Environmental change and management

unit

1

Changing and managing the environment

Biosphere 2, one of the world's largest scientific experiments, sits in the Arizona desert. It is a miniature replica of the world's **biomes** (an **environment** with distinctive climate, plants and animal species). It was built to explore the possibility of sustaining human life on other planets. Eight people were sealed inside for two years with the aim of surviving without outside help. Despite a cost of US$200 million, Biosphere 2 could not generate sufficient breathable air, drinkable water or adequate food for the eight people inside, and after 18 months oxygen had to be pumped in from outside. The Earth supports 7 billion people every day, supplying us with the water, air and food we need to survive. This is done through a multitude of systems – some tiny, others as large as the Earth itself. Without these systems, life as we know it would not exist. Despite this, many human activities are threatening these systems through climate change, species extinction, land and water degradation and pollution.

1.1

How do human activities affect the environment?

1 One of the biggest problems faced by the inhabitants of Biosphere 2 was a build-up of carbon dioxide and falling oxygen levels. How are these levels maintained on Earth?

2 How do you think the inhabitants dealt with their waste?

1.2

How do people change and manage the land?

1 Biosphere 2, built north of the expanding city of Tucson, came under threat in 2007 when the land on which it sits was going to be used for a new housing estate. Apart from housing, what are some other ways in which people change the land?

2 How would the building of Biosphere 2 have changed the surrounding land?

Source 1.1 Biosphere 2 was built in 1987 with the aim of creating an artificial environment on Earth that could sustain human life and be transferred to other planets.

1.3

How do people change and manage fresh water?

1 How do the Earth's systems provide us with a supply of fresh water?

2 Brainstorm some of the ways in which the supply of fresh water on Earth is threatened.

Our environment: The key to sustaining life

As far as we know, planet Earth is the only place in the universe capable of supporting human life. This is because the environment here provides organisms such as plants and animals with everything they need to survive: food, light, water and air. Humans, of course, are one of these organisms, and our survival on Earth is largely due to the services provided by the natural environment around us (see Source 1.2).

Unlike most other organisms, however, humans have the ability to degrade the environment to such an extent that the **ecosystem services** on which we rely become threatened. This is now happening around the world in many different places and in many different ways.

A working environment

The way in which we think about our environment has changed dramatically over the last few decades. Once seen as a bottomless pit of resources providing everything we need, it is now viewed as a fragile system threatened by human actions. The ecosystem services it provides (like clean air,
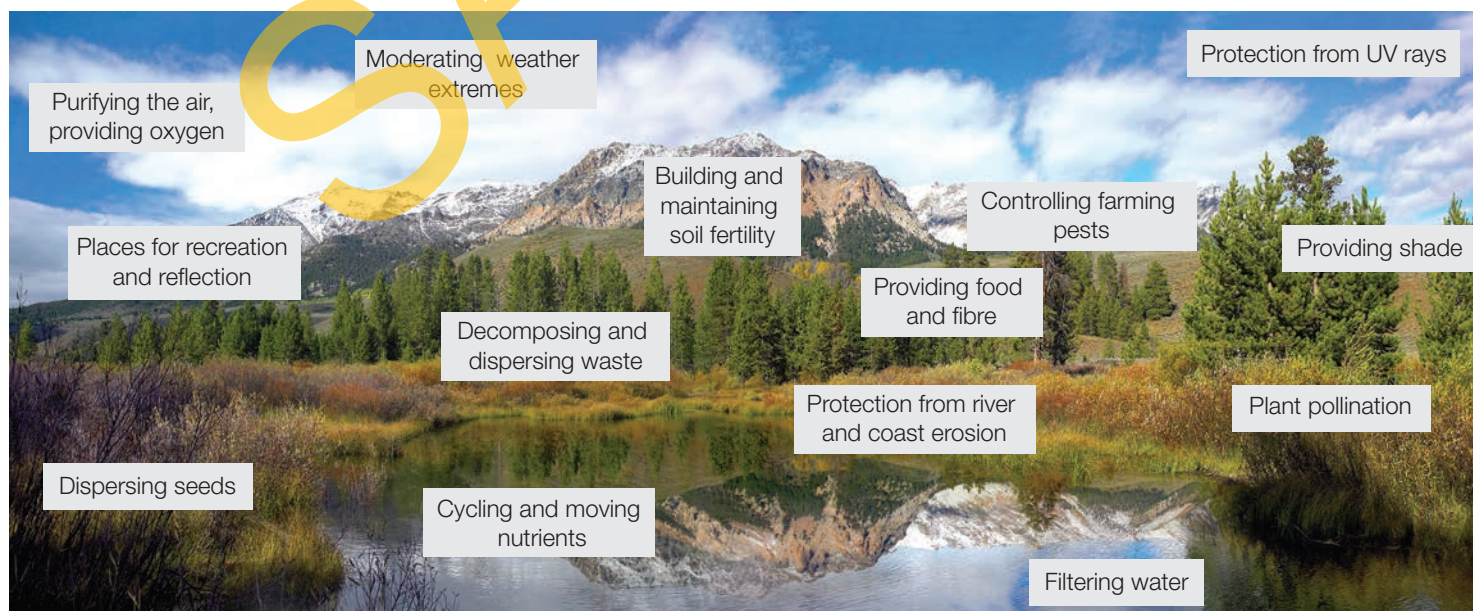
plant pollination and fertile soil) have long been ignored or taken for granted. This is partly because, unlike products we can touch such as food, water and timber, humans have been unable to put a monetary value on these ecosystem services. However, as the environment becomes degraded, the true value of these services is beginning to be recognised.

The four S's of ecosystem services

Ecosystem services can be classified according to the products they provide and the functions they perform. There are four main classifications: **sources**, **sinks**, **services** and **spirituality**.

Sources

Sources (also called provisioning services) are those natural products that can be used or converted by humans for our use. For example, mineral deposits such as coal which we turn into fuel, iron ore which we use in manufacturing, timber from natural forests, and food sources – from plant crops to deep sea fish.

Purifying the air, providing oxygen

Moderating weather extremes

Protection from UV rays

Places for recreation and reflection

Building and maintaining soil fertility

Controlling farming pests

Providing shade

Decomposing and dispersing waste

Providing food and fibre

Dispersing seeds

Protection from river and coast erosion

Plant pollination

Cycling and moving nutrients

Filtering water

Source 1.2   Some of the ecosystem services provided by the environment

Sinks

Sinks (also called regulating services) are those processes in the natural environment that absorb our waste.

For example, micro-organisms in oceans break down oil spills. In a similar way, bacteria in the soil breaks down human waste.

Services

Services (also called supporting services) are things that are done for us by the natural environment that don't produce consumable resources. For example, wetlands filter water and slow floodwaters. Forests absorb carbon dioxide and produce oxygen.

Spirituality

The environment also has a spiritual function for many people. For some, this is a deep connection to the land formed over many generations. For example, the connection that Indigenous Australians have with their tribal lands. For others, it is the experience of spending time in the natural environment and the sense of wellbeing that this brings. For example, people taking part in activities such as surfing and bushwalking often feel a deep connection with the environment. This can also be referred to as cultural services.

Source 1.3   The Walgal and Ngarigo people have lived in the Australian Alps for thousands of years and many have a deep, spiritual connection to the place.

Check your learning 1.1

Remember and understand

1   What are ecosystem services?
2   Why do we often take them for granted?

Apply and analyse

3   Classify each of the ecosystem services shown in Source 1.2 as source, sink, service or spirituality.
4   Can you think of one more example of each?
5   Examine the image of the Australian Alps (Source 1.3) and give an example of a source, sink, service and spirituality function of this environment.

Evaluate and create

6   Which of the ecosystem services shown in Source 1.2 do you consider to be the most valuable to humans? Justify your choice.
7   Which ecosystem service do you think is most threatened by human activities? What would change if this service could no longer be provided by the environment?
8   The designers of Biosphere 2 attempted to provide all of the ecosystem services shown in Source 1.2. Conduct some research to find out which services they were able to provide easily and which were the most difficult to provide.

One world, many views

In December 2011, Miranda Gibson, a 30-year-old school teacher, built a platform in a tree 60 metres above the forest floor in Tasmania's Styx Valley. She then set up home on the platform and vowed not to leave it until the tree and the surrounding forest had been granted protection from logging companies. Armed with a laptop and wireless Internet connection, she wrote a daily blog which was viewed by tens of thousands of supporters. She also made the news around the world. Despite freezing cold, snow and rain, she remained up the tree for 449 days, an Australian record, and was forced down only when a nearby bushfire threatened her safety. While she had many supporters around the world, she also had many critics. At one stage, a pro-logging group camped at the base of the tree to protest against Gibson's protest.

Why is it that some people become so passionate about preserving the natural environment while others do not? For example, one person can look at a rainforest and see the beauty of nature, whereas the person standing beside them can only see the money to be made by turning the tree into timber. We can see these differences all over the world, wherever the natural environment is changing.

Studies show that different people view the environment in different ways because of the fundamental beliefs they hold about human beings and our place in the natural world. The reasons for holding these beliefs are very complex, but it appears that where we live, our standard of living, our education and our religion all play important roles. Although each person's view of the world is unique, researchers have managed to classify them into four major groups (see Source 1.5). It is important to understand that one view is not necessarily 'better' or 'worse' than another, it is simply different.

Source 1.4   Miranda Gibson made her home high in the branches of this tree for 449 days.

World views

Human-centred

Egocentric
I am the most important creature on Earth. Everything and everyone else is important to the extent that they support me and my lifestyle.

Anthropocentric
Humans are the most important species. We are in charge of the Earth and the natural world. We can use nature to support us and our lifestyle.

Earth-centred

Ecocentric
We should do whatever we can to minimise our impact and preserve the Earth's biodiversity. We are no more important than any other organism.

Biocentric
We have a responsibility to use the Earth's resources in a sustainable way. Other species may be useful to us but they also have as much right to exist as we do.

Source 1.5   World views about the environment

What is your world view?

In order to evaluate the different ways in which people view the world, US environmental social researchers have developed a set of 15 statements called the New Ecological Paradigm (NEP) scale. People are asked to read each of the statements and decide whether they agree or disagree with them on a scale from 1 to 5, where 1 is 'strongly disagree' and 5 is 'strongly agree'. This allows researchers to compare the world views of different groups of people within and between countries.

Source 1.6 The New Ecological Paradigm (NEP) scale

1 We are approaching the limit of the number of people the Earth can support.

2 Humans have the right to modify the natural environment to suit their needs.

3 When humans interfere with nature it often produces disastrous consequences.

4 Human ingenuity will ensure that we do not make the Earth unliveable.

5 Humans are seriously abusing the environment.

6 The Earth has plenty of natural resources if we just learn how to develop them.

7 Plants and animals have as much right as humans to exist.

8 The balance of nature is strong enough to cope with the impacts of modern industrial nations.

9 Despite our special abilities, humans are still subject to the laws of nature.

10 The so-called 'ecological crisis' facing humankind has been greatly exaggerated.

11 The Earth is like a spaceship with very limited room and resources.

12 Humans were meant to rule over the rest of nature.

13 The balance of nature is very delicate and easily upset.

14 Humans will eventually learn enough about how nature works to be able to control it.

15 If things continue on their present course, we will soon experience a major ecological catastrophe.

Source: Dunlap, Riley E.; et al. (2000). Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues, 56* (3), 425–442

Check your learning 1.2

Remember and understand

1 What is the main difference between human-centred and Earth-centred world views?

2 Use Source 1.5 to classify Miranda Gibson's world view.

Apply and analyse

3 Read the 15 statements in Source 1.6. In a table, record the numbers of the statements you agree with in one column and the numbers of the statements you disagree with in another. (If you agreed with all or most of the seven even-numbered statements, researchers would classify you as having a human-centred world view. If you agreed with all or most of the odd-numbered statements, they would classify you as having an Earth-centred world view.)

  a Describe your world view based on your responses to this test. Did you find your results surprising?

  b Find a classmate with a similar world view to you and discuss with them their views of Miranda Gibson's anti-logging protest.

  c Find a classmate with a very different world view to yours and find out what they think about the anti-logging protest.

  d Ask an older person such as one of your parents to respond to the 15 statements and compare their responses to yours.

Evaluate and create

4 Do you think the NEP scale is an accurate way to evaluate people's world views? Can you suggest any ways in which this method could be improved?

5 Using the Internet, do some further research on the issue of logging in Tasmania's Styx Valley. Identify the individuals and groups who believe the area should be logged and the individuals and groups who believe the area should be protected from logging.

  a For each of the individuals or groups, summarise their point of view in regard to logging in the Styx Valley.

  b Give some possible reasons why these different points of view exist in relation to this issue.

Challenges to sustainability

Virtually all human activities impact on the natural environment in some way, but humans can reduce these impacts by using the Earth's resources sustainably. The concept of **sustainability** relates to the ongoing capacity of the environment to support the lives of all living things into the future. The sustainable use of resources such as **fossil fuels**, forests and oceans is about carefully managing these resources so that they meet the needs of today without compromising the ability of future generations to do the same – put simply, it is about using the Earth's resources at levels that allow the planet to replace or replenish them naturally. This is a particularly important concept when we consider our use of natural resources that supply us with food and water, such as forests, rivers, the oceans and farmland. If resources are used sustainably, the quality of the environment is maintained and the resources will continue to provide for future generations.

Case study: The fishing industry and world fish production

Fish are a vital food resource, providing over 15 per cent of the animal protein eaten each day by three billion people. Currently, about 540 million people are employed in the fishing (fish catching) or aquaculture (fish farming) industries.

Many of the world's fish species, however, have been fished beyond sustainable levels and their numbers are now in serious decline (see Source 1.7). More than half of the species investigated by the United Nations are described as being 'fully exploited' and have no potential for increased production in the future. Another third of fish species are described as being 'over exploited'. This means that they are currently being fished at an unsustainable level. However, if effective management plans are put in place now to reduce the numbers taken from the sea, these species may recover.

Unsustainable levels of fishing are being driven by the food demands of an increasing world population and by modern fishing techniques. These techniques include using spotter planes and GPS to locate large schools of fish, fishing in deeper waters and dragging huge nets along the ocean floor. Fewer and fewer fish are now surviving to adulthood, because they are being caught and eaten as juveniles, before they have had a chance to breed and produce more fish. This means that the fish being caught are not being replaced.
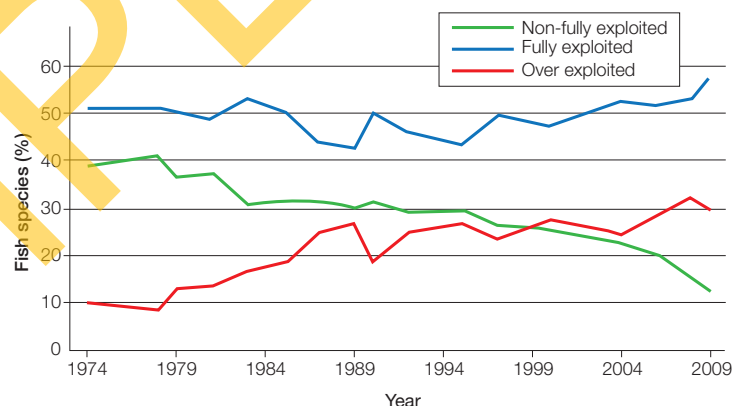
Source 1.7 Global trends in world marine fish species supplies since 1974

Source: FAO

Source 1.8 These Bluefin tuna are caught in the Mediterranean Sea then fattened in cages before being shot, frozen and shipped to Japan to become sushi. Remaining stocks of wild tuna are listed as endangered species but little is being done to protect them.

A warning from the past: The disappearing Atlantic cod

The people of the north-western United States and Canada have fished the coastal waters of the Atlantic Ocean for hundreds of years. The most prized fish of their catch is the Atlantic cod which once existed in vast numbers. Up until the mid-1950s, around 300 000 tonnes of Atlantic cod were caught each year in the region's waters. By the middle of the 1960s, large-scale fishing trawlers, using vast nets and mechanical winches, were catching 100 tonnes of Atlantic cod an hour. By 1968, the amount caught peaked at more than 800 000 tonnes before the Atlantic cod population collapsed. Despite attempts to protect the remaining cod in the last few decades, the population has never recovered (see Source 1.9).
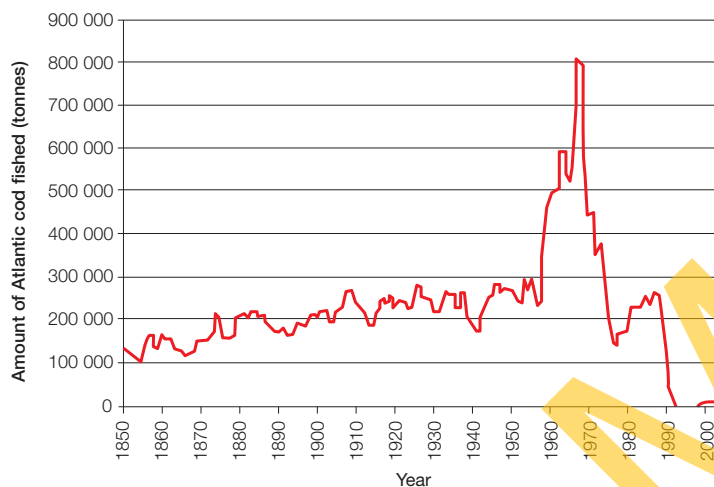
Source 1.9 Amount of Atlantic cod fished off the East Coast of Newfoundland, 1850–2000
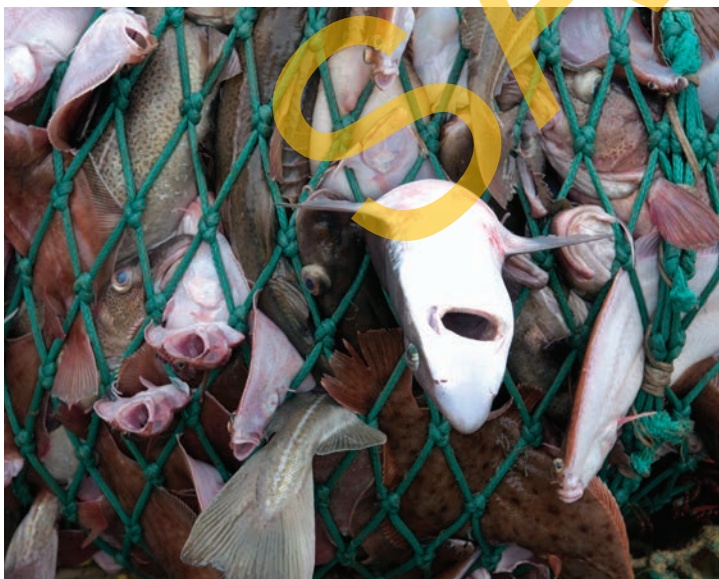
Source 1.10 Large-scale fishing practices implemented from the 1960s onwards devastated the population of Atlantic cod in the United States and Canada.

