Understanding past environments helps us to understand the future

A study of palaeontology and past environments increases our understanding of the possible future range of plants and animals

4.1 Understanding past environments

- ***explain the importance of the study of past environments in predicting the impact of human activity in present environments***

Introduction

As we have already discussed in the module, the history of the Australian continent has dictated, to a large extent, the composition of the Australian **biota**. Isolated as an island continent after its separation from Gondwana, Australia evolved unique (**endemic**) animals and plants. As the climate became more arid during the last 30–40 million years, the typically Australian element of the biota evolved under the new environmental conditions. With the proximity to islands and other land masses, it was also possible for people to enter northern Australia, at least 40 000 years ago. The impact on the Australian environment of the first humans, especially through the use of fire, continues to be widely debated. Europeans arrived more recently. The impact of Europeans on the Australian environment was rapid and extensive.

Extinction rates and declines in abundance and range of native flora and fauna have been highest in regions where settlement first occurred, attributable to inappropriate land and water use, habitat loss and fragmentation, over-exploitation of both terrestrial and marine resources, and the spread of introduced herbivores, predators, weeds and disease. Human impact on the Australian environment has greatly accelerated over the last 200 years due to extensive forest and woodland clearing, changes to water regimes and introduced animals and plants.

Studying past environments and the extinction of species before, during and after the arrival of humans assists in predicting the impact of changes to the present environment. The impact of humans can only be measured when the state of the past environment is known. This is why the study of past environments is highly important in predicting human impact in present and future environments.

A great deal can be learned about current rates of extinction by studying the past, and in particular the impact of human-caused extinctions. These extinctions are thought to have been caused by hunting, and indirectly by burning and clearing forests, although some scientists attribute these extinctions to climate change.

The majority of historic extinctions have occurred on islands. Of the 90 species of mammals that have gone extinct in the last 500 years, 73 per cent lived on islands (and another 19 per cent lived in Australia). Island populations are often relatively small, and thus particularly vulnerable to extinction.

In recent years, however, the extinction crisis has moved from islands to continents. Most species now threatened with extinction occur on continents, and we can now predict that these areas be affected the most from the extinction crisis in the next 100 years (see Fig. 4.1 and Table 4.1).

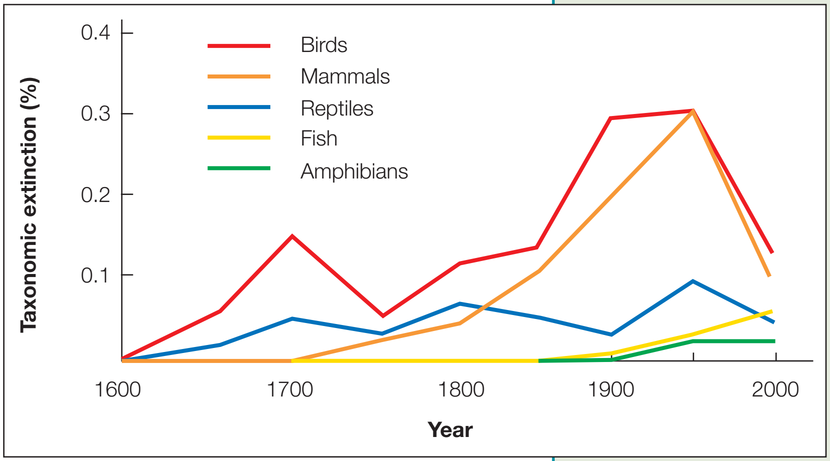


Figure 4.1 Trends in species loss: the graph presents data on recorded animal extinctions since 1600

Table 4.1 Recorded extinctions since 1600

	Recorded extinctions					
Taxon	**Mainland**	**Island**	**Ocean**	**Total**	**Approximate number of species**	**Percent of taxon extinct**
Mammals	30	51	4	85	4000	2.1
Birds	21	92	0	113	9000	1.3
Reptiles	1	20	0	21	6300	0.3
Amphibians[a]	2	0	0	2	4200	0.05
Fish	22	1	0	23	19 100	0.1
Invertebrates	49	48	1	98	1 000 000+	0.01
Flowering plants	245	139	0	384	250 000	0.2

[a] Many species may be on the verge of extinction.
Source: Reid and Miller (1989)

Some people have argued that we should not be concerned because extinctions are a natural event and **mass extinctions** have occurred in the past. Indeed, mass extinctions have occurred several times over the past half billion years. However, the current mass extinction event is notable in several respects. Firstly, it is the only such event triggered by a single species—humans. Although species diversity usually recovers after a few million years, this is a long time to deny our descendents the benefits of biodiversity. In addition, it is not clear that biodiversity will rebound this time. After previous mass extinction events, new species have evolved to utilise resources available due to species extinctions. Today, however, such resources are less available due to human activities destroying habitats and removing the resources for their own use.

Biologists can estimate rates of extinction both by studying recorded extinction events and by analysing trends in habitat loss and disruption. Since prehistoric times, humans have had a devastating effect on biodiversity almost everywhere in the world.

