse country. Give reasons why this is the case.

2 Describe the geographical conditions that allowed the First Australians to travel from South-East Asia to Australia tens of thousands of years ago.

Understanding

3 Describe factors that are thought to have resulted in the loss of Australia's megafauna between 10 000 and 20 000 years ago.

4 Summarise the activities of early European settlers and the impacts these activities had on ecosystems.

Human impact on ecosystems today

As Australia's population approaches 30 million and continues to grow, there is continued competition for both renewable and **non-renewable** resources. This parallels the effect of the global increase in population. Competition for land use is considerable: for agriculture; for habitats for native biota; for industrial and domestic constructions; for roads, waste disposal and the spreading urban development; and for minerals, matter and fuels that sustain a consumer society.

Urbanisation

The community of urban ecosystems has reduced biodiversity and is dominated by people. There is little recycling of matter between the community and the non-living surroundings. Additional inputs of energy and matter are needed from other ecosystems to maintain modern standards of living. There is an increase in output of gaseous and material wastes of many kinds that are disposed of in our atmosphere, on the land and in the water of other ecosystems, which in turn become subject to change. For example, scarce landfill sites are being filled with material that could be recycled. Food scraps and other organic materials in landfill produce methane, a 'greenhouse gas' that could be tapped as a fuel, and of the seven kinds of plastic used for consumable items only two are accepted for recycling. Furthermore, the average household produces more than 27 tonnes of greenhouse gases a year and in 2010 it was estimated that 10% of Australian residential electricity use was attributed to standby power. The home office and home entertainment systems account for two-thirds of standby power consumption.

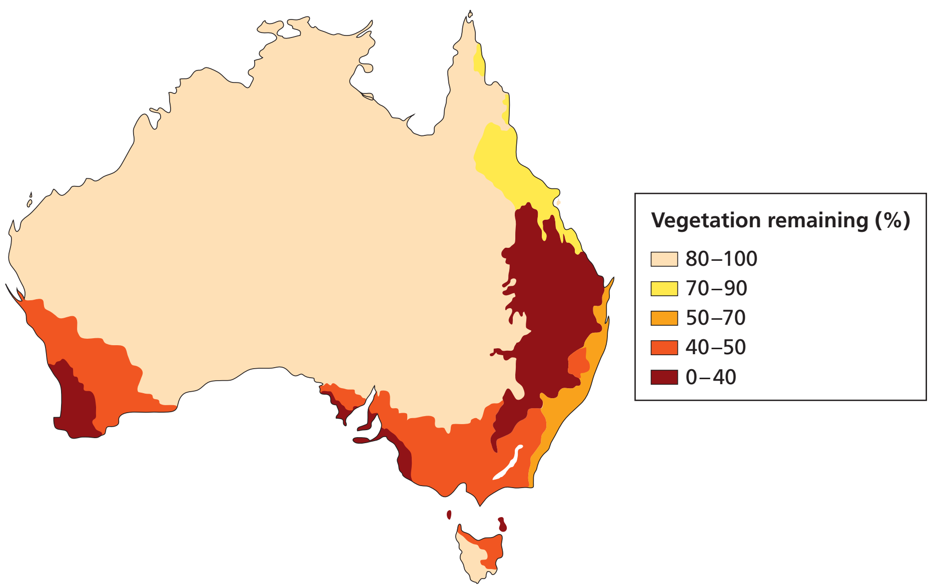
About 6.9 billion plastic shopping bags are used in Australia each year, and a great number of these end up in our waterways and eventually the ocean. There they can take up to 500 years to break down and in the meantime cause a great deal of damage to marine ecosystems. Recently scientists have developed a process of using bacteria to convert carbon-based waste (such as plastic bags) into useful biopolymers.

Urbanisation can cause rapid changes of large magnitude to an ecosystem. Local biodiversity is reduced and, even though new species may potentially move into an urban area, the ecosystem is changed for a very long time, often permanently.

Habitat destruction

Biodiversity is constantly changing, but is reduced by processes such as habitat degradation. Habitat degradation resulting from human activity has put many species at risk, with the clearance of native vegetation a significant threat to biodiversity. Since 1750, more than 20% of Australia's forests have been cleared for crops and grazing with nearly 90% of the vegetation cleared in the more fertile areas of south-eastern Australia. It is estimated that at the turn of this century we, as a nation, were clearing the equivalent of 740 football fields of land, each the size of an international cricket ground, such as the Melbourne Cricket Ground, per day.