Making fishing sustainable

In more recent times, countries such as Australia, New Zealand and the USA have put in place fisheries management plans to make their fishing industries sustainable and to ensure good numbers of fish stock in the ocean in the future. These plans monitor fish populations and place quotas on the fishing industry, limiting the numbers of fish that can be caught. These management plans have proven very effective at increasing and maintaining fish numbers.

Consumers can also play a part in ensuring the sustainability of fish supplies by choosing to only eat fish that have been farmed or caught in sustainable ways. Organisations such as the Australian Marine Conservation Society provide lists of fish that are safe to eat and fish that you should avoid because they are endangered.

Check your learning 1.3

Remember and understand

1 In your own words, define sustainability.

2 Explain why the history of Atlantic cod fishing is an example of unsustainable resource use.

Apply and analyse

3 Copy and annotate Source 1.9 to describe the important trends and changes in the numbers of Atlantic cod caught off the coast of Newfoundland, 1850–2000.

Evaluate and create

4 Aquaculture is seen by many as the best way of providing fish for human consumption in the future. Research this booming industry. Do you see this as a sustainable alternative to traditional fishing?

5 Construct your own line graph to explore global trends in fish supplies into the future.
   a Draw up a set of axes: the vertical axis (*y*-axis) should show the percentage of fish species from 0 to 100 per cent. The horizontal axis (*x*-axis) should show the year from 1974 to 2050.
   b Copy the line showing fish species that are 'over exploited' from Source 1.7 onto your graph.
   c Based on the trend from 1974–2009, continue this line in a different colour to show the likely trend until 2050.
   d Describe the trend shown on your completed graph. If your prediction turns out to be true, what will this mean for the fishing industry and consumers around the world?

Loss of biodiversity

Biodiversity refers to the variety of living organisms on the planet. Biodiversity is measured by the number of species present in a particular ecosystem or region. The Earth's biodiversity is currently under threat, decreasing at a rate that rivals the mass **extinction** of the dinosaurs. It is difficult to give an exact figure on the number of species reaching extinction each year but it has been estimated at between 17 000 and 100 000 species annually. The world's most famous fossil hunter, Dr Richard Leakey, believes that this represents 'a rate comparable with the impact of a giant asteroid slamming into the planet'.

This loss of biodiversity not only impacts the natural environment but also has serious consequences for all human beings on Earth. Ecosystem services such as food, fibre and fresh water supplies, crop pollination by insects and birds, and protection against natural disasters are in decline.

What's causing the loss of biodiversity?

This loss of biodiversity is due almost entirely to the impact of just one species – humans. Our use of the Earth's resources and the changes this use brings to the natural environment are pushing many species to extinction. The five main causes of this are:

- habitat change such as deforestation
- over exploitation of resources such as fresh water
- pollution of land, water and air
- the spread of **invasive species**
- **climate change** brought about by human activity.

Species facing extinction

The International Union for the Conservation of Nature (IUCN) is an organisation that assesses the likelihood that species will become extinct. Of the almost 50 000 species they have studied, 36 per cent can be considered threatened with extinction. Birds and amphibians (such as frogs) are particularly under threat (see Source 1.13).

A world without frogs?

The number of frog species in the world is in dramatic decline and many researchers are linking this to climate change. The skin of frogs is particularly thin and permeable, meaning that moisture is able to pass through it easily. With the drier, warmer climate, many frogs are losing more water through their skin than they are taking in.

Source 1.11   Much of the world's land surface is no longer in its natural state. Farmland and cities have replaced areas once covered by forests and grasslands. Farming, as with this beef cattle farm in Brazil, tends to replace hundreds of species with just one. This greatly reduces biodiversity.

Source 1.12   The last golden toad was seen in 1989, and like 33 other amphibian species since then, it is now considered extinct.

Birds

10 000

Legend:
- No data
- Least concern
- Near threatened
- Vulnerable
- Endangered
- Critically endangered
- Extinct or extinct in the wild

9 000

Amphibians

8 000

7 000

Mammels

6 000

Number of species

5 000

4 000

3 000

2 000

Reptiles **Dragonflies**

Freshwater crabs

1 000

Corals **Freshwater fish** **Conifers**

Cycads

0

Taxonomic group

Source 1.13 IUCN data on the levels of threat faced by the major life groups (known as taxonomic groups)

They are also losing their breeding grounds, as small ponds and water collected in the hollows of trees are drying up and disappearing.

The greatest threat, however, is from disease. A parasitic fungus from Africa, known as amphibian chytrid, has spread across the planet in the last few decades. Warmer temperatures associated with climate change have created favourable conditions for the spread of this parasite which was previously held back by cooler night-time temperatures.

After studying the spread of this disease in Central America, a leading researcher in this field stated that 'disease is the bullet killing frogs, but climate change is pulling the trigger.' He found that two-thirds of all of the region's species of harlequin frogs were already extinct from this combination of factors. He and other scientists believe that frogs may be the planet's early warning system on climate change.

Check your learning 1.4

Remember and understand

1 What is biodiversity?
2 Why is biodiversity important?

Apply and analyse

3 How would a person with a human-centred world view (see Source 1.5) feel about the environmental change shown in Source 1.11?
4 Examine Source 1.13.
   a Which taxonomic group has suffered the most extinctions? Which of the five main causes of biodiversity loss do you think is most responsible for this?
   b Use the graph to describe the levels of threat faced by amphibians.
   c What is the level of threat facing the world's corals? Find out what ecosystem services would be threatened by a loss of coral species.

Evaluate and create

5 Describe the change in biodiversity shown in Source 1.11. Which of the five main causes of the loss of biodiversity does this illustrate?
6 Find an image which illustrates another of the causes and give it a suitable title and caption.
7 Search for the IUCN red list on the Internet. Use this list to investigate Australia's Southern Corroboree Frog. How many of these frogs remain in the wild and what dangers do they face?

Climate change

Although the world's climate has been changing for millions of years, in more recent times there has been an increase in the concentration of certain gases in the atmosphere. Many of these gases – known as greenhouse gases – are found naturally in the environment, but human activities have increased the levels of these gases to a point where they are influencing global climate. The four main greenhouse gases include:

- carbon dioxide from burning fossil fuels such as coal
- methane from the large-scale farming of livestock
- nitrous oxide from the use of fertilisers
- fluorinated gases from refrigerators and solvents.

Greenhouse gases trap some of the Sun's energy within the atmosphere causing temperatures to rise. This is known as **global warming**.

When temperatures rise, other changes take place in the world's ecosystems. Rainfall patterns change, as some places become drier and others become wetter. Ice melts and less snow falls in both the polar regions. Sea levels rise and droughts, floods, cyclones and bushfires become more severe and more frequent. These, and other changes associated with increased greenhouse gases, are changing the world's ecosystems and the services they provide.
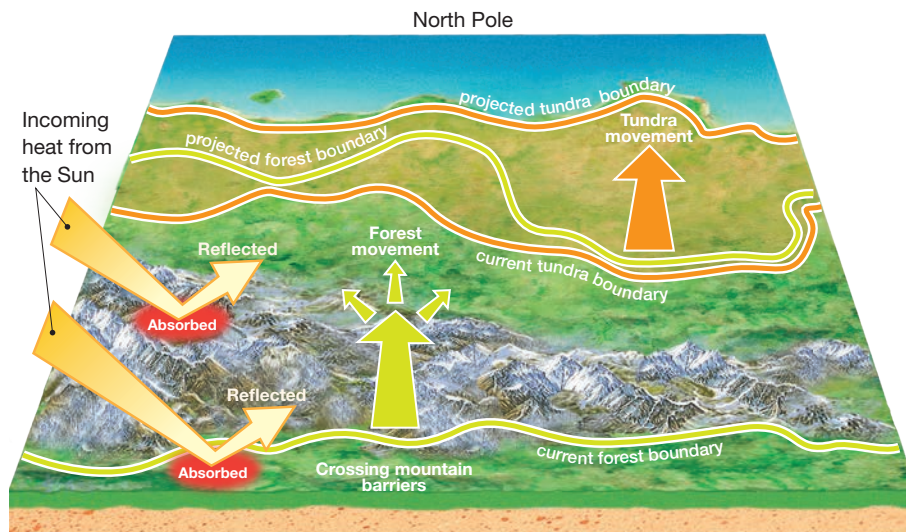
Environmental responses to climate change

Ecosystems develop and flourish under specific environmental conditions. As climate change alters these conditions, the plants and animals within the ecosystems respond in one of four ways:

- they change their basic biology – certain animals may reproduce less often or lay smaller eggs.
- they change the timing of certain events such as flowering – certain plants may flower earlier or later depending on the conditions. This can impact on birds that rely on these plants for food.
- they die out – when a species dies out it can have serious impacts on the entire ecosystem.
- they move – in general, many plants and animals are moving towards the poles and into higher altitudes (Source 1.15), as temperatures in these places are similar to those in their previous habitats. This affects plants and animals already living in these places.

Source 1.14 Some of the causes of human-induced climate change

North Pole

Incoming heat from the Sun

projected tundra boundary

projected forest boundary

Tundra movement

Reflected

Forest movement

current tundra boundary

Absorbed

Reflected

Absorbed

Crossing mountain barriers

current forest boundary

Source 1.15 The movement of tundra (frozen, treeless land) and forests towards the North Pole in the Arctic. As mountain slopes become forested they absorb more heat from the Sun rather than reflecting it, further increasing temperatures.

Source 1.16 A Saami man moves his reindeer herd north in spring.

Case study: Climate change and the Saami

One of the largest Indigenous groups in the Arctic region is the Saami people of northern Scandinavia. Numbering around 70 000 people and living in one of the world's harshest environments, many Saami groups rely on traditional reindeer herding for their livelihood. They migrate north in spring and summer and south in winter to find sufficient food, such as grass and small shrubs, for their herds. A typical herd is made up of several thousand reindeer. Typically, Saami herders will travel hundreds of kilometres a year with their herds.

While it would seem that warmer temperatures would bring better grazing conditions to the frozen Saami lands, the reverse is actually true. Warmer winter temperatures melt the snow, turning it to water. It then refreezes as a layer of ice which the reindeer cannot penetrate to reach the lichen below. This ice is known as *cuokke* to the Saami people and can result in their herds starving to death. The Saami respond by keeping their herds in pens and feeding them hay and straw but this food is expensive and difficult to find. These changing conditions may bring an end to the Saami's nomadic way of life which has existed for thousands of years.

Check your learning 1.5

Remember and understand

1 What are some of the main causes of climate change?

2 How might climate change bring an end to the traditional Saami way of life?

Apply and analyse

3 Discuss with a partner how climate change affects ecosystem services (see Source 1.2). Brainstorm these ideas as a class.

4 Describe the impact of climate change on plants and animals in the Arctic region.

5 Why is more solar radiation absorbed as forests move northwards?

Evaluate and create

6 Construct a flow diagram that shows how plants and animals respond to environmental changes. Add examples of these responses to your diagram.

7 The Saami people are not the only Indigenous people whose way of life is threatened by climate change. Research the impact of climate change on Indigenous people in the Pacific Islands and compare their situation to the Saami.

Pollution

Pollution is any substance released into the environment that has harmful or poisonous effects. Polluting substances reduce the ability of the natural environment to provide ecosystem services. Pollution is often a side-effect of a process intended to benefit human beings. Pesticides, for example, are designed to kill harmful insects that damage crops but they can also pollute our water and kill beneficial organisms such as bees. The loss of bees then reduces the amount of pollination that occurs, setting off a chain of negative effects in the environment. Here we look at some common forms of air, water and land pollution.

Air pollution

Air pollution is the contamination of the atmosphere through the release of harmful gases and small particles. Air pollution can happen on a variety of scales. Sometimes it is local (for example, a factory releases smoke and gases through a smokestack affecting the surrounding area). In urban environments such as Santiago, however, factories, vehicles, houses and other sources of pollution combine to produce large-scale pollution which affects the air quality right across the city (see Source 1.17). When this large-scale pollution causes changes to the atmosphere, for example pollutants such as carbon dioxide and methane trapping the Sun's heat in the atmosphere and causing **global warming**, we have pollution on a global scale.

Source 1.17   Air pollution in Santiago, Chile, is trapped by the Andes Mountains and can remain over the city for days, even weeks.
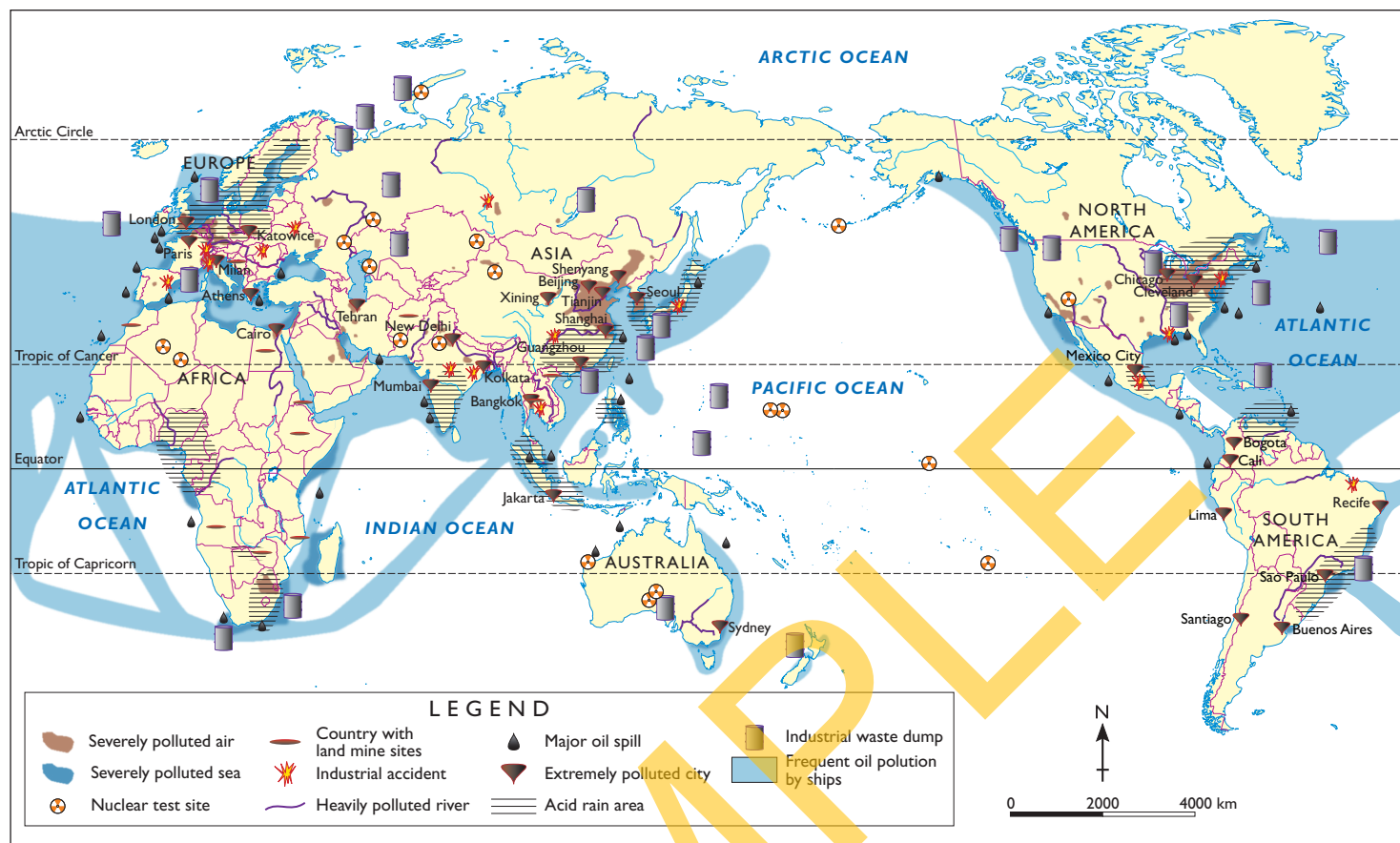
Water pollution

Water pollution is the contamination of rivers, lakes, wetlands, estuaries, seas and oceans through the release of harmful substances. Water pollution can be caused by human activities on or near the water such as shipping and deep-sea oil drilling. Ships, for example, release waste water and oil into the sea causing pollution. Land activities, sometimes a long way from water, can also lead to pollution entering our waterways. These land activities include farming (especially when using fertilisers and pesticides), littering, land clearing, creating tips and **landfill**, processing sewage and industrial activities. Industrial or farming waste released into a river can travel the length of that river and enter waterways, causing water pollution over a widespread area. Likewise, litter washed down stormwater drains during a storm can end up polluting the ocean.