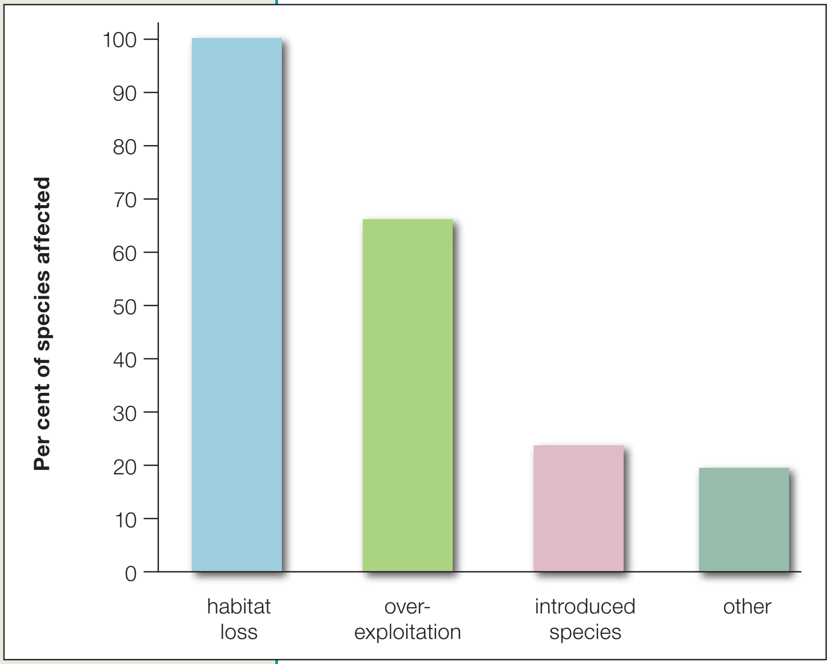


Figure 4.2 Factors responsible for animal extinction

Factors responsible for extinction

A species being rare does not necessarily mean that it is in danger of extinction. The habitat it utilises may simply be in short supply, preventing population numbers from growing. In a similar way, shortage of some other resource may be limiting the size of populations. Studying a wide array of recorded extinctions and many species currently threatened with extinction, conservation biologists have identified a few human factors that seem to play an important role in many extinctions: over-exploitation, introduced species, disruption of ecological relationships, loss of genetic variability, and habitat loss and fragmentation (see Fig. 4.2 and Table 4.2).

Table 4.2 Factors responsible for extinction of different animal groups

	Percentage of species influenced by the given factor[a]					
Group	**Habitat loss**	**Over-exploitation**	**Species introduction**	**Predators**	**Other**	**Unknown**
Extinctions						
Mammals	19	23	20	1	1	36
Birds	20	11	22	0	2	37
Reptiles	5	32	42	0	0	21
Fish	35	4	30	0	4	48
Threatened extinctions						
Mammals	68	54	6	8	12	–
Birds	58	30	28	1	1	–
Reptiles	53	63	17	3	6	–
Amphibians	77	29	14	–	3	–
Fish	78	12	28	–	2	–

[a] Some species may be influenced by more than one factor, thus, some rows may exceed 100%
Source: Reid and Miller (1989)

The extent of environmental change is best illustrated by the number of large animals that became extinct during the period in which people have been in Australia. Most extinctions occurred between 35 000 and 15 000 years ago, at a time when conditions were driest during the last glacial period. Although climate has been considered to be the main cause of these extinctions, there is no evidence to suggest that climatic conditions at this time were more extreme than during the previous glacial phases. However, increased environmental stability resulting from human burning and associated vegetation changes may have sufficiently altered stream flow and lake levels to produce a more drought-prone environment. A generalised summary of the development of the present vegetation and environment in south-eastern Australia is shown in Figure 4.3.