Figure 6.14 ▶ Percentage of Australian native vegetation remaining since 1750

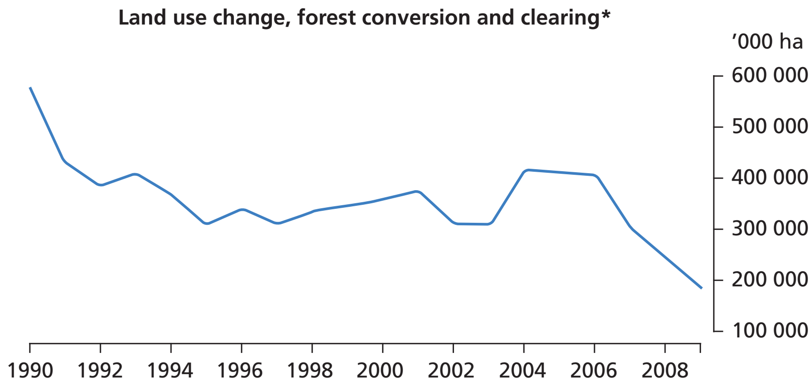


Hutchinson, M., McIntyre, S., Hobbs, R., Stein, J., Garnett, S. & Kinloch, J. (2005) Integrating a global agro-climatic classification with bioregional boundaries in Australia, *Global Ecology and Biogeography, 14*, pp. 197–212.

The pattern of native vegetation loss shown in Figure 6.14 reflects that of European settlement and land use. The greatest reductions in native vegetation have been in eastern, south-eastern and south-western Australia, where post-1750 human settlement and agricultural land use has been the most widespread.

When native vegetation is cleared, habitats that were once continuous become fragmented. After intensive clearing, the separate fragments tend to be very small islands isolated from each other by crop land and pasture. This process is known as **habitat fragmentation**. Small fragments can support only small populations of fauna and flora, and these small populations are more vulnerable to extinction. Those that are separated from each other are unlikely to be recolonised and they do not support species that require large home ranges to obtain resources and locate mates.

Although land clearing is continuing, the extent of forest land conversion has decreased significantly in recent years (Figure 6.15).



*Forest conversion is land cleared for the first time. Reclearing is clearing of land previously cleared.

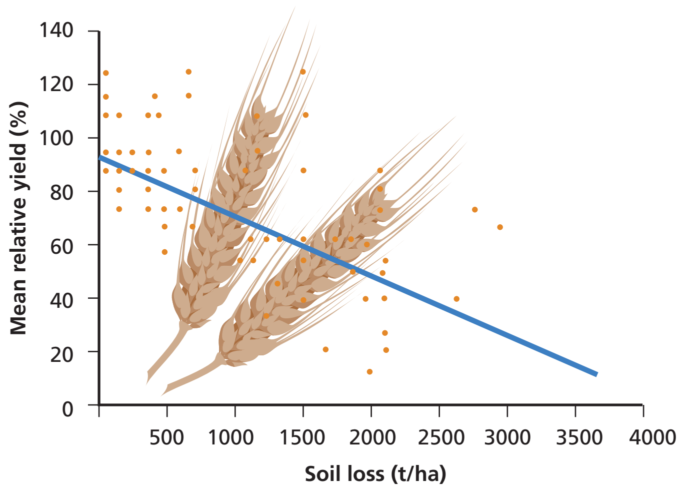
From Australia's National Greenhouse Accounts, *National Inventory Report 2009*, Vol 2, Table 7.2

▲ **Figure 6.15**
Land use change. The 2009 extent of forest land conversion was about one-third of the 1990 level.

Land and soil degradation

Settler John Robertson's records indicate a holding of more than 11 000 sheep on a property of just under 5000 ha, a little more than two sheep per hectare. While this may not sound like a significant number, it is well above the normal carrying capacity for such a large herbivore. Sheep and some other introduced domestic animals have hard hooves as opposed to the soft-footed structures of native animals, and so compact the soil when they graze. This creates opportunities for invasive, shallow-rooted, introduced plants at the expense of the deep-rooted native grasses. With significantly reduced tree cover and increase in shallow-rooted grasses, the topsoil becomes more exposed to the abiotic elements, in particular to wind and rain. Sheep are selective when they graze, taking some plants in preference to others. The vegetation gradually changes in response to these pressures.

▼ **Figure 6.16**
Graph showing soil loss and farm productivity



What happened on John Robertson's property has happened over much of Australia. While soil is the most basic of our agricultural resources, it is also finite. When measured against human lifetimes, soil is a non-renewable resource. To farmers, soil loss by wind or by water means production loss (Figure 6.16). To the animals, plants and other organisms that live in that environment, it means death.

Past land clearance practices, the move to shallow-rooted pastoral grasses and the overuse of fertilisers that have affected soil organisms have placed enormous pressures on the structure of the soil and the ability of the land to hold its topsoil. Farming practices that rely on large and heavy machinery for efficiency have added to the problem by compacting soil, as is evident when removal of topsoil by wind or water exposes the deep, hard ruts in paddocks. Modern agricultural practices can cause rapid changes to the abiotic components of the ecosystem, in turn rapidly changing the biotic components. If there is significant change or loss of topsoil, the ecosystem may be permanently changed.