Source 1.18   When an offshore oil platform exploded in the Gulf of Mexico in 2010, it caused one of the largest oil spills in history.

Land pollution

Land pollution is the contamination of areas of land through the release of harmful substances. Soil contamination is often localised, such as at the sites of old petrol stations, mines, sewage treatment facilities or landfill. Soil contamination can also occur on a much larger scale, such as increasing **salinity** (salt levels) in the soil resulting from rising water tables in Australia's Murray–Darling Basin. Land pollution can cause the contamination of groundwater, which is often an important source of drinking water.

Source 1.19

Source: *Oxford Atlas*

LEGEND

- Severely polluted air
- Severely polluted sea
- Nuclear test site
- Country with land mine sites
- Industrial accident
- Heavily polluted river
- Major oil spill
- Extremely polluted city
- Acid rain area
- Industrial waste dump
- Frequent oil polution by ships

0   2000   4000 km

Source 1.20   Landfill can cause soil contamination.

Check your learning 1.6

Remember and understand

1   Define and give examples of the main forms of pollution.

Apply and analyse

2   Examine Source 1.19.

   a   Describe the distribution of severe air pollution.

   b   Use an atlas to list those countries with landmine sites. Are landmines an example of pollution? Why/why not?

   c   Which countries experience three or more types of pollution? What may be the underlying causes of pollution there?

3   In what ways would the explosion of an offshore oil platform (see Source 1.18) pollute the environment?

Evaluate and create

4   Source 1.19 shows acid rain as a form of pollution. Research acid rain and report on its causes, distribution and effects on ecosystem services.

5   Which type of pollution do you consider has the greatest impact on ecosystem services?

The real cost of your mobile phone

When exploring the ways in which the environment is changing, it is important to look not only at the effects of these changes but also their causes. For example, when investigating declines in fish populations, geographers look for causes such as increases in world population, pollution levels and changing consumption patterns. Similarly, when looking at the environmental changes brought about by industry and mining around the world, geographers need to explore a range of possible causes. One of the main factors driving the growth in mining and production is increased demand for electronic consumer goods such as mobile phones. Current estimates put the number of mobile phone subscribers around the world at about 6 billion. This number has increased significantly over the past decade (see Source 1.25). The **raw materials** used in the production of mobile phones come from different locations around the world. Dramatic increases in demand for these materials has created serious environmental problems in a number of locations.
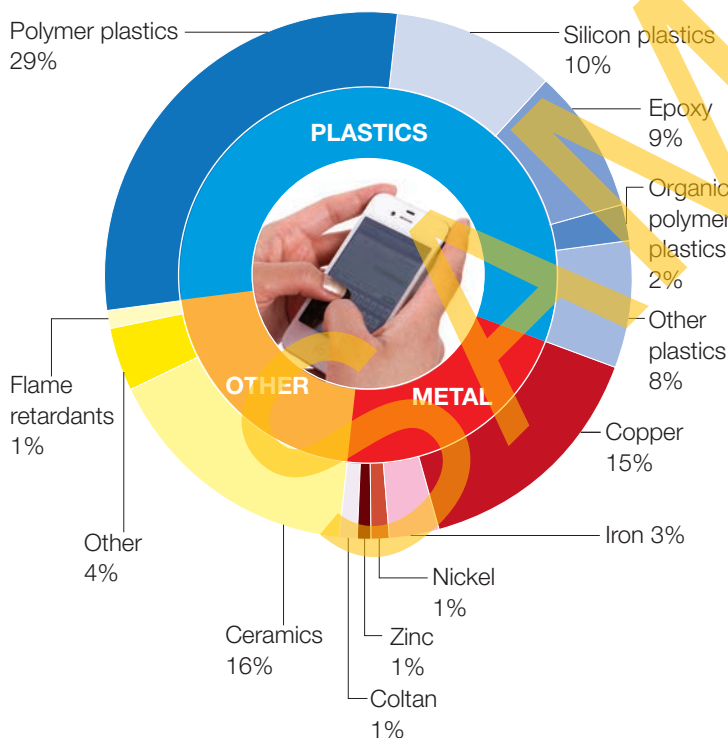
Source 1.21   The raw components of a mobile phone

Plastics

Plastics are a by-product of refining oil. Oil is usually found in the Earth's crust and is accessed by drilling into the crust, either on land or on the seabed. There are significant environmental risks associated with mining and using oil. These range from the potential for oil spills at the mine site to the greenhouse gases produced when oil is used for fuel. Many plastics are hard to dispose of and take thousands of years to break down. Since the 1950s, more than a billion tonnes of plastic has been discarded around the world.

Source 1.22   This bird has died from eating plastic which it mistook for brightly coloured fish. Thousands of sea birds and other marine animals die each year in this way.

Metals

Copper

Because copper conducts electrical signals, it is used a great deal in electronic devices. Copper is mined in many places around the world. Chile's Escondida copper mine is the world's largest. The mine is essentially two giant pits dug into the desert floor. Waste rock is left in piles called tailings and copper is transported in pipes 180 kilometres to the coast. Like many large mines, Escondida is located in the desert. This creates problems for the mining operators who need water for their mining operation and their workers. A desalination plant is being built on the coast to provide this water. The water will be piped to the mine.

Source 1.23 The Escondida copper mine in the Chilean desert

Coltan

Coltan is a mineral ore, high in iron, that is used in mobile phones as well as video-game players and some computers. Australia is the world's largest supplier of coltan. The Democratic Republic of Congo (DRC) in Africa is another large supplier. To reach the coltan in the DRC, miners have stripped away rainforest, including the rainforest in national parks. The roads they cut through the rainforest to reach the mines are then used by local people hunting wild animals for food. One of the animals hunted by locals for meat in the rainforest is the gorilla. The western lowland gorilla is now a critically endangered animal and has all but vanished from the rainforests of the DRC.

Source 1.24 A coltan mine in the Democratic Republic of Congo. As well as causing environmental change there is also evidence that profits from coltan mining are being used by armies in the region to fund long-running and bloody conflicts.
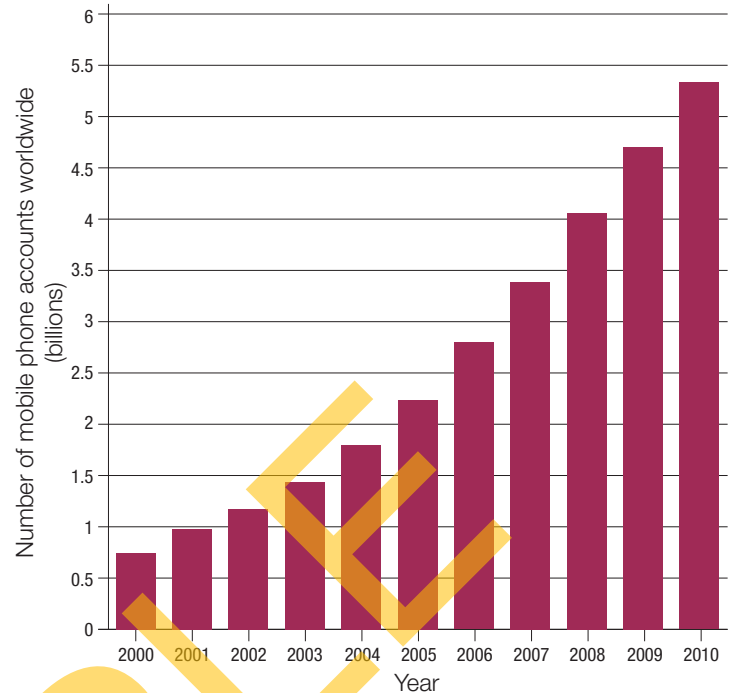
Source 1.25 Growth in the number of mobile phones worldwide

Check your learning 1.7

Remember and understand

1 How does the production and use of plastic change the environment?

2 What is coltan? How has the mining of coltan changed the environment in the Democratic Republic of Congo?

Apply and analyse

3 Examine Source 1.25 carefully.
   a Describe the global trend in mobile phone use over the period.
   b Conduct research to determine the five countries around the world that have experienced the largest growth over this period. Why might this be the case?

4 The bird in Source 1.22 was found on the Midway Islands. Use an atlas to locate these islands and explain where you think the plastic that caused the death of this and many other birds originated.

Evaluate and create

5 Select another popular consumer item of your choice and research the environmental changes brought about by its production and use.

Easter Island

Easter Island is one of the world's most remote places. It lies in the Pacific Ocean, over 2000 kilometres from the nearest inhabited country. When European explorers first visited the island in the 16th century, they found the local people living in primitive conditions and engaged in almost continual warfare. Most baffling of all were the more than 600 stone statues weighing hundreds of tonnes that dotted the island.

The statues were built by the ancient Polynesians who lived on the island, probably as a tribute to tribal chiefs. To move them from the quarry to prominent sites, islanders used the trunks of large trees to create tracks and rollers. Over time, the population of the island reached about 7000 and there was increased pressure on timber resources for statue transport as well as for housing, boats, fuel and agriculture. The trees, however, were not being replaced by new growth, because rats brought by the original Polynesian sailors as a food source ate all the seeds.

The destruction of the island's trees and shrubs led to a decline in living conditions for the people. Statue building ceased, the population declined, soils became less fertile and more easily eroded, water quality declined and, as competition for scarce resources increased, tribal warfare broke out.
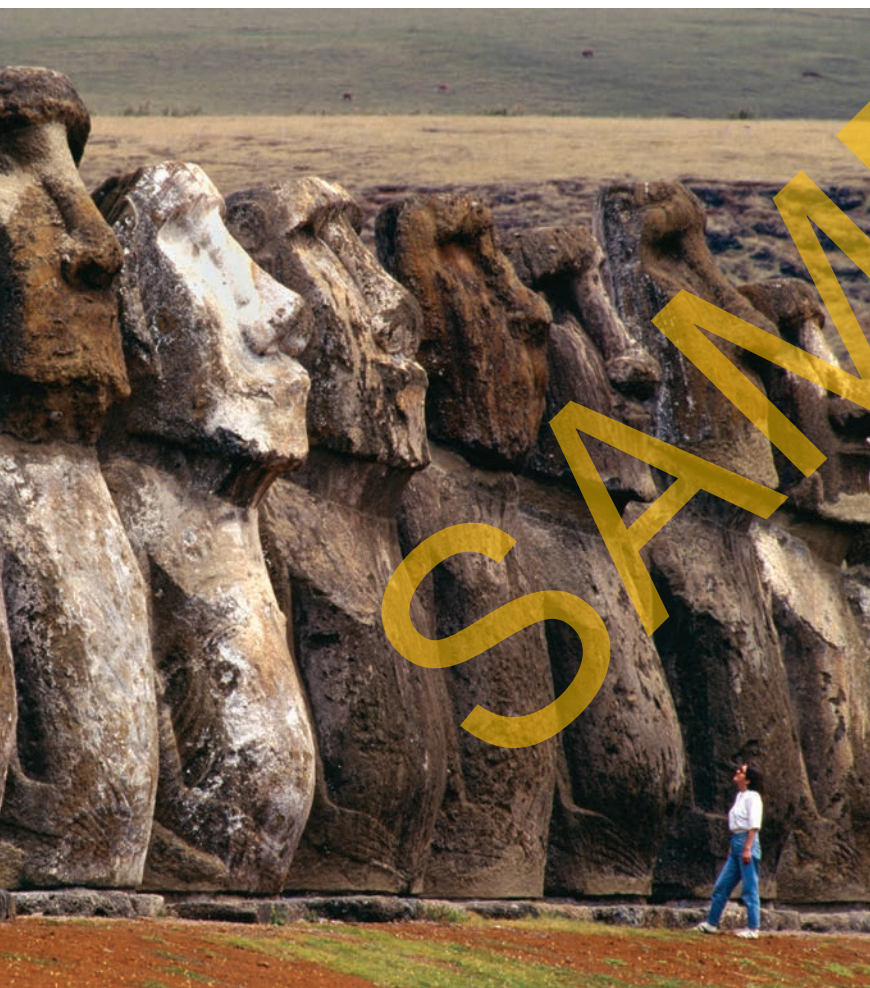
In many ways, the history of Easter Island serves as a warning to the rest of the world about the dangers of extreme environmental change.

skill**drill**

Interpreting topographic maps

Topographic maps show a small region of the Earth's surface in great detail. This includes the height and shape of the land (known as the topography) which is shown through the use of contour lines or relief shading. By examining topographic maps, geographers can better understand the natural environment and the ways in which human activities bring about environmental change. Follow these steps when interpreting a topographic map:

Step 1 Read the title of the map so that you know what the map is showing. You may like to find it in an atlas so that you understand its location relative to other places.

Step 2 Look closely at the legend and find an example of each feature shown in the legend on the map. Take note of those features which often appear together and those that occupy large areas on the map.

Step 3 Use the line scale to roughly estimate the overall size of features on the map. For example, the length of an island or the distance between two cities.

Step 4 Look closely at the legend showing the colours used to represent the height of the land. Look at the patterns of these colours on the map and try to picture the landforms that are shown. Remember that the closer together these colours appear the steeper the land.

Source 1.26 A selection of stone moai statues on Easter Island

Source 1.27

Source: Oxford University Press

Apply the skill

1 Examine Source 1.27.

a Use the legend to describe the relief (shape of the land) of Easter Island. In your description use the names of specific places such as mountains.

b How has the relief affected the distribution of roads and populated places?

2 Examine the distribution of the moai in Source 1.27.

a Use the line scale to estimate the distance from the quarry site at Puna Pau to the Vai Mata ahu (stone platform).

b Describe the distribution of the statues on the island.

c How does the relief affect this distribution?

Extend your understanding

1 How did statue building contribute to environmental change on Easter Island?

2 The reasons for the decline of the Easter Islanders are still widely debated. Use the Internet to find out about two or more conflicting theories. Why is there often disagreement about historical events?

3 Did the Easter Islanders use their resources sustainably? Give three reasons for your answer.

4 What lessons are there from Easter Island for the ways in which we use ecosystem services today?

1.2 How do people change and manage the land?

Degrading the land

The loss of productivity and decline in fertility of land-based environments as a result of human activities is referred to as land degradation. Land degradation currently affects about one-quarter of the world's total land area and about 38 per cent of the world's farmed areas. About 1.5 billion people, including many Australians, are directly affected by land degradation. It is also contributing to climate change, as cleared, degraded land stores much less carbon than natural land cover such as rainforest. The three main types of land degradation are soil degradation, soil erosion and ecosystem decline.

Soil degradation

Soil degradation refers to the loss of fertility of the soil, often due to a chemical change. Soil can degrade by becoming compacted by large machinery and hard-hooved animals such as cattle and sheep, or becoming acidic due to a build-up of fertiliser or a loss of soil nutrients caused by farming the land too intensively. One of the greatest problems for Australia is the build-up of salt in the topsoil (called **salinity**).

Soil erosion

Soil **erosion** is when soil is gradually worn away by natural phenomena such as rivers, rain, waves, glaciers and the wind. Human activities, particularly clearing trees for farming, accelerate erosion in many places. Cleared land is more vulnerable to wind erosion, gully erosion (water scouring away the land) and sheet erosion (the loss of topsoil over a large area). Much of Australia is at risk from one or more of these types of erosion (see Source 1.30).

Ecosystem decline

As well as soils, the natural ecosystems of an area, such as forests and streams, can become degraded. This may be through a loss of vegetation, the invasion of alien plant and animal pests or a decline in the quality of streams and rivers. When coupled with a decline in soil quality, a degradation of ecosystems can lead to **desertification**, particularly in areas close to existing deserts.
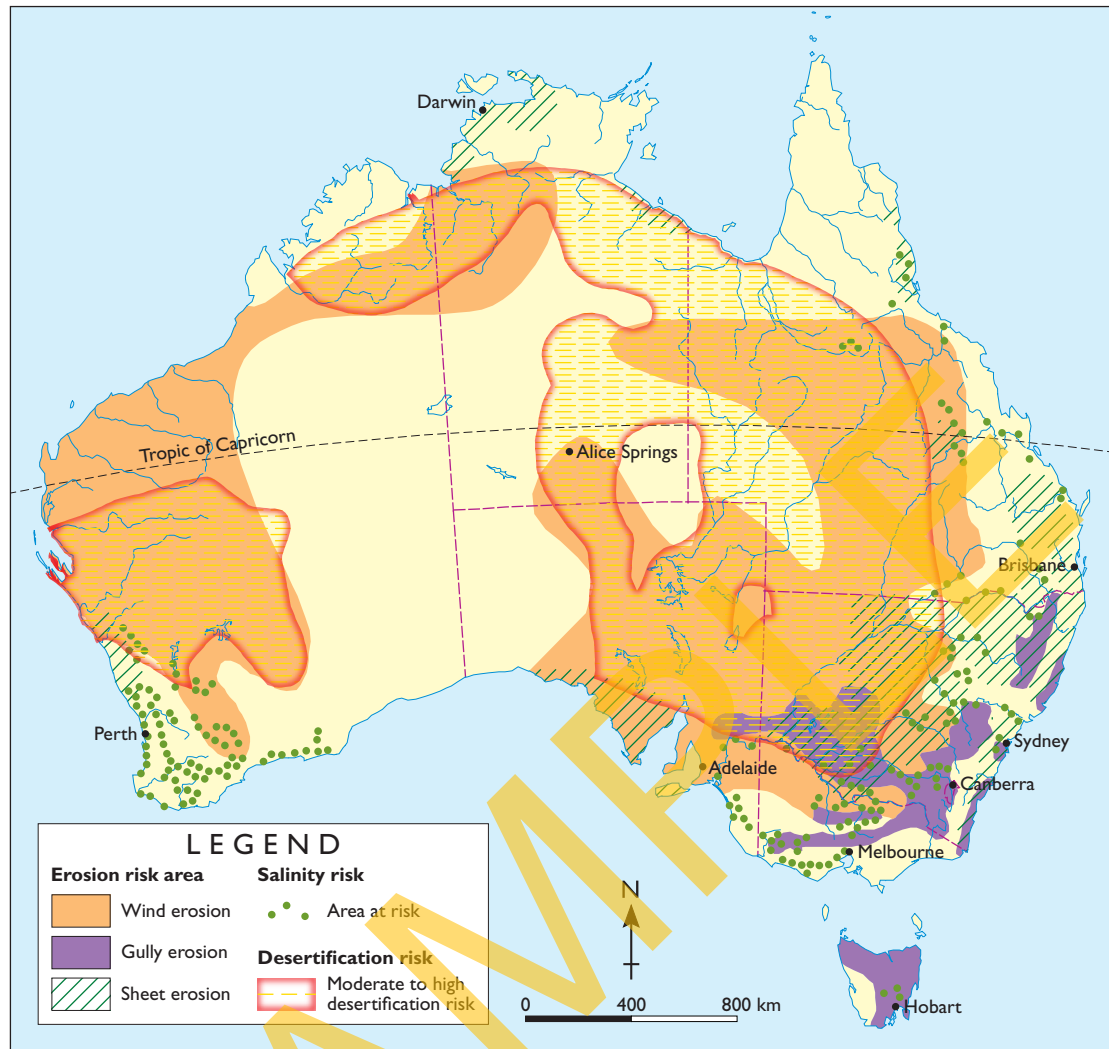

Source 1.28 Soil can be carried on the wind for thousands of kilometres. This dust storm which blanketed Sydney, Canberra and Brisbane in 2009 originated near Kati Thanda (Lake Eyre) in South Australia. Dust was carried as far as northern New Zealand.