Predicting which species are vulnerable to extinction

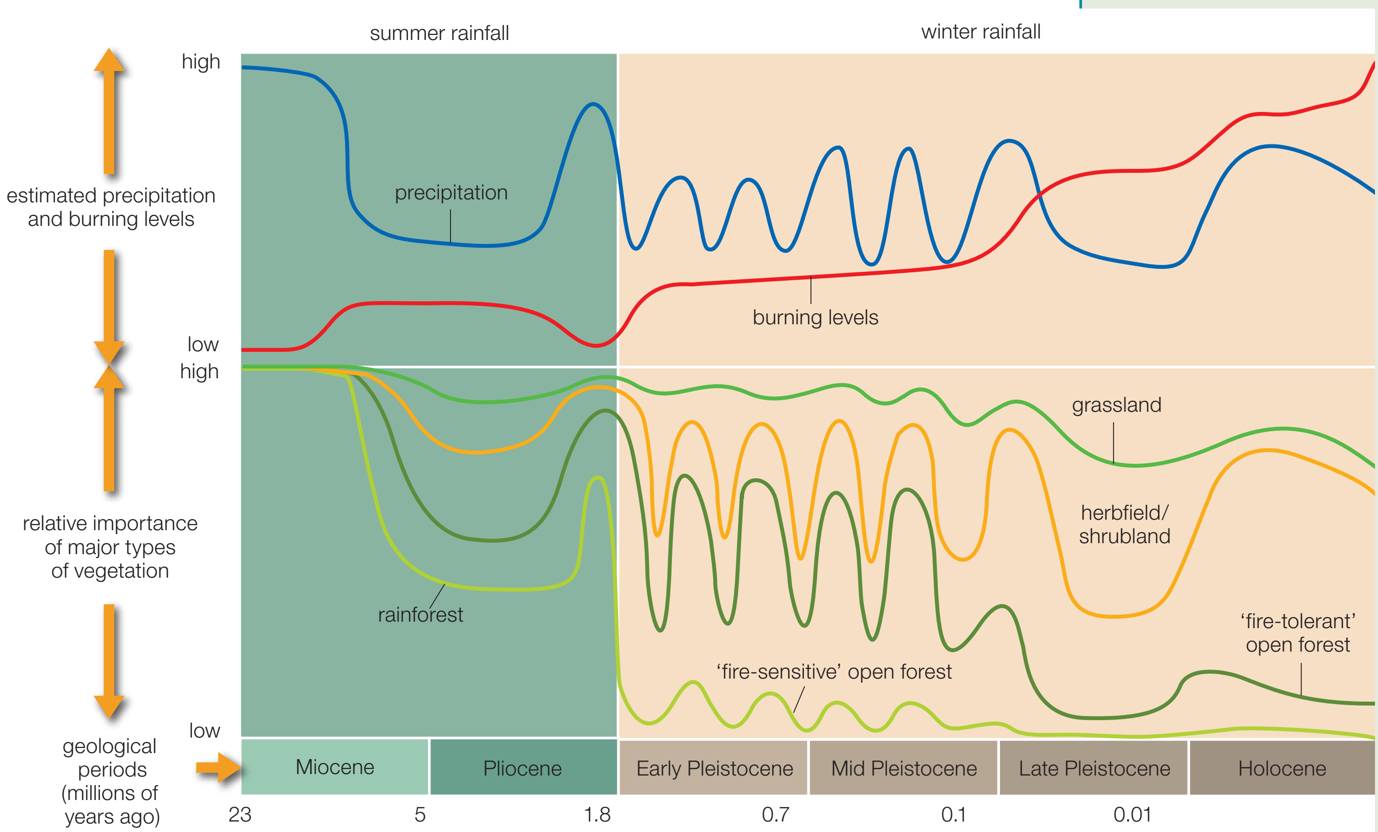
To assess whether a particular species is vulnerable to extinction, conservation biologists look for changes in population size and habitat availability. Species whose populations are shrinking rapidly, whose habitats are being destroyed, or which are endemic to small areas can be considered endangered.

Historical information is critical in explaining the present state of the environment and therefore also in predicting the future. In environmental management this usually involves two aspects:

1. baseline information for some point in the past which has relevance to the ecosystem being managed. In Australia, this has most often been taken to be the moment of first European settlement, as representing the state of the environment prior to the impacts and changes brought by that settlement
2. measurements of change since that point in time. Recognition of different rates and types of change in the past is a crucial foundation to understanding change in the present and to managing human activity into the future.

An example of this approach to environmental management is the Parramatta River. It has been commonly assumed that the mangroves along the banks of the Parramatta River (the central river flowing into Sydney

Figure 4.3 Summary of vegetation and environment changes in south-eastern Australia over the last 23 million years



Harbour) are remnants of former more extensive growth, destroyed in the course of the city's European history. This assumption, based on the present distribution of mangroves, has been overturned by research conducted by L. C. McLoughlin in 1987 and 2000 exploring historical sources back to initial settlement, finding major changes in the vegetation from the early 1800s up to 2000. The earliest data showed mangroves confined to patches only in lower areas of the river and other prominent vegetation such as saltmarsh. The latest data showed increased mangrove growth to eventually line all available sections of the riverbanks and invade and replace saltmarshes. Such assumptions have had a significant influence on foreshore planning, management and restoration activity. Fortunately, this study has now provided more accurate information about the human impact on vegetation such as mangroves along the Parramatta River.

4.2 Distribution of flora and fauna in present and future environments

- ***identify the ways in which palaeontology assists understanding of the factors that may determine distribution of flora and fauna in present and future environments***

Palaeontology

Fossils are the remains of once-living organisms that were adapted to their environments. They can provide valuable information about what past environments were like. Through palaeontology, the study of fossils, we can predict the environmental requirements of organisms in the past from those of closely-related organisms living in the present day. Such predictions will be most reliable in the case of younger rocks which contain fossils that have representatives alive today. As we go further back in geological time, the predictions become less reliable because we encounter fossils of extinct groups about whose environmental requirements nothing is directly known.

Palaeontologists can:

- determine how the organisms have changed over time
- understand how organisms may be related
- understand why some organisms have become extinct
- see the effect of species extinction on other organisms
- recognise changes in past distribution of organisms in order to provide information about how the distribution may be currently changing.

The environmental information obtained from fossils may be as simple as whether the rocks in which they occur were deposited in the sea, in a brackish estuary, in fresh water, or on the land. For example, rocks containing fossils of corals, brachiopods or echinoderms must have been deposited in the sea because living representatives of those groups are found only in the sea today. Similarly, fossils of land-dwelling animals such as kangaroos indicate deposition on land or in an adjacent body of fresh water.