The 1983 dust storm that hit Melbourne carried about 2 million tonnes of topsoil out into the ocean. Dust from this storm has been located in the layers of accumulated snow on Mt Cook in New Zealand.

In 2009, another dust storm extending 600 kilometres along the east coast of Australia from New South Wales to Queensland dumped up to 75 000 tonnes of dust per hour into the Tasman Sea (Figure 6.17). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) estimated that the storm carried about 16 million tonnes of dust from the Central Australia deserts.

These events are modern-day examples of how evidence of dust found in ice cores indicated Australia was very dry 15 000 years ago.

▼ **Figure 6.17**
Topsoil on the move: the 2009 dust storm over Redcliffe, Queensland.

Dreamstime.com/Antonio Ribeiro

Alamy/Jo Hanley

Figure 6.18 ▲ Salination of land. Dry-land salinity caused by a combination of land clearing and irrigation practices can reduce biodiversity and devastate ecosystems.

Salinity

One of the most significant problems associated with replacing natural vegetation with crops that require irrigation is salinity. Farm dams and irrigation channels can become important local sites of biodiversity, but irrigation contributes significantly to increasing groundwater. This raises the water table, and its often high salt content, to the surface (Figure 6.18). In the first instance, this can cause **waterlogging** and, depending on evaporation and the degree of surface flushing, **salination** (increased salt concentration).

Even if the surface is flushed regularly by rain or other water sources, the salination problem is not solved but simply moved to another location. Like all run-off, it inevitably ends up in a stream. In the 2001 Australian Government State of the Environment report, 5.7 million hectares of land were identified as showing signs of salination, with 17 million hectares predicted to be at risk by 2050. In the 2006 State of the Environment report, salination was identified as a major pressure on biodiversity, particularly in the southern Murray–Darling and the south-west of Western Australia.

Monoculture practices

A biologically diverse ecosystem, such as an old-growth forest or a tropical rainforest, is healthy, complex and stable. Nature tends to increase diversity through the process of succession. However, modern agricultural practice often results in the reduction in the number of crop or livestock species. Crops are grown over a wide area for a large number of consecutive years. This allows large harvests with minimal labour.

When only one species of organism is grown, such as a wheat field, biodiversity is reduced. This type of farming resulting in a **monoculture** often requires extensive use of fertilisers along with pesticides and herbicides to reduce the natural tendency of the community to diversify. Another downside of this practice is the spread of disease and susceptibility to changing environmental conditions. Cultivated plants grown in genetically homogeneous monocultures do not possess the necessary ecological defense mechanisms to tolerate the impact of pest outbreaks.

As a result of reduced biodiversity in monocultures, natural enemies of pests are no longer present. If pest outbreaks occur, beneficial populations of insects are missing, and if favourable weather conditions happen simultaneously, the effect on the crop can be catastrophic.

Government and community groups such as Greening Australia, Landcare, Caring for Our Country and other organisations have been reclaiming areas in an effort to return land to the original natural ecosystem. Native seeds have been collected and planted. The success of these projects show that even though growing crops rapidly reduces biodiversity, the duration of the change can be short term.

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Figure 6.19 ▶ A pine plantation is an example of a monoculture.

Human activities put pressure on resources

European-style agriculture was introduced to Australia by early settlers who had limited understanding of the patterns of our climate; particularly that of rainfall, natural vegetation and the condition of soils. As intensive 'foreign' farming practices took their toll, irrigation to restore water supplies and the use of fertilisers to restore depleted soils became common practice.

Competition for available water was, and still is, considerable because the increase in population stretched the supplies of water to urban centres and increased demands for industrial use.

Disruption of water flow

Changing the distribution of water for human use has changed ecosystems in a number of ways.

- Irrigation: Irrigation places demands on supplies of water, particularly during prolonged dry periods. Removal of vegetation and redistribution of water affect the cycling of water. Water loss from irrigation channels by evaporation and leakage is considerable.
- Major engineering works: Infrastructure such as dams and reservoirs are constructed along inland waterways to store and regulate water for industrial and domestic use in addition to irrigation. Hydro-electric power stations combine storage with power generation. Downstream, vegetation may be deprived of the regular flooding essential for their survival, and fish may be stranded.
- Degradation of urban streams and waterways: Conventional drains deliver stormwater directly into streams, causing physical and chemical disturbance to the aquatic organisms living there that are adapted to occasional flooding rather than frequent flushing.
- Desnagging: This is the removal of logs and other wood material from streams for recreational boating and improved water flow. Desnagging has greatly reduced the number of breeding sites for native fish and increased erosion rates. Maintaining water flow in summer by discharging oxygen-poor water from the bottom of dams has been shown to affect aquatic animals for up to 100 km below the outlet.
- Drainage of wetlands: Wetlands are complex ecosystems in their own right and they provide resting and feeding points for migratory birds. They are also important for processing large quantities of **pollutants** that would otherwise pass downstream into estuaries and coastal waters.