Source 1.29 In some arid and semi-arid areas of Australia, cattle grazing has led to a breakdown in soil structure and the loss of plants. This can lead to areas such as this becoming desertified.

AUSTRALIA: DISTRIBUTION OF LAND DEGRADATION

L E G E N D

Erosion risk area

■ Wind erosion

■ Gully erosion

▨ Sheet erosion

Salinity risk

• Area at risk

Desertification risk

▨ Moderate to high desertification risk

0   400   800 km

Source 1.30

Source: *Oxford Atlas*

Check your learning 1.8

Remember and understand

1 What is land degradation?

2 Why is land degradation a concern for many people in Australia and around the world?

Apply and analyse

3 Conduct research to compare the footprint of a cow with that of a kangaroo. What does this tell you about the relative impacts of introduced and native species on Australia's soils?

4 Use an atlas to estimate the distance covered by the 2009 dust storm shown in Source 1.28.

5 Examine Source 1.30.

   a Describe the areas of Australia at risk from gully erosion. Use the names of states and specific places

in your description. You may need to refer to a more detailed map of Australia to assist you.

   b Which areas are most at risk from salinity?

   c List those areas that are at risk from erosion, salinity and desertification.

   d Use the SHEEPT method to list the reasons why some places are more at risk of land degradation than others. For more information on the SHEEPT method, refer to section GT.2 of 'The geographer's toolkit'.

Evaluate and create

6 Examine Source 1.29, showing a degraded environment in Australia. Discuss in a small group some steps that could be taken to restore this land. Use these steps to develop and present an action plan. This should include an annotated copy or field sketch of Source 1.29.

Soil degradation: Salinity

Salt is a natural part of the Australian environment. Deposited by salt-laden winds from the sea and from the weathering of rocks, it is a component of most soils. It has been estimated, for example, that in parts of Western Australia the soil typically contains between 170 and 950 tonnes of salt per 10 000 square metres. Because this salt has accumulated slowly over millions of years, Australia's native vegetation has adapted to the salty soils. The native deep-rooted trees and shrubs soak up much of the rainwater entering the soil. This keeps the **water table** low in the ground and means the salt stays deep in the soil and away from plant roots.

However, changes in the Australian landscape since the arrival of Europeans have significantly altered this system. Large areas of native vegetation have been cleared and replaced by shallow-rooted crops and grasses (Sources 1.32 and 1.33). This means that much more water is held in the soil and so the water-table rises, bringing with it the salt that has accumulated over millions of years. It collects in low-lying areas, killing the introduced plants. As the water evaporates, salt is left at or near the surface, creating large salt pans where nothing can grow (see Source 1.31). The salt also moves across the landscape turning freshwater streams into salty drains.

In some places, **irrigation** also increases the amount of water in the soil. This has the effect of raising the water table and bringing salt to the surface. Studies estimate that salinity currently affects 19 500 Australian farms and 20 000 square kilometres of agricultural land, much of it in Western Australia's wheat belt. At present, it has the potential to affect 46 000 square kilometres of agricultural land. This is expected to increase to 136 000 square kilometres within 50 years. This makes salinity Australia's most serious and widespread land degradation issue.
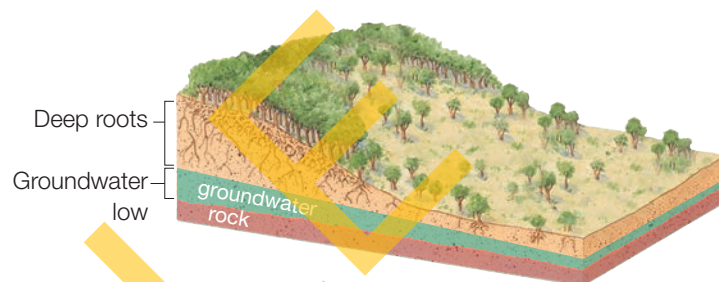
Source 1.32 Salt in the Australian landscape before land clearing
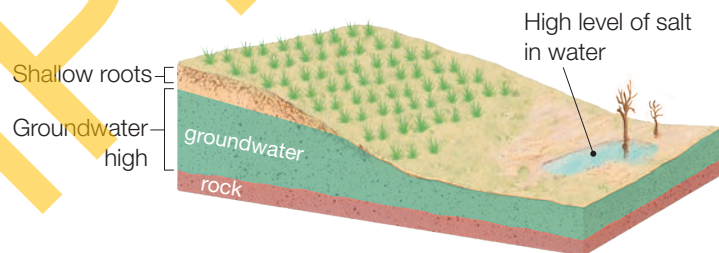
Source 1.33 Salt in the Australian landscape after land clearing

**Source 1.31** Salt rising to the surface in the Western Australian wheat belt

Salinity in the Western Australian wheat belt

The largest area of salty soils in Australia is in the south-west corner of Western Australia, a region known as the wheat belt. This is a vast area of 19.3 million hectares, 16 per cent of which is at risk of salinity due to rising water tables. Most of this is agricultural land and would result in lost profits for farmers of at least $80 million a year. Source 1.34 shows the areas of the wheat belt with rising water tables in 2000 and the predicted salinity-affected areas in 2050.

Salinity in the wheat belt also poses a threat to biodiversity as plants and animals lose their habitats. As salt accumulates in the low-lying regions in the landscape such as freshwater lakes, plants and animals that live in these regions are at the greatest risk. At least 1500 plant species in Western Australia suffer from salinity with 450 possibly becoming extinct. Animal species are likely to decline by one-third if salinity continues to spread. For more information on the key concept of change, refer to section GT.1 of 'The geographer's toolkit'.

WESTERN AUSTRALIA: DRYLAND SALINITY RISK IN THE SOUTH-WEST IN 2000 AND 2050

LEGEND
- High risk of salinity
- Public land
- Border of wheat belt
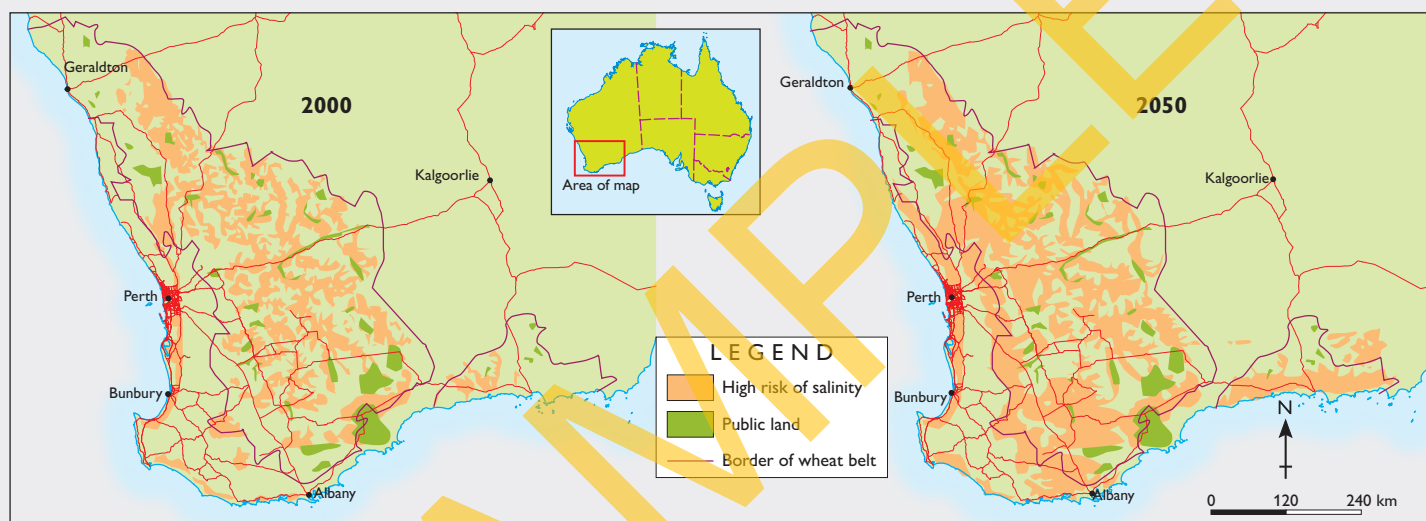
Source 1.34

Source: Oxford University Press

Check your learning 1.9

Remember and understand

1 Where does salt in the soil come from naturally?
2 How did the arrival of European settlers in Australia affect soil salinity?

Apply and analyse

3 Classify the causes of salinity using the SHEEPT method. For more information on SHEEPT, refer to section GT.2 of 'The geographer's toolkit'.
4 Examine Source 1.34.
   a Describe the predicted change in salinity in the wheat belt between 2000 and 2050 both in terms of area and distribution.

   b How do you think this change will impact on the natural environment of the region?
   c One of the largest costs of salinity is road repair. Why do you think this might be the case?

Evaluate and create

5 Discuss ways in which farmers may be able to lower the water table and reduce salinity.
6 Australia is not the only country to suffer from soil salinity. Research salinity in one other country such as Bangladesh, Spain or Egypt. Compare the causes and effects of salinity in Australia with the country of your choice. What are the similarities and differences?

Repairing degraded land

In many local areas, attempts are being made to repair the damage of the past. These attempts tend to be small in scale, as repairing degraded land is expensive and difficult to achieve over a large area. For the repairs to be effective and not cause further damage, it is important for those undertaking the work to have a detailed understanding of the complex ecology of the site.

Case study: Fighting salinity at Toolibin Lake

Toolibin Lake, in the Western Australian wheat belt, is a small ephemeral wetland (meaning it only fills with water occasionally, depending on rainfall).

As one of the last remaining freshwater wetlands in the region, it contains important habitats for a number of plant and animal species, many of which are endangered. In the 1970s, the lake bed began to show signs of increasing salinity and many trees died. Source 1.35 shows the distribution of salinity in the area. A geographic investigation found that this was due to the flow of salty water into the lake from surrounding farmland together with a rising water table. In the 1990s, a number of measures were put in place to lower the water table and reduce the salinity (Source 1.36).

These measures included measuring the salt levels in the stream that flows into the lake and diverting excessively salty water to a nearby lake. Pumps on the lake bed were installed to lower the water table and to remove salty water from the soil. Around the lake, belts of trees were planted to intercept water as it flowed towards the lake and also to help in lowering the water table.

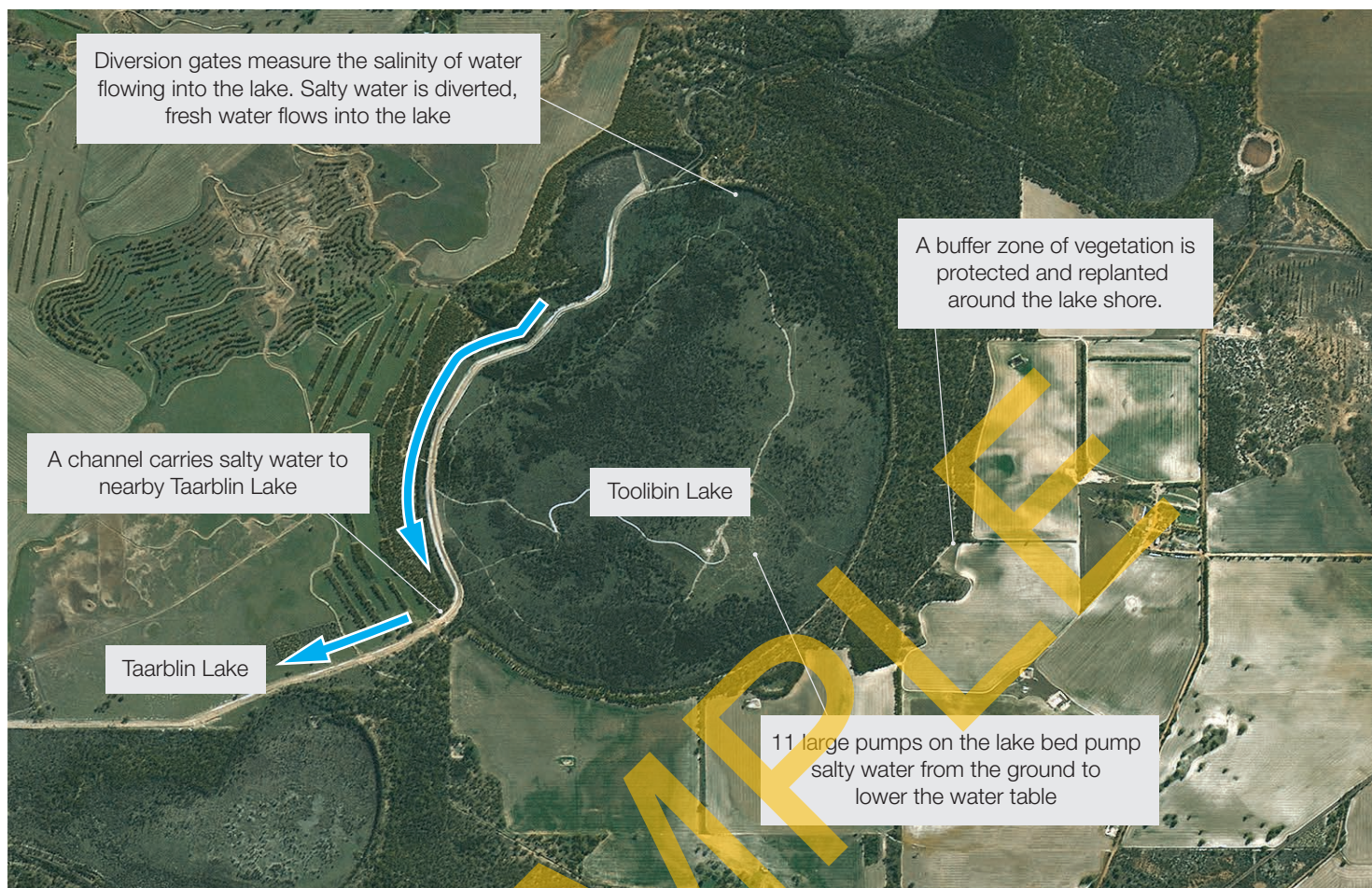TOOLIBIN LAKE: AREAS OF SALINITY
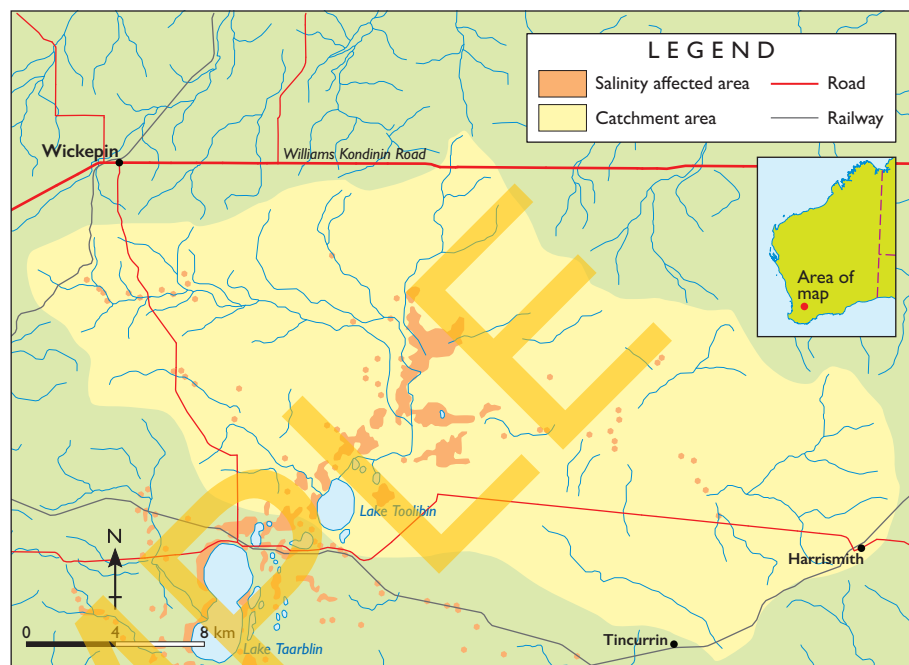
Source 1.35

Source: Oxford University Press

A review of these measures in 2010 showed that the water table had been held below the target of 1.5 metres across most of the lake. However, an analysis of satellite imagery from 1990 to 2009 showed that in some areas of the lake, trees had flourished, but in others, they had continued to decline.