Fossils of reef-building corals indicate that the rocks in which they occur were deposited in warm, shallow seas. At the present-day, reef-forming corals are found in tropical seas and only at depths of less than 200 m where sunlight can penetrate the water to reach the photosynthesising algae within their cells.

Fossil evidence may provide clues about the interactions of organisms with each other, biotic and abiotic factors of past ecosystems, and evidence of climate change in past environments. This fossil evidence therefore provides us with the factors that may have determined the distribution of fauna and flora in the past and hence distribution in present and future environments.

Factors determining distribution of Australian marsupials

By looking at the evidence for changes between past and present climate, and observing the changes in the distribution of organisms that formed fossils over time, we can understand more about the factors that may determine distribution of flora and fauna in present-day environments and predict the movement and distribution of organisms in the future. South American marsupials have been eventually dominated by placental mammals over time. This could indicate the possibility of a similar occurrence with our Australian marsupials.

Palaeontologists can compare past life to modern groups of organisms to discover genetic relationships and the age of different groups. The fossil record for kangaroo-like marsupials in Australia extends back 45 million years ago (see Fig. 4.4) to a time when rainforest was widespread. As the Australian plate drifted north, aridity increased and grasslands and open forests became more common. The number of living species of grazing macropod kangaroos that adapted to a diet of grasses reflects success in the drying environments, while the once common browsing (leaf-cutting) sthenurine kangaroos have declined, possibly due to reduced availability to low-leaf foliage. The living kangaroo most similar to the ancestor of all kangaroos is the musky rat kangaroo, *Hypsiprymnodon moschatus* (see Fig. 4.5), which lives in rainforests and eats a variety of foods. It has simple, rounded molars for crushing soft food items. Species of *Macropus*, such as the red kangaroo (see Fig. 4.6) have high-crested molar teeth that efficiently shear and grind food into

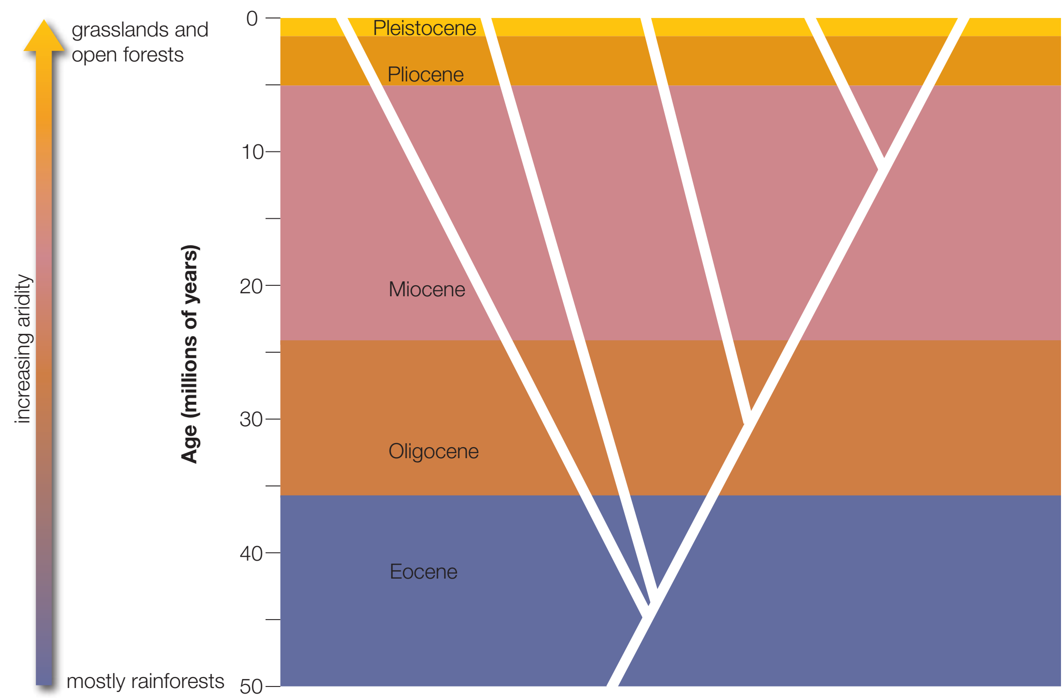


Figure 4.4
A phylogenetic tree representing a simplified view of the relationships of kangaroos

Figure 4.5 The musky rat kangaroo, *Hypsiprymnodon moschatus*

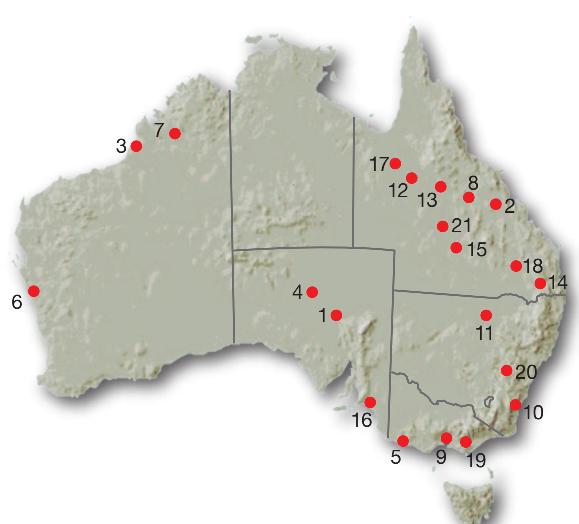
Figure 4.6 The red kangaroo, *Macropus rufus*

a paste. This allows a high proportion of nutrients to be extracted from relatively poor-quality grasses.