Eutrophication

Rain and floods move salt and other substances, such as fertilisers, off the land and into the streams. In the summer of 1991, the world's largest toxic blue-green algal bloom (from cyanobacteria) occurred along a 1000 km stretch of the Darling River, gaining world attention. 'Algal' blooms are also increasingly common along coastal areas where streams and rivers enter the sea.

'Algal' blooms and infestations of aquatic plants, such as the introduced water hyacinth, are symptoms of **eutrophication**: the enrichment of water by nutrients, particularly the phosphorus and nitrogen of fertilisers, in run-off. Under conditions of high light (aided by tree removal around streams) and reduced flow (aided by diversion of water for irrigation practices), populations of cyanobacteria increase enormously. Some blooms are toxic, affecting the nervous system, but others are relatively harmless.

The increase in the abundance of photosynthetic cyanobacteria supports large numbers of aerobic bacteria, which decompose dead plant material. In doing so, the bacteria use large amounts of oxygen from the water, depriving many aquatic invertebrates and fish of oxygen and many die.

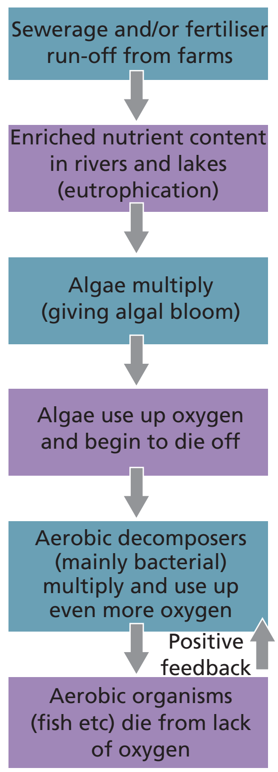
Marine ecosystems

The oceans impinge on all aspects of our identity, from the variability of our rainfall, the evolution of our animals and plants, to the way we live our lifestyle. The oceans are a rich resource; they cover nearly 70 000 km of coastline and an Australian exclusive economic zone (200-nautical-mile boundary around the coast) of just under 12 million km^2.

WOW

Svalbard Global Seed Vault

Deep inside a mountain, 150 m deep, on a remote island between Norway and the North Pole, lies the Svalbard Global Seed Vault. It is a fail-safe, state-of-the-art seed storage facility with a combination that no single person knows in its entirety, built to withstand the test of time and natural or man-made disasters. The vault has been likened to a Noah's Ark of plants. It aims to preserve the world's crop biodiversity by storing duplicates of all seed samples from the world's crop collections. It will secure, for centuries, millions of seeds representing every important crop variety available in the world today.



▲ **Figure 6.20** Flow chart of eutrophication

More than 4000 species of fish live in our waters, and about a quarter of them are found nowhere else. The value of marine ecosystems has been recognised by the establishment of marine parks and reserves along stretches of the coast, but as with other kinds of ecosystems, there is competition for their use: for food, recreation, transport, commercial livelihood and as a repository for our wastes.

Commercial fishing, particularly by over-harvesting, has reduced the populations of many species, some almost to extinction. Sharks for example are at an all-time low. Worldwide they are hunted for shark products such as shark-liver oil, leather, fishmeal and fertiliser. In surveys taken off the coast at Eden (south coast of New South Wales) and Sydney, populations of small, bottom-dwelling sharks, and skates and rays that live below 200 m, showed an 80% decline between 1977 and 1997. Worldwide, one third of the sharks, rays and skates on Earth are threatened with extinction.

The reduction in populations of these and other fish affects other species through disruptions to food chains. Penguins and seals, for example, now compete with the fishing industry for food. In the Southern Ocean, penguins account for 80% of the biomass of all sea birds and birds are major predators on marine creatures in the surface layers. Tension exists between conserving penguins and sustaining fish yields.

Accidental catching of other fish, birds, mammals and turtles takes its toll, and abandoned fishing lines and plastic materials kill or maim many marine animals such as turtles, seals and marine birds, either by ingestion or by enmeshing and drowning.