Researchers then examined the ways in which the two dominant tree species, sheoak and paperbark, had responded to changing water and salt levels. They found that the trees had responded in very different ways. New sheoak seedlings were found on the floor of the lake but the paperbark trees had continued to decline in health and numbers. This information could then be used to develop new management plans for the lake. Much of this is now centred on working with the local Landcare group. Landcare is a national network of thousands of locally-based community groups who care for the natural resources of Australia. In the Toolibin Lake much of this work has focussed on increasing the number of trees planted on surrounding farms. The farms in the area tend to grow cereal crops such as wheat. Getting the farmers to put trees on their farms will further reduce salinity across the region.

Building an eco-bridge

Additional measures are being introduced to help endangered animals in the region such as the red-tailed phascogale, which is a small marsupial. Farmers and other land managers are being encouraged to plant trees in corridors between existing stands of native trees, fence off remaining vegetation and creeks and to control feral pests such as cats and foxes. It is hoped that these activities will provide a large, linked safe area, known as an eco-bridge, for native species to thrive.

Diversion gates measure the salinity of water flowing into the lake. Salty water is diverted, fresh water flows into the lake

A buffer zone of vegetation is protected and replanted around the lake shore.

A channel carries salty water to nearby Taarblin Lake

Toolibin Lake

Taarblin Lake

11 large pumps on the lake bed pump salty water from the ground to lower the water table

Source 1.36 An aerial photograph of Toolibin Lake showing the measures used to lower the water table and reduce salinity

Source 1.37 The red-tailed phascogale, a small marsupial, is one of 32 rare or endangered animal species in the wheat belt.

Check your learning 1.10

Remember and understand

1 Where is Toolibin Lake located?

2 Why is the water in Toolibin Lake becoming salty?

Apply and analyse

3 Examine Sources 1.35 and 1.36 carefully before completing the following tasks.
   a What are some of the possible causes of salinity that you can identify?
   b What are some of the measures that were used to try and reduce salt levels in the lake?

4 What is an eco-bridge? Explain how the measures put in place to protect endangered species could also help to reduce salinity.

Evaluate and create

5 In small groups, discuss why repairing land degradation in the Toolibin Lake area has been so difficult. What do you think this means for repairing the damage of a much larger area such as the entire Western Australian wheat belt?

6 Research a Landcare project in an area close to you. Who is involved in this project and what are their aims?

Ecosystem decline: Disappearing forests

One of the leading causes of land degradation on a global scale is **deforestation**. Forests have been cleared by humans for thousands of years. Traditionally, forests have been cleared for farming, to clear the way for human settlements and to provide building materials. Today, two key economic realities continue to drive deforestation:

1   Trees grow slowly and other crops such as soya beans grow quickly. As populations continue to grow and expand, and people tend to their current needs rather than the needs of future generations, forests continue to be cleared and replaced by farms to provide people with income and food.

2   Many ecosystem services provided by forests, such as absorbing and storing carbon and filtering water, do not have a monetary value and cannot be bought and sold. Produce from farms and timber from forests are easily bought and sold so are seen as more valuable to local populations than intact forests.

Case study: The Amazon rainforest

The Amazon, the world's largest tropical **rainforest**, provides an example of the changes that are sweeping across many forest biomes today. Well known as a biodiversity hot spot due to its large numbers of plant and animal species, the Amazon is now considered to be an environmental hot spot too. The Amazon covers an area roughly the size of Australia, but since the 1970s, an area the size of New South Wales has been cleared for other uses. In recent years, rainforest clearing has slowed but still continues. Source 1.39 shows deforestation levels since 1990. Some climate scientists believe that unless the remaining rainforest is protected, a combination of climate change, droughts, fires and deforestation will gradually turn the rainforest into **savanna** and **grasslands**.

Source 1.38   A section of Amazon rainforest in Brazil that has been cleared for cattle ranching
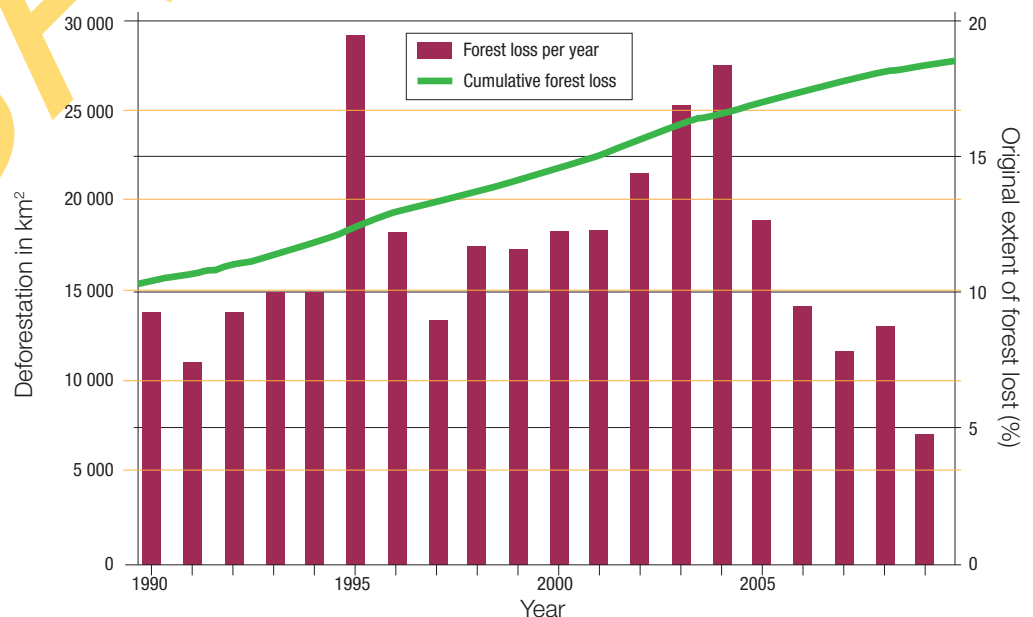
Source 1.39   Annual and cumulative deforestation of the Amazon rainforest in Brazil

Using satellite images to analyse environmental change

Dual satellite images are a useful tool for observing change over a large region of the Earth's surface. By examining them closely, you can describe changes that have occurred and suggest explanations for these changes.

Step 1   Examine two satellite images taken at the same location at different points in time.

Step 2   Locate the area on the Earth's surface using an atlas.

Step 3   Look closely at the first image. Describe the natural and human features that you can see.

Step 4   Describe the differences between the first image and the second one.

Step 5   Try to quantify the changes. For example, if there has been desertification, calculate the area of desert shown in each of the images. The difference will give you the area that has changed over time.

Step 6   Suggest an explanation for these changes based on your observations.

Apply the skill

1   The two satellite images in Source 1.40 show a section of the Amazon rainforest in the state of Rondúnia, western Brazil, in 1975 and 2012. Follow the steps above to describe the satellite images shown and explain the changes that have taken place in this section of the rainforest over the 37-year period.
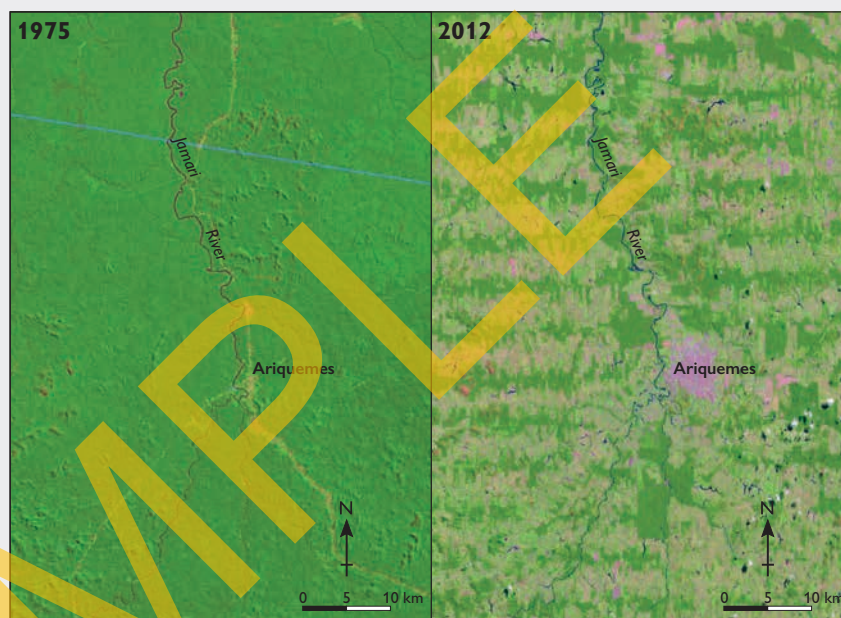
Source 1.40   Two satellite images of a section of the Amazon rainforest in the state of Rondúnia, western Brazil. The image on the left was taken in 1975 and the image on the right was taken in 2012.

Check your learning 1.11

Remember and understand

1   Why are forests cleared?

2   What do many climate scientists believe may happen to the Amazon rainforest in the future?

Apply and analyse

3   Look closely at Source 1.39.

   a   Describe the trend in Amazon forest loss since 1990.

   b   Roughly calculate the average amount of rainforest lost each year.

4   Look closely at Source 1.38.

   a   Brainstorm the ecosystem services provided by an intact rainforest. Refer to Source 1.2 for a list of ecosystem services.

   b   Highlight those services that will be lost if the rainforest is cleared and underline those services that will be changed but not lost.

   c   How would replacing forests with farms affect biodiversity?

Evaluate and create

5   Imagine that the Brazilian government decided to ban forest clearing and instead encouraged people to replant the forest.

   a   How would this decision affect ecosystem services and the Brazilian economy?

   b   Is this likely to happen? Give some reasons for your answer.

Managing our forests

Many of the world's forested areas have been altered by human activities. It has been estimated that of the 60 million square kilometres of forest that once covered the Earth, only about two-thirds still remains. Each year the world loses about 50 000 square kilometres of forest, most of it converted to farmland to support growing populations. For reference, the entire state of Tasmania is around 70 000 square kilometres. While deforestation may seem to be an unstoppable process, there are encouraging signs of change in some countries, including Australia.

As nations become more economically developed, rates of deforestation slow. In North America, for example, the total area of forest is increasing rather than decreasing. Similarly, rates of deforestation in Brazil have been declining for several years, as the country becomes more economically developed. There is also a greater awareness of the value of leaving forests intact due to the ecosystem services they provide, particularly the storage of carbon. In many places around the world forests are being replanted to offset **carbon emissions** and to reclaim degraded land.

Slowing and reversing deforestation

Conserving the remaining forests, for example, in reserves such as national parks

Pricing forest ecosystem services such as carbon storage to encourage countries to protect forests

Selective logging by cutting down only a few trees rather than clearing a whole forest

The replacement and replanting of trees to increase forested areas

Using timber grown in plantations rather than sourced from native forests

New and improved farming practices to reduce the need for land to be cleared

**Source 1.42**   Methods of slowing and reversing deforestation

Source 1.41   In the Philippines, local volunteers are replanting mangrove trees to restore important ecosystem services such as protection from storms, food supply and carbon storage.

Case study: The Tarkine Wilderness Area

The Tarkine Wilderness Area of north-west Tasmania is home to one of Australia's most remarkable rainforests (Source 1.43). The forest is believed to have survived largely intact from the time when Australia was part of the ancient supercontinent, Gondwana. It provides a habitat for over 60 rare, threatened and endangered species of plants and animals and has been described as one of the world's greatest archaeological sites because of evidence of ancient Aboriginal habitation.

Much of the Tarkine Wilderness Area is administered by Forestry Tasmania, a forest management company owned and operated by the Tasmanian government, that has allowed some logging of the rainforest and several mines to operate in the area. Ten more mines are planned and mining companies have been given licences to examine 56 other potential sites. Environmental groups have campaigned for decades to have the forest protected as part of a **national park**. Although the Tarkine has been given National Heritage status, only about 5 per cent of the Tarkine rainforest is protected. Environmental campaigners continue to fight for more conservation of Tasmania's old-growth forests and protection from mining and logging interests.

TASMANIA: THE TARKINE WILDERNESS AREA
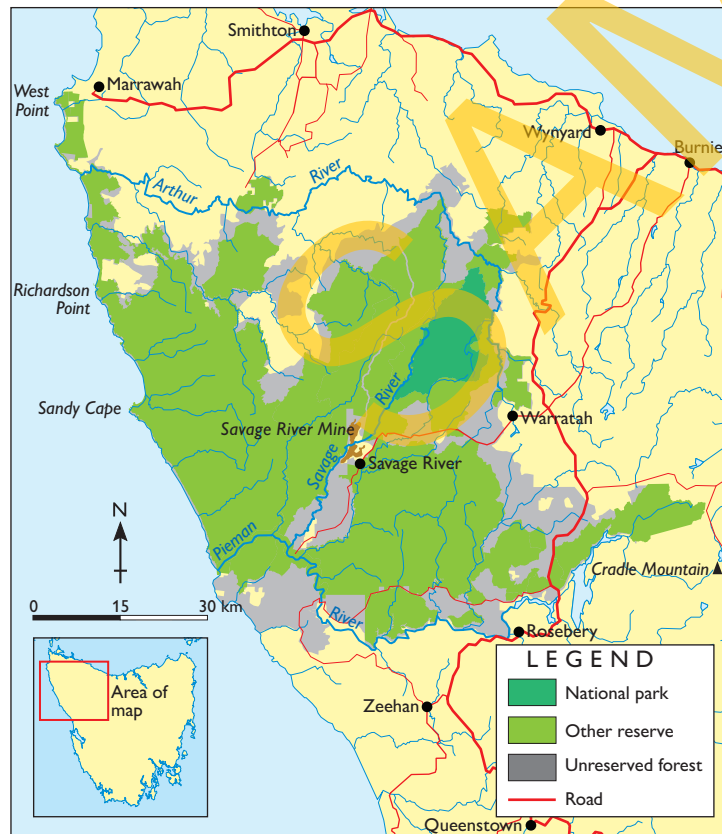
Source 1.43   Source: Oxford University Press

Source 1.44   The Savage River open-cut mine in the Tarkine Wilderness Area

Check your learning 1.12

Remember and understand

1   What environmental factors have motivated the people shown in Source 1.41 to carry out this work?

Apply and analyse

2   Why do you think deforestation often slows when nations become more affluent and economically developed?

3   Describe the Savage River mine shown in Source 1.44. How has it changed the natural environment?

Evaluate and create

4   While some people support the idea of a Tarkine National Park, others are opposed. Compile a list of groups and individuals who you think would be supporters of the national park plan and another list of those you think would be against it. Beside each group you have listed, explain the likely motivation for their position.

5   Why is conserving forests often difficult to achieve?

6   Compare the issues facing the Tarkine Wilderness Area with those facing the Amazon rainforest. What are the similarities and differences?

7   Examine Source 1.42. Rank these methods in order from most effective to least effective. Justify your ranking.

Ecosystem decline: Invasive species

Invasive species is a term used by geographers and scientists to describe groups of organisms (e.g. plants, animals, bacteria or fungi) found in an area they are not native to. In many cases, invasive species upset the biological diversity of areas they spread to and can have other negative effects. Many ecosystems around the world are threatened by invasive species of plants, animals and insects. Sometimes, invasive species are brought to a new place deliberately. For example, goats and rabbits were brought to Australia on the First Fleet to provide a source of food for the new settlers. Other species may be brought to a new place accidentally. For example, rats often hide aboard ships going to new places. Other marine pests were brought to Australian seas unintentionally in ballast water carried on container ships.

However they move from one place to another, invasive species have the potential to degrade the land and disrupt the natural balance of the ecosystem. They often compete with native species for food, land or water, leading to a loss of biodiversity. Australia has 362 invasive species, the second highest number in the world (see Source 1.45). Some of the world's most successful invasive organisms include the castor oil plant, Chytrid frog fungus, domestic cat, black rat, American mink and the water hyacinth.

WORLD: NUMBERS OF INVASIVE SPECIES BY COUNTRY

Source 1.45

1 Castor oil plant (*Ricinus communis*)

Native to: North-east Africa and the Middle East

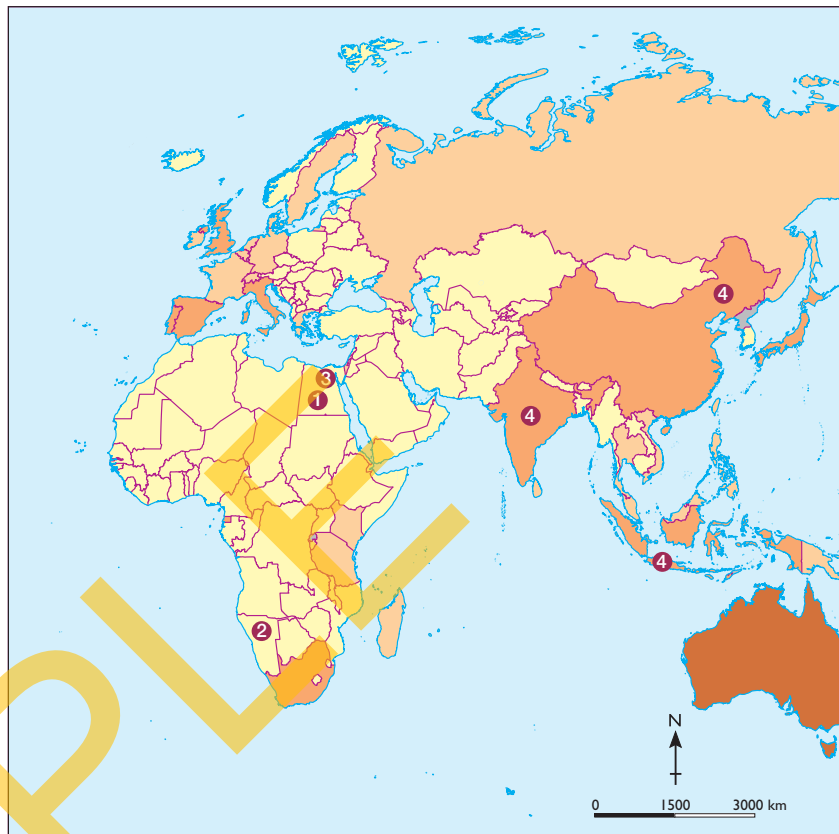**Invaded**: Common on every continent except Antarctica

Method of invasion: Carried as an ornamental plant and cash crop in the production of castor oil. Seeds dispersed by rodents and birds.