Hypsiprymnodon, which retains many ancestral kangaroo features, does not hop bipedally and has a less specialised foot structure, differing from all other kangaroos in retaining the first toe. Kangaroos such as *Macropus* species have a hopping form of locomotion and can achieve speeds greater than 50 km/h as a result of the reduction of the number of toes. This is an advantage in the grasslands for avoiding predators.

Fossil sites in Australia

There are a number of fossil sites around Australia (see Fig. 4.7) that are rich in fossil samples providing information about the species and environment in that area in the past. Table 4.3 summarises the fossil findings in each area, which in turn can provide evidence and assist in indicating the possible factors that may determine distribution of plants and animals currently and in the future, by telling us factors that influenced them in the past.



1 Andamooka
2 Bluff Downs
3 Broome
4 Coober Pedy
5 Dinosaur Cove
6 Geraldton
7 Gogo
8 Hughenden
9 Inverloch-San Remo
10 Koonawarra
11 Lightning Ridge
12 Maxwelton
13 Minmi Crossing
14 Murgon
15 Muttaburra
16 Naracoorte
17 Riversleigh
18 Roma
19 Strzelecki Ranges
20 Wellington
21 Winton

Figure 4.7 Fossil sites in Australia

Table 4.3 Australian fossil sites and their findings

Fossil site	Age of fossils (years ago)	Examples of fossil specimens	Past flora and fauna proposed from evidence
Lightning Ridge	110 million	■ *Steropodon galmani* (small monotreme) ■ *Tachyglossus aculeatus* (short-beaked echidna) ■ *Ornithorhynchus anatinus* (platypus) ■ *Muttaburrasaurus langdoni* (herbivorous dinosaur) ■ *Rapator ornitholestoides* (carnivorous dinosaur)	Forests of ferns and pines and the beginnings of flowering plants, herbivorous and carnivorous dinosaurs, and monotremes.
Murgon	55 million	■ Placental mammals (condylarth) ■ Crocodiles ■ Snakes ■ Frogs ■ Salamanders ■ Marsupial mammals ■ Rainforest plants	Rainforests, no dinosaurs but reptiles, songbirds, large numbers of marsupial mammals, few placental mammals, and amphibians lived near the streams.
Koonwarra	115–118 million	■ *Australurus plexus* (mayfly nymph) ■ *Tarwinina australis* (flea) ■ *Ginkgoites australis* (ginkgo leaf)	Large freshwater lake with fish, plants, insects, crustaceans, spiders, birds and crabs.
Inverloch	115 million	■ *Ausktribosphenos nyktos* (placental mammal) ■ *Koolasuchus cleelandi* (large amphibian)	Dinosaurs and mammals.
Riversleigh	25 million—40 000	■ Parrots ■ *Emuarius* (ancestral to emus and cassowaries) ■ Marsupials ■ Crocodiles ■ Snakes ■ Lizards ■ Turtles ■ *Yalkaparidon*, dasyurids, thingodontans (marsupial mammals)	Rainforests with high diversity of animals such as birds, reptiles, large numbers of marsupials, kangaroos, possums, wombats and monotreme mammals.
Bluff Downs	5 million	■ Bluff Downs giant python (*Liasis* sp.), ■ Koala-like mammal (*Koobor jimbarretti*) ■ Ancestral dasyurids	Lakes and streams, wetland area with rich diversity of animals such as birds, reptiles and mammals, many very large animals (e.g. giant python 8 m long).
Wellington caves	5 million—30 000	■ Diprotodon (giant marsupial kangaroo) ■ *Thylacoleo* (marsupial lions)	Leaf-browsing decreasing and grass-grazing marsupials increasing (kangaroos, wallabies and tree-kangaroos) over time, and grasslands expanding.
Naracoorte	300 000	■ *Macropus giganteus* (eastern grey kangaroo) ■ *Wallabia bicolour* (swamp wallaby) ■ *Sthenurus brownei* ■ *Protemnodon brehus*	Large range of vertebrates: megafauna—large-sized animals, marsupials, birds, reptiles and frogs.

Extension information: visit www.amonline.net.au/fossil_sites/index.htm for Australian fossil sites in detail (Australian Museum online).

Reasons for evolution, survival and extinction in Australian species

SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P12

■ ***gather, process and analyse information from secondary sources and use available evidence to propose reasons for the evolution, survival and extinction of species, with reference to specific Australian examples***

Introduction

The history of life on Earth over the past 3500 million years has been characterised by a dramatic increase in biological diversity. This increase in diversity did not occur in a gradual way over time but it is the collective result of a number of rapid evolutionary spurts followed by occurrences of mass extinction. This rise and fall of extinctions over time has resulted in an overall increase in biological diversity.

Mass extinctions are often followed by occurrences of diversification, during which biological diversity is restored and eventually increased. This occurs by the rapid evolution of the survivors of the extinction, which adapt to repopulate the environment space left by the extinct organisms.