Figure 6.21 ▶ A seal entangled by marine debris

Alamy/Photoshot Holdings Ltd

The **by-catch** (undersized fish caught and discarded) poses problems. As populations of fish (such as the valuable snapper) decrease, there are fewer fish reaching reproductive age to sustain population growth. Scientists and commercial fishers are trying to develop traps with meshes that will allow undersized fish to escape unharmed. Forcing fishing boats to harvest species such as leatherjackets and silver trevally at larger sizes may reduce yields in the short term, but may increase yields in the longer term.

Pollutants such as hydrocarbons (oil), either deliberately or accidentally discharged, can also disrupt marine ecosystems. Continuous monitoring of fish stocks, water quality and indicator species over time provides the data necessary for developing effective management strategies that will conserve species and sustain commercial operations. Fishing sustainably reduces numbers in a population but does not reduce biodiversity. On the other hand, overfishing to depletion will change the marine ecosystem and this change will last for a long time.

Introduced species can become pests

Because of its isolation, Australia has generally been fortunate in preventing the spread of plant and animal disease from other parts of the world. Diseases cause huge financial losses to farmers in other countries. Australia is able to sell its products to overseas markets because of the absence of diseases, such as mad cow disease, foot-and-mouth disease and various fungal diseases of plants.

Despite close monitoring and scrutiny, illegal trade in Australian native animals continues. Our unique snakes, parrots and other birds, and even spiders and small mammals, are among many examples of wildlife that are smuggled out of the country. Conversely, many attempts at illegal importing of **exotic** species have been made. The potential impact on native communities is considerable.

Without the normal homeostatic mechanisms for population control, such as natural predators, many **introduced species** become serious pests that seriously affect habitats, food chains and the ecosystem. However, not every introduced species will become a pest. A pest species will feed on or compete with native species for food or shelter to the detriment of biodiversity in that area. They usually breed quickly and produce large numbers of offspring, which often gives them a competitive advantage over indigenous species.

In the early days of colonisation by the British, many animals and plants were introduced. For example, acclimatisation societies introduced sparrows and trout to make Australia more like Europe. Goats, pigs, wheat and other cereal crops were among those introduced for domestic purposes, and rabbits and foxes for sport. Others came accidentally, such as the common garden snail and black rat. Many introduced mammals such as deer, camels, pigs, cats and dogs have become feral pests that are out-competing native mammals and changing the balance of populations in ecosystems.

Concerns about the escape of exotic 'garden' plants (e.g. those brought in to beat water restrictions and drought) are well founded. *Gazania* is one of the 10 most serious weeds sold in Australian nurseries and there are reports of it severely altering the vegetation structure in plant communities by replacing and suppressing native plants (Figure 6.22).

Shutterstock.com/kukuruxa

◀ **Figure 6.22** *Gazania*: one of the 10 most unwanted plants in Australia

The introduction of foreign species into Australian waters, such as in the ballast of ships, has the potential to cause irreversible harm as they do not have natural predators and compete successfully with native species. At least 250 marine species are known to have been introduced to Australia's marine waters. Port Phillip Bay in Victoria has recorded at least 120 introduced species and the Great Barrier Reef in Queensland is facing serious environmental threat from marine organisms brought in by foreign mining ships.

Current research into biological methods of controlling introduced pest species forms a large part of specialist scientific work.

WOW

Biosecurity

Australia's biodiversity can be viewed as a commercial asset that needs protection. Each year more than 7 million passengers and about 20 million tonnes of cargo arrive at Australian airports and sea ports. Biological matter can easily accompany these arrivals. The *Quarantine Act 1908* has provided a national approach to the protection of Australia's international borders from incursions by exotic pests and diseases. Despite best efforts, invasive species cost Australia more than $7 billion annually!

Ecosystem models can be used to predict the impact of change

To better understand how ecosystems function and change, models are often applied. The development of models of interactions between components of ecosystems has advanced rapidly over the last few decades. Ecosystem models are useful representations of elements within the ecosystem, the relationship between the elements and the relationship with surrounding ecosystems.

Ecosystem models are very useful for simulating and analysing the long-term dynamics and properties of complex ecosystems. They allow the use of information from different disciplines as well as analysing, interpreting and understanding field observations. This provides a basis for predictions of the impacts of changes in real ecosystems, the development of tools for management support and policy advice.

Chapter 3 provides more detail on how ecologists construct and use various models of ecosystem interaction.

Models, such as those demonstrating ecosystem interactions, are built using data gathered and the interpretation of that data. The most accurate and comprehensive data set would entail examining every part of the ecosystem, such as in a census collection. However, this is highly impractical for most ecosystems. A more practical approach is to examine parts of the ecosystem through random sampling. Simple random selection ensures that the sample is representative if all members of the population have an equal chance of being selected. The reliability of the model is determined by the representativeness of the sampling.