Preferred biomes: Grassland, temperate forest.

Impacts: Displaces native plant species, poisonous to many animal species including humans.

2 Chytrid frog fungus (*Batrachochytrium dendrobatidis*)

Native to: Africa

Invaded: All six continents. The fungus has infected 93 frog species, more than half of which are Australian.

Method of invasion: Frogs carrying the fungus introduced as a food source and for scientific purposes.

Preferred biomes: Rainforests, freshwater sources

Impacts: About one-third of all amphibian species have the fungus causing a decline of frog species worldwide.

3 Domestic cat (*Felis catus*)

Native to: Unknown (first domesticated in ancient Egypt)

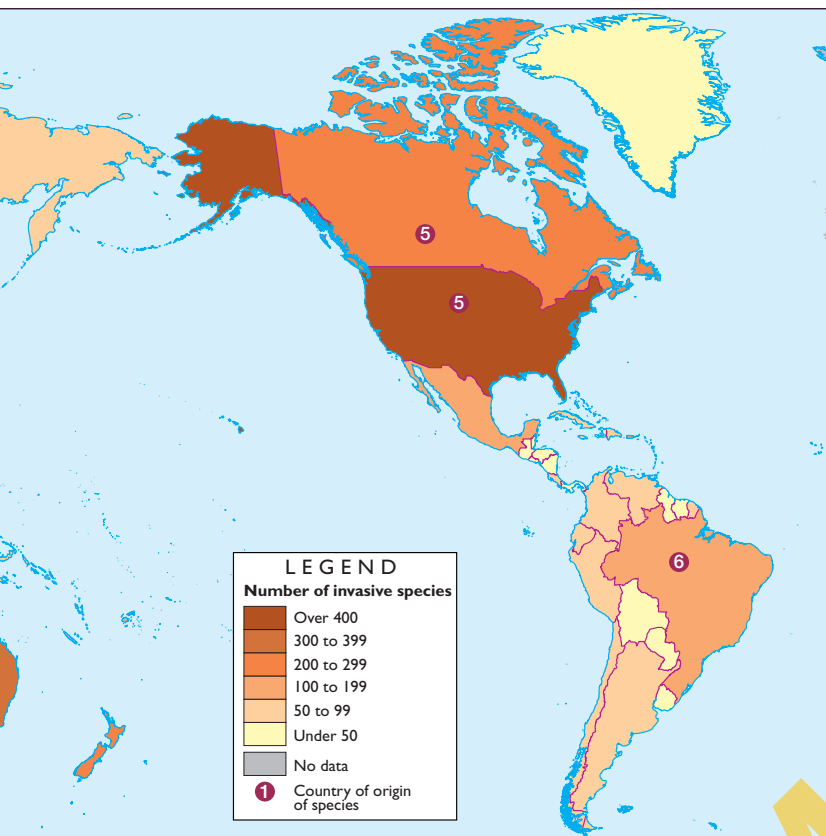**Invaded**: Virtually every country, listed as a harmful species in more than 60

Method of invasion: Carried as pets or to restrict rat numbers and then released or escaped into the wild.

Preferred biomes: grasslands, forests and tundra close to water

Impacts: Caused or contributed to the extinction of birds and small mammals around the world, particularly on islands.

Source: Oxford University Press

LEGEND
Number of invasive species

- Over 400
- 300 to 399
- 200 to 299
- 100 to 199
- 50 to 99
- Under 50
- No data
- ❶ Country of origin of species

❹ Black rat
(Rattus rattus)

Native to: South-East Asia, north-east China and India

Invaded: Widespread around the world

Method of invasion: Deliberately introduced as a food source or accidently introduced as a stowaway on ships

Preferred biomes: Grassland, temperate forest, tropical forest

Impacts: Preys on native birds (especially flightless species and the eggs of seabirds), reptiles and insects, eats native plants and seeds, major agricultural pest. They have caused or contributed to the extinction of birds, mammals, reptiles and plants.

❺ American mink
(Neovison vison)

Native to: North America

Invaded: Widespread throughout Europe

Method of invasion: Bred in mink farms for their fur, they escape or are released by animal activists

Preferred biomes: Forests near wetlands and rivers

Impacts: Kills large numbers of native species such as voles and salmon, can drive native mink from their habitats.

❻ Water hyacinth
(Eichhornia crassipes)

Native to: South America

Invaded: Widespread in streams and rivers around the world particularly in North America and Europe

Method of invasion: Carried as an ornamental plant

Preferred biomes: Freshwater sources including rivers, lakes and streams

Impacts: Grows as a thick mat clogging rivers and streams, inhibiting plants and some fish species and providing a habitat for other pests including malarial mosquitoes.

Check your learning 1.13

Remember and understand

1 How do invasive species move between countries?

2 How can an animal that is not a pest in one country become a major pest when introduced to a new country?

3 How do rats cause land degradation?

Apply and analyse

4 Compare the six examples of invasive organisms shown. What are some of the similarities? How is each unique? Which do you consider has had the greatest impact?

5 Examine Source 1.45.

a Which countries have the highest numbers of invasive species?

b Why do you think these countries have so many invasive species? What features do they share that might help to explain the high numbers?

c Why do you think that Africa and the Middle East have such low numbers of invasive species?

Evaluate and create

6 Some researchers consider humans to be an invasive species. Complete a file card for the human species describing their method of invasion, preferred biomes and impacts.

7 Australia is one of the most invaded countries but is also the origin of many plants and animals that are considered invasive species in other countries. These include the golden wattle, Queensland fruit fly, Australian magpie, spotted jellyfish and brushtail possum. Research one of these invading Australians. Describe how and where it has spread and its impact on native plants and animals.

Caring for Country

Indigenous Australians have a special connection with the land. They feel responsible for looking after the stories, places, resources and culture of an area. This is sometimes referred to as 'caring for Country'. Important aspects of caring for Country are connecting with ancestors and maintaining the natural resources of a region. In this way, Indigenous Australians seek to live sustainably. This concept of caring for Country applies to all landscapes including the forests, deserts, wetlands and mountains.

The Australian Government recognises the special connection that Indigenous Australians have with the land in a number of ways, such as the establishment of a network of Indigenous Protected Areas. In these areas, the traditional owners of the land have agreed to promote biodiversity and to protect the natural and cultural values of the land. At present, there are 42 Indigenous Protected Areas across Australia covering a total of 420 000 square kilometres. These areas protect some of Australia's most fragile and vulnerable environments.

AUSTRALIA: INDIGENOUS PROTECTED AREAS, ABORIGINAL LANDS AND OTHER PROTECTED AREAS, 2012

LEGEND
- Indigenous protected areas
- Aboriginal lands
- Other protected areas (e.g. National Parks)

0   400   800 km
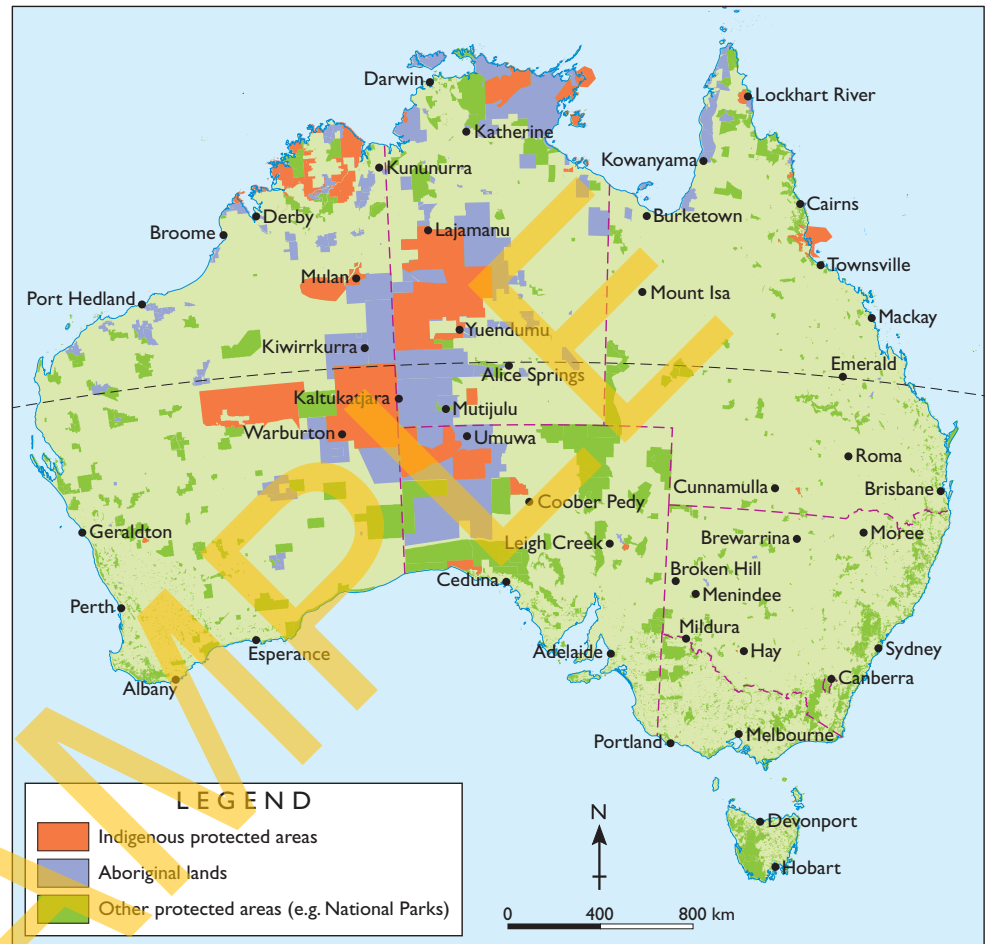
Source 1.46

Source: Oxford University Press

Check your learning 1.14

Remember and understand

1 What is an Indigenous Protected Area?

2 What do you think Mandingalbay Yidinji traditional owner Dale Mundraby means by 'putting country back together'?

Apply and analyse

3 The Mandingalbay Yidinji Indigenous Protected Area is located very close to the city of Cairns. How is this both an opportunity and a challenge for the managers of the Indigenous Protected Area?

4 Examine Source 1.46.

   a What is the closest Indigenous Protected Area to your home?

   b Describe the distribution of Indigenous Protected Areas and Aboriginal lands in Australia. What could account for this distribution pattern?
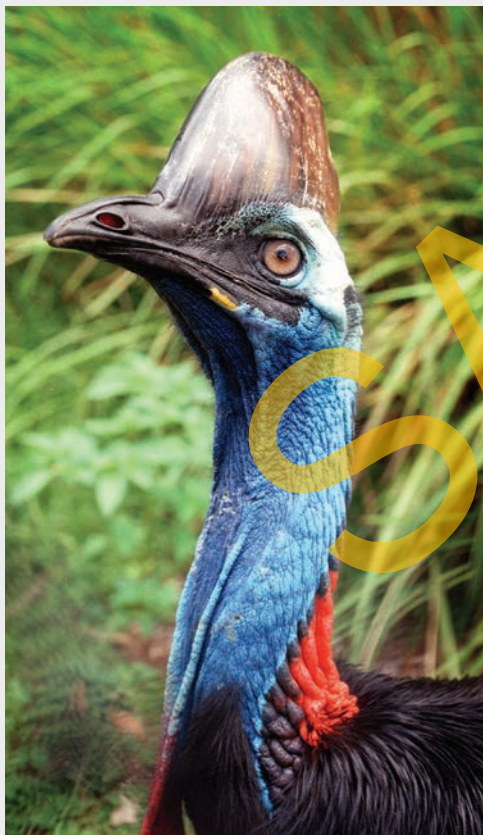
Evaluate and create

5 Complete a geographic sketch of the oblique aerial photograph provided (Source 1.48). On your sketch label Cairns, Trinity Inlet, saltwater wetlands, mangroves, agricultural land, mountain ranges and rainforests. You will need to consult an atlas or use the Internet to help you.

6 In your own words, define ecotourism. Do you think that ecotourism is a sustainable use of this Indigenous Protected Area?

Mandingalbay Yidinji Indigenous Protected Area

> We had a native title determination and Indigenous Land Use Agreements, but it wasn't until we started developing the Indigenous Protected Area project that we could see a way of 'putting country back together' – to manage country in a tenure-blind way with our partners.
>
> Dale Mundraby, Mandingalbay Yidinji traditional owner

Trinity Inlet is a large saltwater estuary in Far North Queensland. On the west bank of this estuary is the city of Cairns, while on the east bank lies the Mandingalbay Yidinji Indigenous Protected Area. Covering almost 10 000 hectares, the Indigenous Protected Area is a world of saltwater wetlands, rugged ranges covered in rainforest, mangroves, salt marshes and sandy beaches. It is home to many rare and endangered plants and animals including the cassowary (see Source 1.47) and several frog species found nowhere else in the world.

Prior to 2011, this region was divided into a number of reserves, national parks and private plots. Unsustainable farming practices led to a loss of biodiversity, particularly in the saltwater wetland of Trinity Inlet. Following a successful native title application, the Indigenous Protected Area was established in a process which the local Aboriginal people, the Mandingalbay Yidinji, described as 'putting country back together'. The traditional owners now work in partnership with governments to restore the area.

Specific programs include trapping feral pigs, collecting seeds and re-vegetating mangroves in barren areas, as well as building walking tracks and other facilities for visitors. The managers of the Indigenous Protected Area see **ecotourism** as the future of the region, once plants become established and birds and animals return to the area.

For more information on the key concept of place, refer to section GT.1 of 'The geographer's toolkit'.

Source 1.47   Australia's second largest bird, the cassowary, is vulnerable to extinction due to the loss of rainforest across large parts of Queensland.

Source 1.48   An oblique aerial photograph looking north-east towards the Mandingalbay Yidinji Indigenous Protected Area from Cairns.

Invasion of the cane toad

Native to Central and South America, cane toads were released in northern Queensland cane fields in 1935 to help control cane beetles which were eating and destroying the sugarcane plants. The cane toads were of little benefit to the farmers but as they spread beyond the cane fields, southwards into New South Wales and westwards towards Western Australia, they soon became pests themselves. Like many introduced species, cane toads have no natural predators in Australia, so there was little to stop their spread.

Source 1.49   The cane toad has become a serious pest in Queensland and the Northern Territory.

Animals such as snakes, goannas, freshwater crocodiles and quolls have eaten frogs for millions of years. They see cane toads as a new food source. However, the poisonous skin of the cane toad kills its attacker within minutes. This is devastating the local populations of these native animals.

AUSTRALIA: DISTRIBUTION OF CANE TOADS, 2012
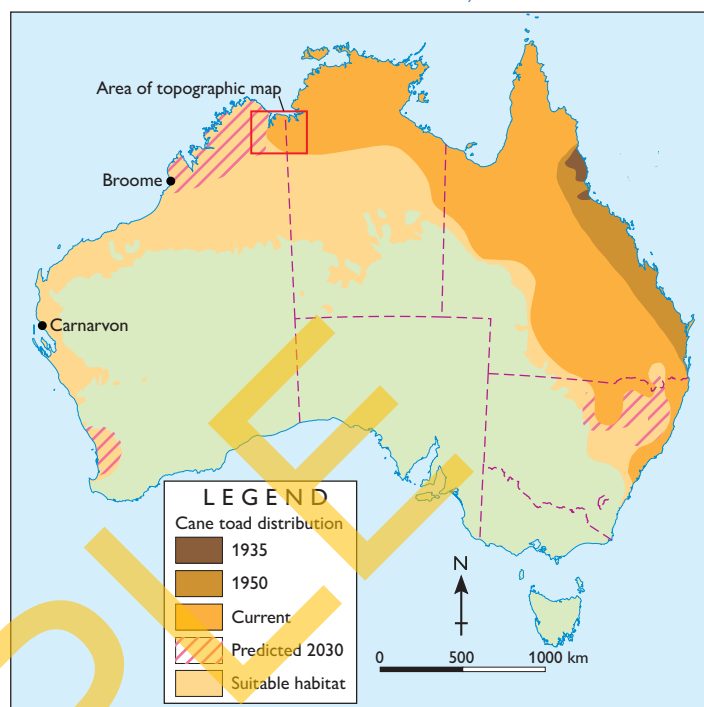
Source 1.50   Source: Oxford University Press

skill**drill**

Using a topographic map to explore environmental change

Because topographic maps show the shape of the land in great detail, they are one of the most useful tools used by geographers. By adding extra information, topographic maps can be used to show changes over time and the reasons for these changes. Source 1.51 has been drawn to show the expansion of the cane toad's territory every year from 2006 to 2012. The **contour lines** on the topographic map show the shape of the land over which the cane toads are spreading (including the heights of valleys, hills and ridges). Geographers use this information to measure and predict the rate and direction of the cane toad's spread. Follow these steps:

Step 1   Look closely at the lines and dates showing cane toad expansion to estimate in which direction the spread is moving.