The reasons for the mass extinction of the dinosaurs, including Australia's megafauna, continue to be debated amongst scientists around the world. There are three main theories as to why this extinction occurred.

1. *Human impact*—hunting large and slow, easy prey.
2. The last *ice age*—with significant amounts of water trapped in ice, sea levels drop and climates become drier and colder. Habitats would be destroyed and food would be scarce. With such extreme conditions larger animals would find it the most difficult to survive.
3. A combination of both *human impact and the ice age*—habitats destroyed and scarce food supply leads to large declines in numbers and human hunting directly leads to the final extinction.

Other approaches that species take that are more successful for survival and evolution are retreating into a suitable environment without being affected by environmental changes, or evolving through adaptations to the change in environment. Variation in species creates better opportunities for survival in changing environments.

Aims

1. Gather, process and analyse information from secondary sources and use available evidence.
2. Propose reasons for the evolution, survival and extinction of species, with reference to specific Australian examples.

A list of Australia's lost kingdoms: www.lostkingdoms.com/facts/index.cfm

Method

Part 1: Gather, process and analyse information from secondary sources and use available evidence

For a reminder on how to undergo this process go to page 18 ('Searching for information'). Read Section 4.1 and then select two Australian examples for each of the following categories:

- species that have evolved and changed (e.g. made adaptations) over time
- species that have survived unchanged (e.g. by retreating) over time
- species that have become extinct over time.

Start your search using the website listed above, selecting examples from the most recent periods such as Holocene (10 000 to present) and Pleistocene (1.6 million—10 000 years ago) for those organisms that may have survived and evolved over time, and the less recent periods for organisms that became extinct. Other suggested websites can be found in the secondary source task in Section 2.6 of this module.

Once you have gathered information from secondary sources and processed and analysed the relevant information for your six selected examples, use the evidence available to attempt Part 2.

Part 2: Propose reasons for the evolution, survival and extinction of species, with reference to specific Australian examples

Copy (see Student Resource CD) and complete Table 4.4 by proposing reasons why each of your six selected Australian species examples evolved, survived or became extinct over time. Four examples have been provided: two extinct examples, the thylacine (Tasmanian tiger), which became extinct in 1936, and the diprotodon that became extinct 50 000 years ago coinciding with the arrival of humans into Australia; one survival example, the spotted cuscus (*Phalanger maculates*); and one evolution example, the kangaroo (*Macropus* species).

SR TR

Table 4.4

Results

Table 4.4 Reasons for the evolution, survival and extinction of some Australian species

Australian example	Species evolved, survived or became extinct	Proposed reasons
Thylacine (Tasmania tiger)	Extinct	■ Introduction of the dingo 3500 years ago ■ Hunted by farmers in Tasmania (seen as a predator to sheep and chickens) ■ Tasmanian government bounty for threat to farming ■ Disease ■ Possibly all of the above reasons in succession
Diprotodon optatum (marsupial mammal—megafauna)	Extinct	■ Human hunting ■ Climate change ■ Or a combination of both
	Extinct	
	Extinct	
Phalanger maculates (spotted cuscus)	Survived	■ Retreated with the rainforest as the climate changed
	Survived	
	Survived	
Macropus species (kangaroo)	Evolved	■ Developed adaptations to the changes that occurred in the environment (such as change from forests to grasslands with increasing aridity) ■ Reduced number of toes and can hop bipedally at high speeds away from predators in open grassland, unlike earlier ancestors ■ Also change from those with leaf-browsing diet to those that were grass-grazers
	Evolved	
	Evolved	

Discussion questions

1. Describe the main reasons you proposed for your selected Australian species:
   (a) evolving over time
   (b) surviving over time
   (c) becoming extinct over time.
2. Other than your selected examples, identify any further reasons you could propose for the evolution, survival and extinction of a species.
3. Discuss the main reasons why some Australian species have evolved and survived while others have become extinct.
4. List two reasons why you can only *propose* reasons for extinction and that they could not be considered valid conclusions.

4.3 Understanding and managing the present environment

■ *explain the need to maintain biodiversity*

Biodiversity refers to the variety of all forms of life, the diversity of the genetic characteristics they contain and the ecosystems of which they are components. Genetic diversity within a species is what allows populations to adapt to changes in the environment. To maintain biodiversity we must maintain genetic diversity within the species as well as maintaining the living species within their habitats.

The value and benefits of maintaining biodiversity fall into four main categories:

- direct economic value of products we obtain from species of plants and animals, and other groups:
  —bioresources such as food, fibre, timber and medicines
  —the potential of any undiscovered bioresources is significant (e.g. ants possess specialised glands for producing antibiotics to reduce disease in their colonies). These discoveries hold great potential for therapeutic use
- indirect economic value of benefits produced by species without consuming them
  —ecosystems underpin many of our natural resources and provide services such as healthy soil, clean water and crop pollination
- ethical—ethically all species have a right to exist just as humans do
- aesthetic value—humans enjoy the beauty of the natural environment, and countries like to conserve their heritage to be passed down.