One of the most widely used models is that of ecological succession. The concept of secondary succession is applied to restoration ecology projects worldwide in an effort to predict how to restore ecosystems that have suffered natural or human-made disturbances. An understanding of abiotic conditions and the roles of species can be used to predict successional outcomes.

QUESTION SET 6.4

Remembering

1 Summarise the consequences of land clearance.
2 Describe methods that could be taken to restore damaged land.
3 Suggest some agricultural practices that can contribute to salination.
4 Describe conditions that contribute to the development of algal blooms.
5 List the advantages and disadvantages of commercial fishing.

Understanding

6 Do you consider soil to be a renewable or non-renewable source? Justify your answer.
7 Discuss the advantages and disadvantages of large-scale irrigation.
8 Using an example, explain how human activities on waterways have changed ecosystems.

Applying

9 Consider a foreign species that has just been found in Australia for the first time. Describe the characteristics a biologist would look for in order to decide if this species is a potential pest.

CHAPTER SUMMARY

- Physical isolation caused by continental drift allowed Australia's unique life forms to develop.
- Australia's biodiversity is unique and globally significant, with a high number of endemic species.
- Large numbers of species can disappear in a relatively short time in mass extinction events.
- The fossil record, rocks, soil and ice cores provide evidence for past ecosystems and changes in ecosystem components.
- Communities change progressively over time, with one community being replaced by the next in serial replacement known as succession.
- As succession progresses, local species of flora and fauna will change. Such changes interact and lead to new abiotic conditions and opportunities for different species.
- Primary succession takes place on bare sites devoid of life.
- r-selected species of plants are fast-growing and reproducing, and are typical of early colonising plants; they are the first to occupy unused resources and living space.
- Organisms can recolonise recently disturbed communities via secondary succession.
- The end of succession is marked by a climax community made up of slow-growing, long-living K-selected species.
- Natural disturbances such as tsunamis and fire are followed by succession.
- Over thousands of years, Aboriginal and Torres Strait Islander peoples have developed a close and unique connection with the lands and environments in which they live.
- Urban ecosystems are dominated by people and biodiversity is low.
- Urbanisation causes a major change to ecosystems very rapidly and for a very long time.
- Clearing of native vegetation reduces biodiversity and can lead to habitat fragmentation.
- Land and soil degradation encourages shallow-rooted plants at the expense of deep-rooted plants including trees; topsoil is at risk of being blown or washed away.
- Dry-land salinity can be caused by a combination of land clearing and irrigation practices. It can reduce biodiversity and devastate ecosystems because abiotic changes lead to biotic changes.
- Growing one species in an area (monoculture), along with the use of pesticides and herbicides, reduces biodiversity.
- Humans have changed the distribution of water for their own use, changing ecosystems in the process; changes to water quality and quantity have resulted.
- Widespread use of fertilisers, and the run-off of water enriched with these fertilisers, causes algal blooms and infestations of aquatic plants.
- Commercial fishing has reduced the populations of many species, some almost to extinction.
- Succession models can be applied to predict changes to ecosystems, such as those undergoing rehabilitation after damage.

CHAPTER GLOSSARY

by-catch the unwanted fish and other marine creatures trapped by commercial fishing nets during fishing for a different species

climax community the end-point in a community succession where the community has become relatively stable; e.g. old-growth forests and rainforests

continental drift the theory describing movement of continents resulting from movement of plates in the Earth's crust

deflected succession when a community is prevented from reaching a stable successional end- point because of some form of interference

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

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

exotic not indigenous; non-native

fire regime the season, intensity and frequency of fire in a given area over a period of time

Gondwana the southern supercontinent that drifted apart to form present-day Antarctica, India, Africa, Australia and South America

habitat fragmentation the breaking up of a habitat into small parts

introduced species a species brought into an environment from another place

K-selected species a slow-growing, long-lived species typical of those in a climax community

Laurasia the northern supercontinent formed after Pangaea broke up; it included what is now North America, Europe, Asia, Greenland and Iceland

mass extinction the disappearance of large numbers of species in a relatively short time

megafauna large animals

monoculture the agricultural practice of growing a single crop or plant species over a wide area for a large number of consecutive years

non-renewable a resource that exists in limited supply and cannot be replaced if it is used up within normal human timescales

nudation the development of bare sites with no organisms inhabiting the affected area

palaeontologist a scientist that studies palaeontology, the science of the forms of life that existed over the course of Earth's history (e.g. the study of fossils)