Step 2   Are the lines becoming closer together or further apart from one year to the next? This will tell you if the rate of spread is increasing or decreasing.

Step 3   Select an area between two lines that shows a typical rate of spread. Use the line scale to estimate the distance between the lines in this place. This will give you a rate in

NORTH-EAST WESTERN AUSTRALIA AND NORTH-WEST NORTHERN TERRITORY: ADVANCE OF THE CANE TOAD 2006–2012
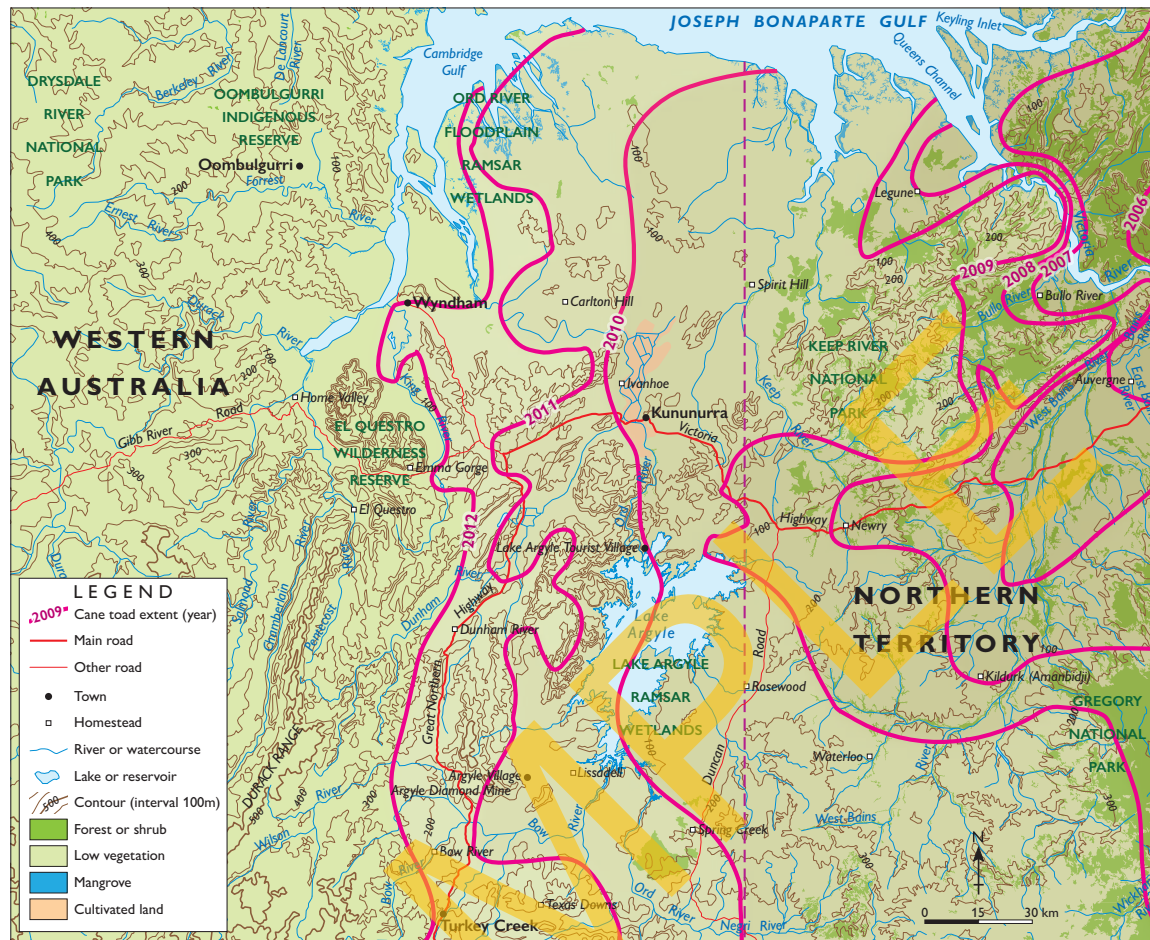
Source 1.51

Source: Oxford University Press

kilometres per year. Divide this by 52 to give you a rate per week. This could also be expressed as metres per week.

Step 4 Look at the contour lines and other features shown in the legend to identify any natural or built features that are affecting the pattern and rate of spread being shown on the map.

Apply the skill

Examine Source 1.51 carefully and complete the following tasks.

1 Using the steps provided, estimate the direction in which cane toads are spreading across northern Australia.

2 Calculate the rate of spread for the cane toad between 2011 and 2012.

3 Use the rate of spread you calculated, together with the line scales provided in Sources 1.50 and 1.51, to estimate the amount of time it will take cane toads to spread to the Western Australian towns of Broome and Carnarvon.

4 What natural features appear to be affecting the rate of spread of the cane toad?

Extend your understanding

Examine Source 1.50.

1 Estimate, in square kilometres, the size of the region currently inhabited by cane toads.

2 Estimate the size of the region cane toads are predicted to inhabit under current climate conditions.

3 How do you think climate change will affect the distribution of cane toads? Why do you think this is the case?

4 Kakadu National Park in the Northern Territory contains vast areas of protected wetlands and large numbers of unique plants and animals. Cane toads were first detected in the park in 2001 and since then have had a range of devastating impacts on this unique environment. Research these impacts and the efforts taken by park authorities to minimise them. Discuss the effectiveness of these methods with your classmates.

1.3 How do people change and manage fresh water?

Water degradation

Inland waters such as rivers, lakes and wetlands are some of the world's most degraded environments. Human activities have reduced the quality and quantity of clean fresh water in many of these places. Extracting water from rivers to use in homes, factories and farms, and damming rivers for water supply, flood control and hydroelectricity have all affected the health of these inland waters. Pollution from farms and industry sources entering these waters has also caused damage.

People extract large amounts of fresh water from various natural sources. The highest demand for fresh water is for irrigating farms to grow food. In Australia, for example, 70 per cent of the water extracted from rivers and **aquifers** is used in farming. As the world's population and its demand for food and water grows, many of the world's water resources are becoming degraded by having too much water extracted. This has led to shrinking lakes in some regions and increased salinity in the water in others.

Damming the rivers

Of the world's 292 large river systems, two-thirds have been changed by dams and reservoirs. Dams disrupt the flow of water, flooding some areas and stopping water reaching other areas. Damming also disrupts ecosystem services such as the provision of fresh water, fertile soil and food production. The natural interaction between rivers and coastal ecosystems is degraded as fewer nutrients and less water and sediment reach the river mouth and sea.

Pollutants in the water

Water pollution is the contamination of our rivers, lakes, wetlands, estuaries, seas and oceans. This pollution can be the result of human activities near the water such as shipping, fishing and oil drilling, or from activities conducted on land, a long way from the waterways. Land activities such as the use of fertilisers and pesticides in farming, littering, clearing land, creating tips and landfill, processing sewage and industrial activities can all cause pollution of the waterways.

The results of water pollution are devastating. People lose access to safe, clean, drinking water. Fish and other animals in the water are killed or slowly decline in health and population numbers and an important food source is lost. In extreme cases, water pollution can contribute to widespread food shortages and famine.

Source 1.52   An irrigation dam near Mahabaleshwar in western India

Source 1.53   A toxic bloom of blue-green algae caused by excess nutrients from farm fertilisers has built up in a dam in northern California.

Africa's disappearing lake

Lake Chad was once one of Africa's largest and most important freshwater lakes. It provided water to millions of people across four countries and supported a great diversity of wildlife. In 1963, it was the world's sixth largest lake with a total surface area of 23 000 square kilometres. By 2001, this had declined by almost 75 per cent to a paltry 300 square kilometres. This decline is due to a combination of factors including:

- increasing population in the region (e.g. the population of all four affected countries is expected to double by 2050 adding another 300 million people to the region.)
- increasing demand for water to irrigate crops
- drying of the climate due to a decrease in the number of large rainfall events such as monsoonal storms
- extremely high rates of evaporation due to the climate and the shallowness of the lake
- increasing desertification in the Lake Chad catchment area.

For more information on the key concept of sustainability, refer to section GT.1 of 'The geographer's toolkit'.
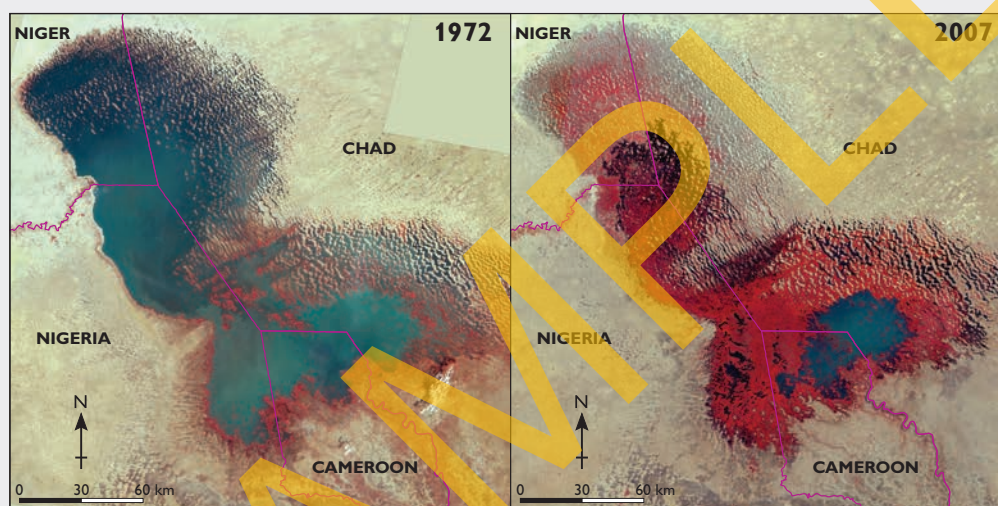
Source 1.54 Satellite images of Lake Chad

Check your learning 1.15

Remember and understand

1 In what ways can building a dam contribute to water degradation downstream?
2 Which human activities contribute to water degradation?

Apply and analyse

3 How do you feel about the scene in Source 1.53? What has caused water degradation in this river?
4 Use the SHEEPT method to classify the factors responsible for the degradation of fresh water resources around the world. (For more information on the SHEEPT method refer to section GT.2 of 'The geographer's toolkit'.)

5 Examine Source 1.54.
  a Describe the changes in Lake Chad evident in these two satellite images.
  b Do you think that Lake Chad will disappear completely? Give some reasons for your answer.
6 Examine Source 1.52.
  a Why do you think this dam might have been constructed? Give evidence from the photograph for your answer.
  b How has this dam changed the natural environment?

Evaluate and create

7 Construct a flow diagram to explore the links between the factors responsible for the decline of Lake Chad.
8 What are some of the issues affecting the health of fresh water resources in your region?

Water degradation in the Murray–Darling Basin

The Murray–Darling Basin is one of Australia's most important resources. Home to more than 2 million people, it produces one-third of Australia's food. It also generates 39 per cent of Australia's income, raised from selling food and fibre overseas. This includes more than half of Australia's cereals, including all of its rice, and virtually all of its oranges.

Many farmers capture rainwater in dams and use it to irrigate their crops and fields but rainfall in the basin is highly variable. If additional water is needed for irrigation it is drawn from the rivers feeding the basin. Farming, along with the basin-wide clearing of natural vegetation, has led to widespread salinity problems in the soil and water resources of the region.

While the amount of salt in the basin is not increasing, it is becoming more concentrated in certain areas. Brought to the surface by the impact of human activities, it is moving into the streams and rivers. As the salt levels increase, natural ecosystems are being placed under stress and cannot cope.

Salt-sensitive plants and animals are dying and are being replaced by plants that flourish in the increasing salinity, changing the ecology of the rivers.

Human activities are being impacted too. The water is becoming less suitable for domestic uses such as drinking and cleaning, and cannot be used to irrigate crops and pastures. The salty water also corrodes the metal pipes the water is transported in.

As salt is moved downstream, areas nearer to the mouth of the river are becoming even saltier. In the irrigation regions of northern Victoria, areas of rising water tables are predicted to triple in the next 50 years, bringing more salt to the surface and into the tributaries of the Murray River. Without efforts to remove salt from the system, river salinity at the town of Morgan is expected to increase by 25 per cent in the same time period.

Source 1.55 Salty water seeps from the ground into streams and lakes near Loxton, South Australia.

MURRAY–DARLING BASIN: MOVEMENT OF SALT TO THE SURFACE
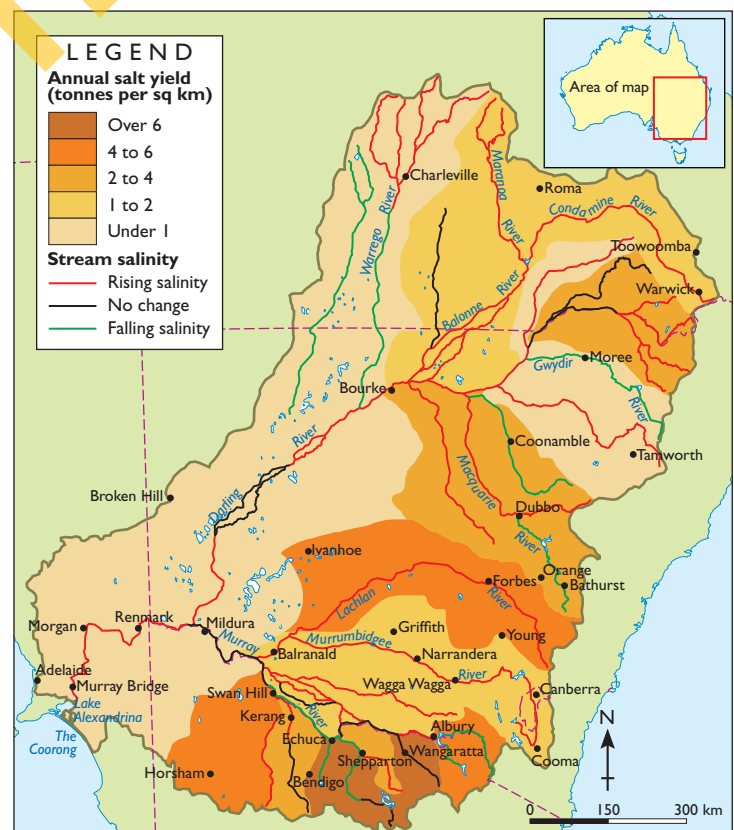
Source 1.56

Source: *Oxford Atlas*

Managing salinity in the Murray–Darling Basin

There has been a range of responses to the issue of salinity in the Murray–Darling Basin, some at the local scale and others at the regional scale. The effectiveness of these management responses has differed from place to place, however, and in some instances the response has created new problems. Two main approaches to salinity management in the basin are currently being used. One approach is to improve farming systems so that farmers use less water. Another approach is the use of salt interception schemes.

Case study: Salt interception in Pyramid Creek

At 17 places along the Murray River, salty water is pumped from the ground and carried to a basin (known as a salt management basin) before it can flow into a river or stream. The salt management basin is often lined with sheets of plastic so the salt is trapped. It is estimated that these schemes stop half-a-million tonnes of salt entering the river system. One such scheme operates at Pyramid Creek near the town of Kerang in northern Victoria (Source 1.57). Salt from this scheme is harvested by a private company, Pyramid Salt, and is sold for use as table salt and swimming-pool salt. The company expects to harvest 36 000 tonnes of salt per year under the scheme.

PYRAMID CREEK: SALT INTERCEPTION SCHEME

Source 1.57 Satellite image of Pyramid Creek near the town of Kerang, northern Victoria, and the Pyramid salt company with their salt harvesting ponds

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Check your learning 1.16

Remember and understand

1 Explain why stream salinity is a major problem in the Murray–Darling Basin despite the total amount of salt in the region staying relatively constant.

2 Describe the impacts of salinity shown in Source 1.55.

Apply and analyse

3 Examine Source 1.56.

   a Which regions of the Murray–Darling Basin produce the most salt?

   b Why do you think this might be the case?

   c List the rivers in the Murray–Darling Basin that have rising salinity.