At an international level, biologists are working together to discover and record all the types of organisms on Earth, the world's biodiversity, so that it can be synthesised into a classification system that will reflect our knowledge of all of life. Today, despite the fact that we realise that biological diversity is one of our most precious resources, species are being lost at a rate 100 to 10 000 times faster than before human intervention. We do not know the exact rate of extinction of species, but in Australia since European settlement in 1788, 75 per cent of rainforests, 99 per cent of south-eastern temperate lowland grasslands and 60 per cent of south-eastern coastal vegetation have been cleared, resulting in significant loss of species. The dramatic loss of species caused by human activity worldwide is known as the **biodiversity crisis**. Each species represents an immense amount of genetic information. At present, we do not know what will be the ecological impact of a continuing loss of species.

Current effort to monitor biodiversity

■ *process information to discuss a current effort to monitor biodiversity*

SECONDARY SOURCE INVESTIGATION

PFAs

P5

BIOLOGY SKILLS

P12
P14

Aim

1. To process information.
2. To discuss a current effort to monitor biodiversity.

Background information

The Australian government's *Environment Protection and Biodiversity Conservation Act 1999* was created to meet Australia's obligations as a signatory to the 1992 Convention on Biological Diversity. This Act protects all native fauna and provides for the identification and protection of threatened species. In each Australian state and territory, there is a statutory listing of threatened species. At present, 380 animal species are classified as either endangered or threatened under the *EPBC Act*. In fact, a complete cataloguing of all the species within Australia has been undertaken; it is a significant step in the conservation of Australian fauna and biodiversity. In 1973, the federal government established the Australian Biological Resources Study (ABRS), which coordinates research in the taxonomy, identification, classification and distribution of Australian flora and fauna.

Monitoring biodiversity

Monitoring is essential to any action plan to conserve biodiversity. It provides information on how the management plan for conserving biodiversity is performing. If species continue to decline in population numbers, then the current management plan is not effective and requires change. Changing management involves assessing human-related activities such as mining, forestry and recreation, as well as conservation-related activities such as those existing in reserves and national parks.

Ideally all species in existence would benefit from having their populations monitored; however, this would be a very time-consuming and costly process, and funding is limited. So, at present, monitoring programs tend to focus on threatened species or ecosystems, or ecosystems that provide economic value through industry (e.g. mining, logging and tourism).

You carried out abundance (or population) measurements of selected species in your biology field trip earlier this year. If you were to repeat your data collection at the same time next year, it would be possible to see changes over that time and allow you to comment on the population status or health of species biodiversity in that area.

Many government funded groups are monitoring biodiversity, using more complex versions of the methods you may have used during your field trip. These programs are collecting abundance measurement and information regarding human impact on different organisms such as native plants, birds, reptiles, mammals and amphibians. Amphibians have been identified as good indicators of environmental health because they are very sensitive to changes in their environment (their skin is permeable to both liquids and gases). Because of this sensitivity their decline within an ecosystem may also indicate that other components of the ecosystem are in a state of decline or bad health. Information can also inform us about the nature of the population decline and the potential threats causing decline.

The following case study attempts to provide a balanced argument and highlights the complexities and difficulties in managing and conserving biodiversity.

Method

Part 1: Process information

Refer to page 18 for suggestions and reminders on how to go about processing information. Read Section 2.10 (page 50) in the Local Ecosystem module discussing the nationally endangered Baw Baw frog (*Philoria frosti*) and the case study below, and process your information to begin completing Part 2.

Part 2: Current effort to monitor biodiversity

Copy (see Student Resource CD) and complete Table 4.5 and use this to attempt to discuss the points for and/or against this current effort to monitor biodiversity. You will be using this task to address PFA P5 in describing the scientific principles employed in a particular area of biological research. In doing so, we are looking at one of the current critical issues surrounding Baw Baw frog research.

SR TR

For websites on how different groups and government departments are monitoring biodiversity

Case study—Baw Baw frog

The Baw Baw frog is one of Australia's most critically endangered amphibians and it is Victoria's only endemic amphibian, being restricted to the Baw Baw Plateau in the Central Highlands of Victoria. The dramatic decline of the species in recent years coincides with a global decline in amphibian populations. This decline in amphibian populations also corresponds with the overall global biodiversity crisis. Since 1996, the Australian Government has provided funding to support research and population monitoring on the species through its endangered species program. Population monitoring is a key action in the draft National Recovery Plan (2002–2006) and State Action Statement for the species. These plans identify research and management actions required to conserve the species and are supported by legislation at both state (*Flora and Fauna Guarantee Act 1988*) and federal (*Environment Protection and Biodiversity Conservation Act 1999*) levels. The effort to protect and conserve the Baw Baw frog and its habitat is also likely to benefit the conservation of a number of other threatened species and communities located in the same area as well as contributing to the identification of the likely causes of decline.

An additional advantage of the Baw Baw frog monitoring program is that it is designed to distinguish between 'real' population trends and natural population fluctuations that can occur in response to variable factors such as weather and food resources. The longevity of the monitoring program (24 years as of 2007) and the selection of an appropriate number of survey sites in which to census, provides the program with sufficient power to detect 'real' trends in population size over time. However, monitoring programs that are designed to measure 'real' trends in population often require many surveys or repeated measurements of abundance over a season or year and as a result can be very expensive. This high cost can inadvertently prevent monitoring from occurring when funding is in short supply or not made available.