Pangaea the supercontinent consisting of all of Earth's land masses; it existed from the Permian through Jurassic periods before breaking up during the late Triassic

pioneer plant a plant capable of invading bare sites, such as a newly exposed soil surface

pollutant the waste derived from human activities that is added to the environment

primary succession the colonisation of plants in a barren place

refuge the region in which certain species or communities of organisms are able to persist during a period in which most of the original geographic range becomes uninhabitable because of climatic change

r-selected species a fast-growing and reproducing organism, often the first to occupy unused resources and living space

salination increased salt concentration

secondary succession the recolonisation of disturbed plant communities

succession the progressive change of communities over time

waterlogging what happens to plants when the water table rises into the root zone; results in anaerobic conditions that may kill some plants; may also cause salinity levels in the soil to rise

CHAPTER REVIEW QUESTIONS

Remembering

1 Describe fire-stick farming and identify its effects.

Understanding

2 Explain how the fossil record and sedimentary rock characteristics provide evidence of past ecosystems.

3 Account for the high percentage of endemic species in Australia.

Applying

4 Dingoes occur on mainland Australia; they have never inhabited Tasmania. Identify a likely reason for their geographical distribution.

5 Suggest at least three personal actions and three social actions that could be taken to reduce the negative effect of human activity on either a marine or land ecosystem.

Analysing

6 Identify the r-selected and K-selected species in the graph in Figure 6.23. Give reasons for your answer.

7 Compare an urban ecosystem with a natural ecosystem.

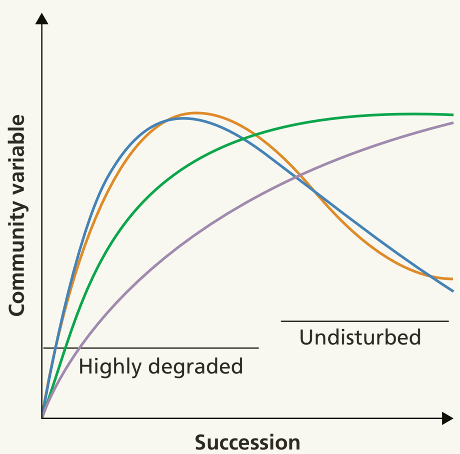
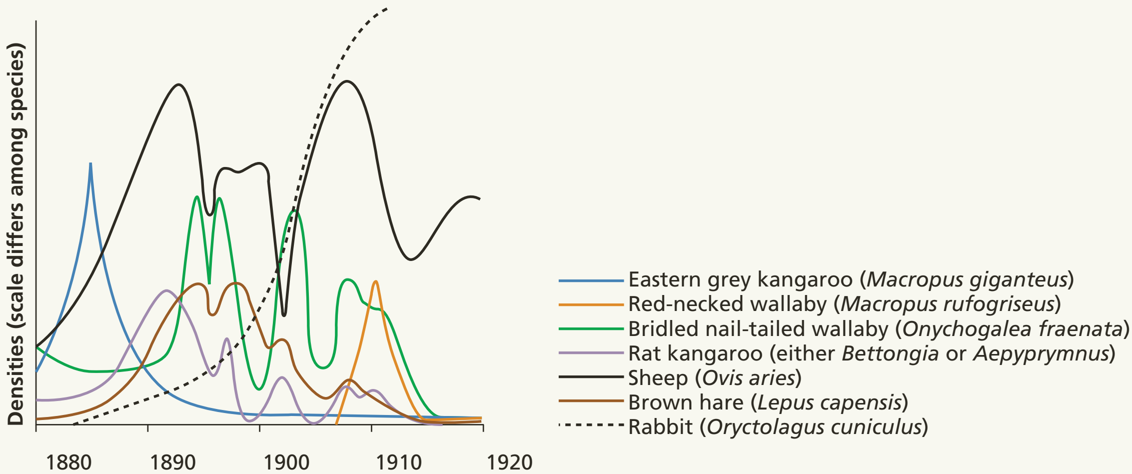


Figure 6.23 ▲ Change in communities in the process of succession.

8 Study the graph in Figure 6.24.
   a At what time was biodiversity at its highest?
   b How have the native herbivores fared against the exotic animals?
   c Describe changes in the herbivore community of the New England tablelands between 1880 and 1920. Suggest possible reasons for these changes.

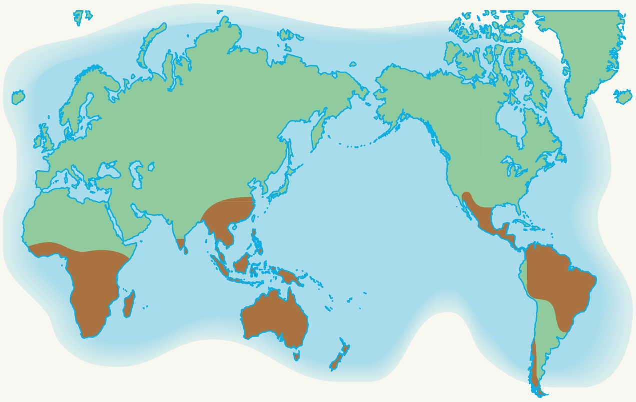


Recher, H. F. et al. (eds) (1992) *A Natural Legacy: Ecology in Australia*, Pergamon Press, Sydney, p. 260.