Presently, the causal mechanisms responsible for the decline of the Baw Baw frog are still yet to be formally established. Currently, the most plausible reasons for the decline of the species are:

- an introduced pathogen (eg. chytrid fungus)
- climate change (this species is very sensitive to small changes in temperature and relative humidity).

Other potential threats to the frog include:

- habitat clearance and fragmentation (e.g. alpine resort development and timber harvesting)
- introduced flora and fauna (e.g. cattle, deer, rabbit, cat, fox, and dog)
- forestry activities (e.g. roading and timber harvesting)
- fire (inappropriate fire regimes)
- increased UV-B radiation
- atmospheric pollution (e.g. industrial and agricultural emissions)
- multiple and interacting factors (combinations of the above factors).

Approximately 70 per cent of the current total population of adult Baw Baw frogs occurs in state forest where the primary land use has been identified as timber harvesting. Since the discovery of the Baw Baw frog in state forest in 1996, forestry activities have been identified as a serious threat to the long-term survival of the species. The sensitivity of the Baw Baw frog, due it its narrow ecological requirements, suggests that forestry activities may impact through:

- direct destruction of frogs and habitat
- changes to climatic and water conditions from activities in and adjacent to frog habitat (e.g. stream-flow amount is reduced up to 25 years following timber harvesting)
- sedimentation of breeding habitat following activities in and adjacent to frog habitat
- fragmentation of populations, and/or destruction or modification of dispersal habitats.

The case of conserving the Baw Baw frog presents a very interesting issue because the frog is situated within an area of very high timber-resource value. The Victorian Government has been faced with the challenge of implementing components of biodiversity and resource-use legislation

SR TR

For further information from websites on the Baw Baw frog

Figure 4.8
Baw Baw frog

that are in conflict with each other. The biodiversity legislation states that the Baw Baw frog will be protected and its long-term survival ensured, whilst legislation relating to the timber harvesting industry states that the government will guarantee resource security for specified volumes of timber from the area where the Baw Baw frog is located. Due to the substantial economic value of native forest timber to local and state economies in Victoria ($3000 million in commercial turnover each year and provision of many jobs), scientists are often faced with the predicament of having to demonstrate negative impacts of resource use on the prospects of survival of a species before conservation initiatives are implemented. Demonstrating such impacts, or lack there of, can often take considerable periods of time when researching impacts on biodiversity. These lengthy periods of time can sometimes discourage governments from wanting to invest in such projects.

In the case of the Baw Baw frog, the Victorian State Government allocated funding to undertake research involving experimental timber harvesting within the habitat of the frog to investigate the potential negative impacts of forestry activities on the species. This research was identified as an action in both the draft National Recovery Plan (2002–2006) and State Action Statement for the species. However, due to concerns expressed by the Australian Government and local environmental groups over the risk of conducting the research on an endangered species with a very small distribution, the research was discontinued. This case provides an example of when concerns expressed by external stakeholders and the public can influence decisions made by governments.

Due to the extended drought across south-eastern Australia, the management of water resources within Melbourne's water catchments has more recently become a significant issue in Victoria. Because the Baw Baw frog lives in Melbourne's primary water catchment (the Thomson Catchment and Reservoir) and that re-growth forest following timber harvesting activities can significantly reduce run-off of water up to 25 years after harvesting, a future decision by the Victorian Government to protect the habitat of the frog by excluding timber harvesting may be influenced more so by the increasing economic value of water within the Thomson Water Catchment compared with the harvesting of timber.

Source: Dr Greg Hollis, Senior Biodiversity Officer, Department of Sustainability and Environment

Results

PFA P5: Describe the scientific principles employed in a particular area of biological research

PFA P5

Table 4.5 Current issues, research and development in biology—monitoring the Baw Baw frog

Issue: Should forestry activities continue in the habitat of the Baw Baw frog?	
Points FOR issue (i.e. in favour, such as benefits, positive outcomes and positive consequences)	**Points AGAINST issue** (i.e. negative factors such as expense, limited uses and negative consequences)

SR TR

Table 4.5

Discussion/conclusion

Summarise your overall points for and against the issue, summing up the discussion with a conclusive statement.

Analysis questions

1. Describe two ways in which the Australian government is involved in monitoring biodiversity.
2. Discuss why it is important for governments to support biodiversity monitoring initiatives.
3. Explain the importance of amphibians like the Baw Baw frog when aiming to monitor biodiversity.
4. List the possible threats towards the rapidly declining Baw Baw frog population.
5. Discuss the main points for and against the effort to monitor biodiversity in Baw Baw frog habitats.

REVISION QUESTIONS

SR TR

Answers to revision questions

1. Explain the importance of the study of past environments in predicting the impact of human activity in present environments.
2. Identify the ways in which palaeontology assists our understanding of the factors that may determine the distribution of flora and fauna in present and future environments.
3. Explain the need to maintain biodiversity.
4. Using a *named* Australian example, identify a reason for the extinction of the species.
5. Discuss an example of a current effort in Australia to monitor diversity.