▲ **Figure 6.24**
Changes in relative abundance of native and exotic herbivorous mammals on the New England tablelands from 1880 to 1920.

9 The Proteaceae family, which includes plant genera such as *Banksia*, *Grevillea*, *Hakea* and *Protea*, has a distribution as shown in Figure 6.25. Many botanists believe Proteaceae represents a family of flowering plants that evolved early. Explain the current distribution of these plants.

White, M. E. (1994) *The Greening of Gondwana*, Reed. By permission of Mary White



◀ **Figure 6.25**
Distribution of family Proteaceae

Evaluating

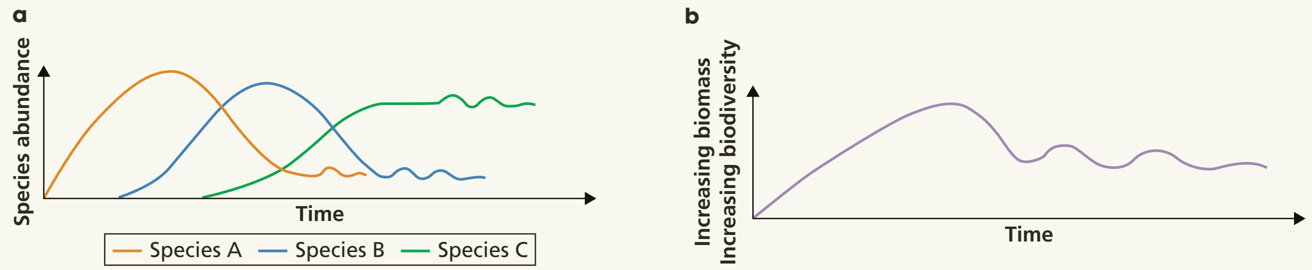
10 Living in modern cities requires the use of many resources. Discuss the implications for terrestrial ecosystems.

11 Present arguments for and against farming native animals and plants.

12 The Australian Department of Agriculture manages quarantine controls at the country's borders. It provides a national approach to the protection of Australia's international borders from incursions by exotic pests and diseases. Justify the role of the service and identify some of the major challenges the service faces.

Creating

13 Use the information in Figure 6.26 (a and b) to create a story about changes in the area described by the data.



▲ **Figure 6.26**
Graphs of changes in biomass and diversity with succession

14 Copy the following table and give an example of each kind of change. Make a comparative note about the scope and duration of each change. An example has been given for you.

Change	Example	Duration	Magnitude	Speed
Flood	Mains pipe bursts and floods school oval	Short duration of less than 24 hours	Flood localised to oval only	Flash flooding
Fire				
Urbanisation				
Removal of vegetation				
Salination				
Monoculture agricultural practices				
Eutrophication				
Commercial fishing				
Introduced species				
Climate change				
Drought				

15 Describe a possible long-term change that could cause secondary succession to occur in your local community. Given the change you describe, predict the stages in succession. Present your findings as a poster.

16 Effects of human activity constitute a major challenge to the stability of ecosystems. Select an example of a human activity from the list below and find out its implications for the sustainability and biodiversity of ecosystems. The form of presentation is negotiable. Decide on about four questions that will be used as focus questions for the investigation. Use named examples in your report.

Investigate and report on one of the following topics.

- Emerging technologies associated with the development of bioplastics
- Disposal of tyres of vehicles
- Disposal of computers and associated technologies such as printer cartridges
- Illegal trading in wildlife
- The transport of wastes from one country to another
- The introduction of marine species in ballast water

- Commercial fishing
- Ecotourism
- The impact of developmental pressures, such as mining, on marine ecosystems
- The use of native animals for food
- Plantations and aquaculture
- Bioremediation or phytoremediation of contaminants in soil and water
- Dredging of waterways
- Introduction of nursery plants that have become weeds and pests

17 What happens to waste material in your home? Design an investigation that traces the amount of different kinds of waste, their origin and their disposal. Present the information in the form of a table.

Reflecting

18 Investigate and describe examples of at least three different kinds of habitat destruction that have affected species in your local or regional area.

a Consider what measures have been or could be taken to counter the effect. Present your findings in a table.

b Reflect on how the knowledge and skills you have gained by studying this unit of biology has increased your awareness of the costs of decreasing biodiversity in the local examples you investigated.

19 Increase in human population has placed pressure on resources. Identify the resources you consider are essential for human survival and suggest strategies for managing their sustainability.