Evaluate and create

4 The managers of the Pyramid Creek salt interception scheme believe that incorporating salt harvesting helps to make the scheme more sustainable. What do you think this means?
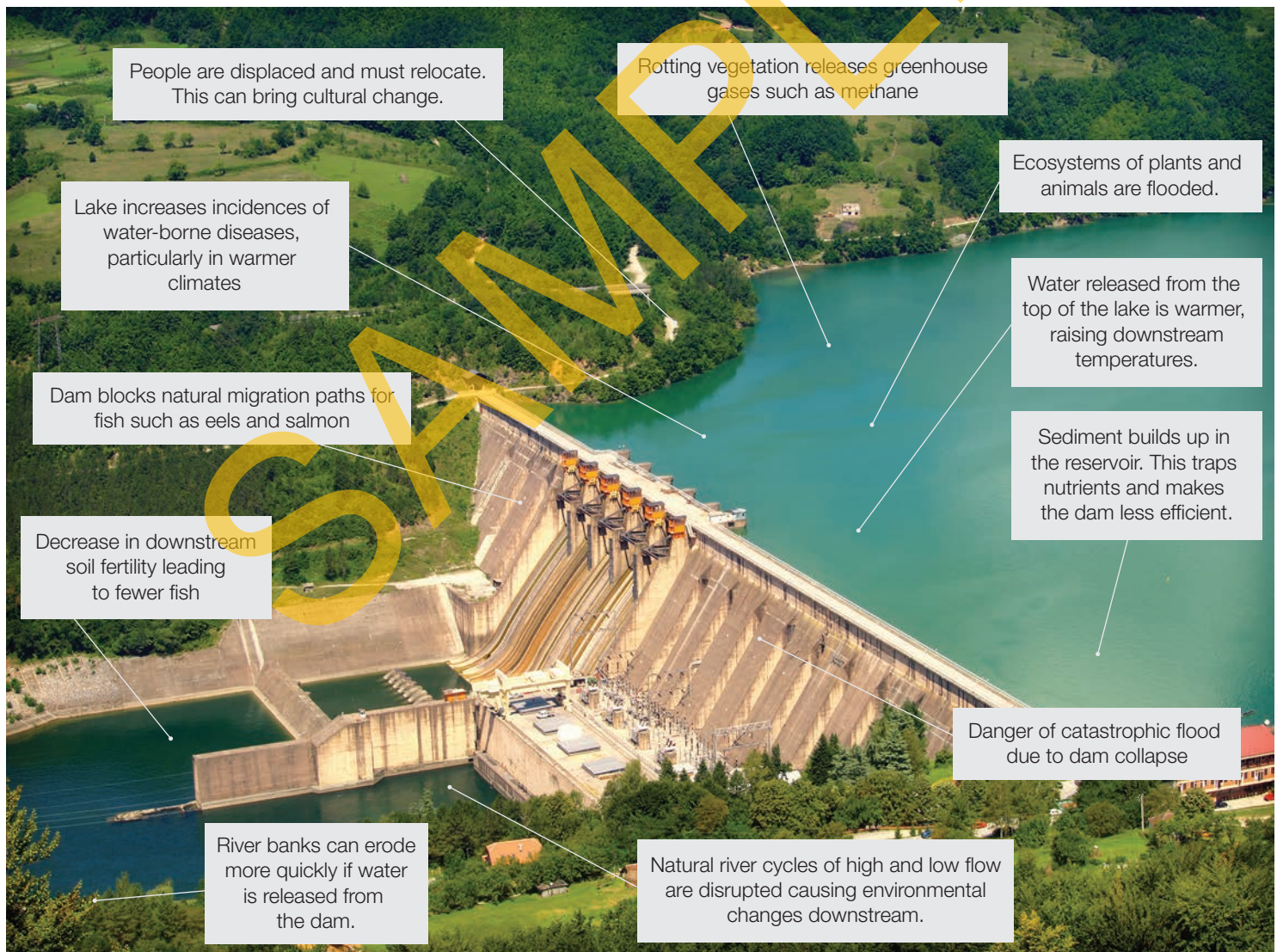
Damming the rivers

There are many human activities that bring environmental change to streams and rivers but perhaps the most dramatic of these is building a dam across a river. One of the main reasons dams are built is to allow a reservoir of water to build up behind the dam which can then be used for the irrigation of farms, a reliable water supply for towns and cities, flood control and for recreation. The energy of the moving water can also be captured behind the dam, and when released through pipes and turbines inside the dam can be used to generate electricity.

This type of electricity (hydroelectricity) provides a cleaner alternative to other methods of power generation such as coal and oil burning. As international pressure mounts to reduce carbon emissions, more and more dams are being built across fast-flowing rivers all over the world. Generally speaking, the bigger the dam, the greater the amount of electricity it can generate. Big dams (over 15 metres high) are now considered the most efficient. There are more than 50 000 big dams in the world, half of which are in China, who has 1600 more under construction. China is by far the world's leading hydroelectricity generator and is home to the Three Gorges Dam, the largest dam in the world.

While big dams bring many benefits, they can also create problems for the environment. Source 1.58 shows some of the human and environmental impacts of damming a fast-flowing river.
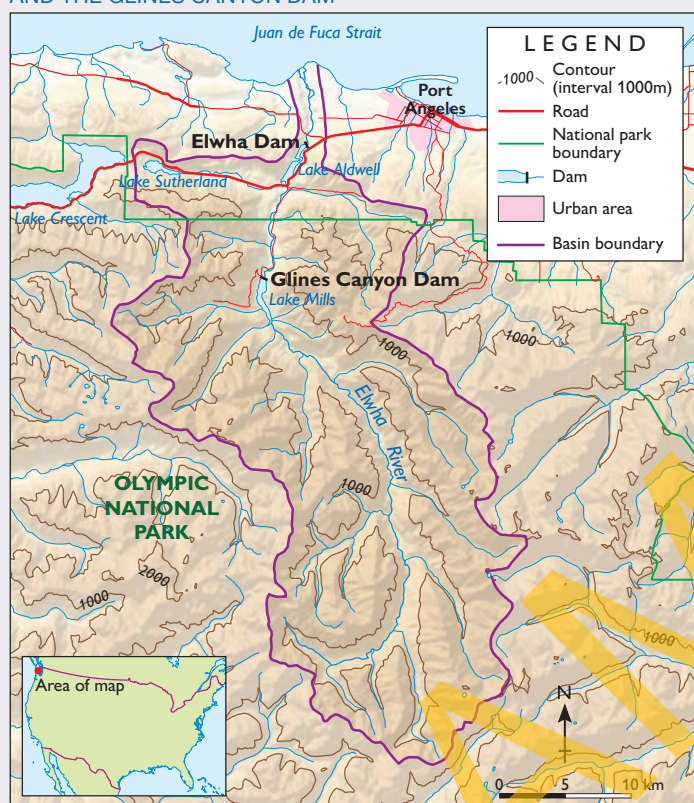

People are displaced and must relocate. This can bring cultural change.

Rotting vegetation releases greenhouse gases such as methane

Lake increases incidences of water-borne diseases, particularly in warmer climates

Ecosystems of plants and animals are flooded.

Dam blocks natural migration paths for fish such as eels and salmon

Water released from the top of the lake is warmer, raising downstream temperatures.

Decrease in downstream soil fertility leading to fewer fish

Sediment builds up in the reservoir. This traps nutrients and makes the dam less efficient.

River banks can erode more quickly if water is released from the dam.

Danger of catastrophic flood due to dam collapse

Natural river cycles of high and low flow are disrupted causing environmental changes downstream.

Source 1.58   Some of the human and environmental impacts of damming rivers

The world's largest river restoration project

While much of the world seems engaged in a dam-building frenzy, in the north-western United States two large dams are being torn down piece by piece. For nearly 100 years there have been hydroelectricity dams on the Elwha River in Washington State, but in 2011 excavators mounted on barges began dismantling them.

Most of the Elwha River runs through the Olympic National Park. Studies on the impact of the dams found that natural ecosystems had significantly declined in quality and capacity as a result of the dams. The greatest impact was on the Chinook salmon, whose migration to spawning rivers had been blocked. This resulted in a 70 per cent decrease in spawning sites (where salmon reproduce). This then impacted on river fertility and reduced the amount of food available to wildlife in the national park such as bears. By removing the dams, it is hoped that the natural ecosystems will be restored. For more information on the key concept of sustainability, refer to section GT.1 of 'The geographer's toolkit'.

ELWHA RIVER: FORMER LOCATIONS OF THE ELWHA RIVER DAM AND THE GLINES CANYON DAM

Source 1.59   Source: Oxford University Press

Source 1.60   The 64-metre-high Glines Canyon dam partially removed in March, 2012.

Check your learning 1.17

Remember and understand

1   Why are many fast-flowing rivers dammed?

2   Why has the Glines Canyon dam been removed?

Apply and analyse

3   Most of the world's big dams are in China. Brainstorm the factors that may be responsible for this. Classify them using the SHEEPT method. (For more information on the SHEEPT method, refer to section GT.2 of 'The geographer's toolkit'.)

4   Examine Source 1.59.

   a   Describe the location of the dams on the Elwha River.

   b   Estimate the length of this river and the area of its catchment.

   c   Why is it important to consider the whole catchment rather than just the river when analysing the impact of a dam?

Evaluate and create

5   Source 1.58 shows some of the negative impacts of dams. Create a similar diagram with a dam's potential positive impacts on people and the environment.

6   Debate this topic: 'Despite their negative impacts, dams are beneficial to people and the environment.'

Pollutants in our water

More than one billion people around the world today lack access to safe drinking water. This is due to many factors, one of which is the contamination of freshwater sources such as rivers, streams and groundwater with harmful substances. As well as making water unsafe to drink, pollutants reduce the ability of the environment to provide other ecosystem services such as food supply, pest control and recreation.

Pollutants that enter our waters can be classified as either physical, chemical or biological.

Physical pollutants

Physical pollutants include particles of soil eroded from the landscape and washed into the waterways and any litter such as plastic bags, cigarette butts, shopping trolleys and tyres. It is estimated, for example, that more than 7 billion cigarette butts are littered in Australia each year. Many of these end up washed into drains and carried to streams and coasts where they release chemicals and present a danger to marine life and seabirds.

Soil washing into the waterways is a major source of pollution. These particles of soil can make water cloudy and prevent sunlight entering the water, affecting the plants and animals. When the sediment settles, it can smother small animals and plants living in the water. These sediment particles may also have other substances bound to them such as chemicals and bacteria that can cause pollution.
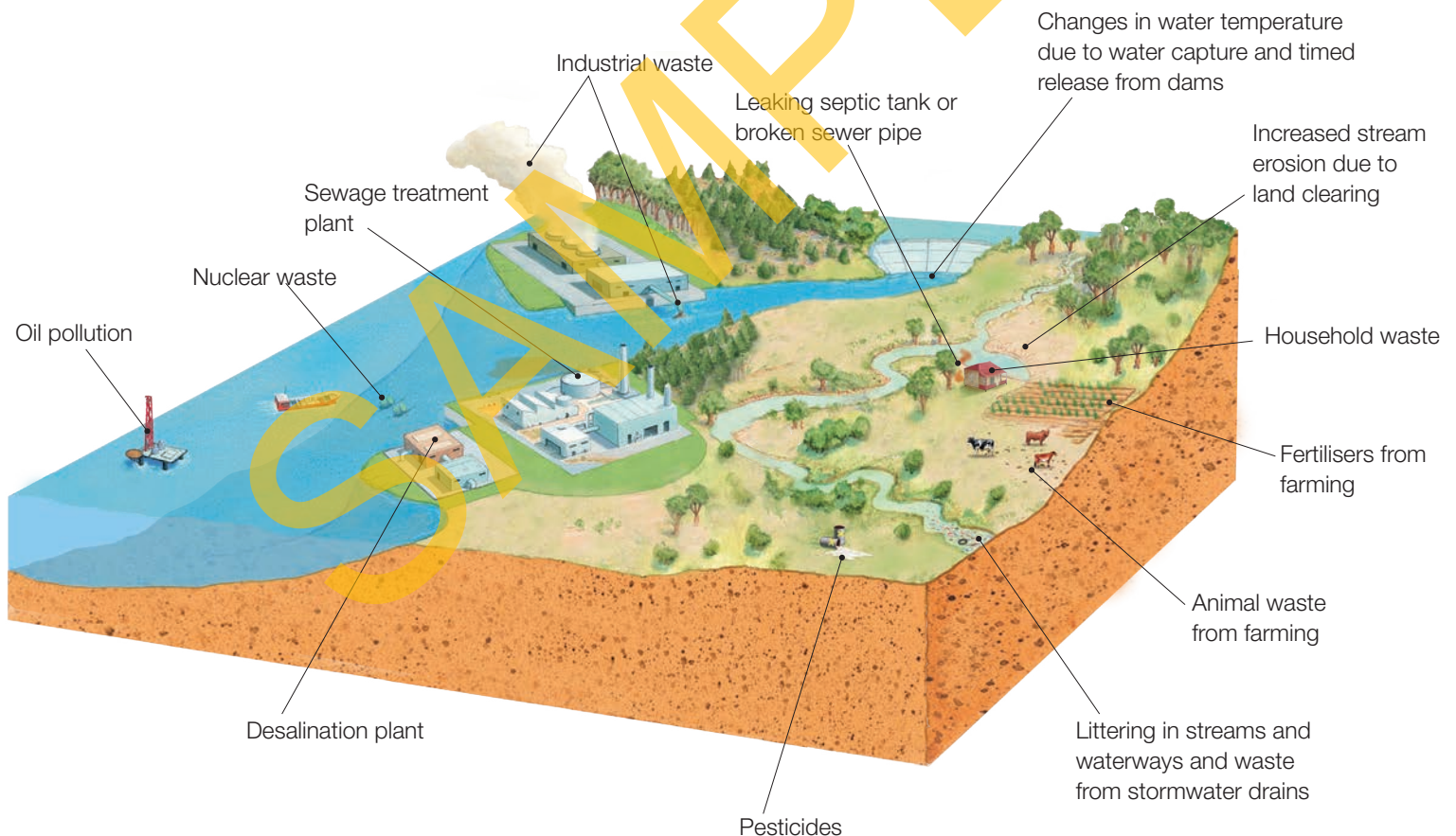
Source 1.61   Major sources of water pollution

Chemical pollutants

Chemical pollutants include heavy metals, oils, pesticides, industrial chemicals and salt. When the concentration of chemicals in waterways reaches levels that are above natural levels it causes pollution. For example, too much of a naturally occurring plant nutrient changes the chemical balance of water causing excessive plant and algae growth.

Biological pollutants

Biological pollutants include bacteria, parasites and invasive plants and animals. Biological pollutants come from a range of sources including sewage treatment plants, farms, factories and storm water. They can cause harm to other plants and animals in the water, or cause harm to people who drink the water. Bacterial and parasitical pollution such as giardia in the water is usually spread by human and animal waste entering waterways, causing illness.

Source 1.63   An estimated 100 million tonnes of mining waste was discharged into the Queen River in Tasmania between 1893 and 1995, giving it the reputation as Australia's most polluted river.

keyconcept: place

The Ganges River

One of the world's most polluted rivers is the Ganges River of India. An estimated 2900 million litres of sewage is emptied into the river every day, creating a toxic river. In addition, the river is used to dispose of medical waste, dead bodies and waste from tanneries (where leather is made from animal skins) and other factories. A count of harmful bacteria in the river found levels 100 times higher than those considered safe for human use. Millions of people rely on the water of the Ganges for drinking, bathing and cleaning, as well as for its **spiritual** significance.

For more information on the key concept of place, refer to section GT.1 of 'The geographer's toolkit'.
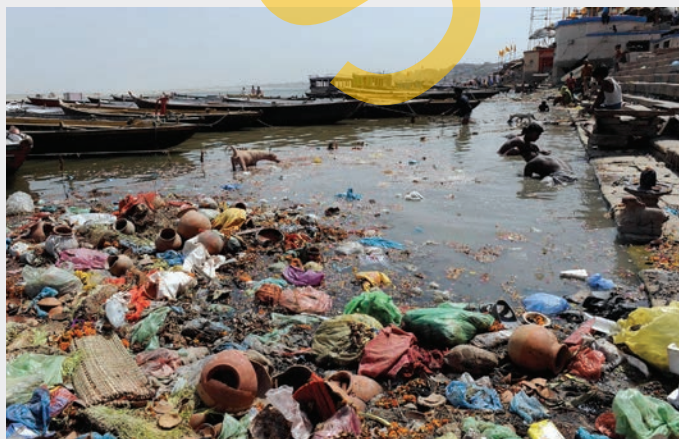
Source 1.62   Around 2 million people a day bathe in the Ganges River, one of the world's most polluted rivers.

Check your learning 1.18

Remember and understand

1 What are the three main types of water pollution?
2 Which of these is the main source of pollutants in the Ganges River?

Apply and analyse

3 Examine Source 1.61, showing some of main sources of water pollution. Classify each of these as physical, chemical or biological.
4 As well as water pollution, what other environmental impacts of mining can you identify in Source 1.63, showing the Queen River valley? How might these also contribute to water pollution?
5 There have been several government attempts to reduce pollution in the Ganges River but these have been largely ineffective. Discuss some possible reasons for this with a partner and then with your class.

Evaluate and create

6 The United Nations considers these 10 rivers to be the most 'at risk': Salween–Nu, Danube, La Plata, Rio Grande, Ganges, Indus, Nile, Murray–Darling, Mekong and Yangtze.
   a Locate each of these rivers on a world map and describe their distribution.
   b Select one of these rivers and research the problems it faces.
   c Present your findings to the class.

Living water

Indigenous Australians have been part of the Australian landscape for more than 40 000 years. Over that time they have developed relationships with the land and the water that have helped them to survive and thrive in some of the harshest environments on Earth. As non-Indigenous Australians struggle with issues such as **water scarcity** and degradation, some are learning that the principles followed by Aboriginal and Torres Strait Islander peoples provide a model that can help them to view and use water more sustainably.

While Indigenous views and values vary from place to place and are both diverse and complex, it is possible to see some common principles with regards to their relationship with water. For example, many Aboriginal peoples refer to permanent sources of water as 'living water'. This describes the importance of water as not only a life-giving force but also of having a life of its own. Indigenous people do not see water as a mere commodity or resource but as a sacred source of life.

> Water is the life for us all. It's the main part. If we are gonna lose that I don't know where we gonna stand. If that water go away, everything will die. That's the power of water.
>
> John 'Dudu' Nangkiriyn

Holistic views of the natural world

Indigenous Australians believe that all features of a landscape (land, water, animals, plants and people) are inextricably linked together to form one interconnected whole. Change in one part of the landscape will bring change to the others. This fundamental belief is a key component of Aboriginal views of creation as well as the management of land and water. This traditional view, dating back tens of thousands of years, is now accepted as scientific fact by many researchers and scientists who refer to it as interconnection.

This holistic view of landscapes links Indigenous people with the natural world. Indigenous people believe that they have custodial responsibility for the land and water in the country in which they live and that this responsibility is passed to them by their ancestors and from them to their descendants. Water resources such as rivers, lakes, billabongs and groundwater are protected by a complex series of laws, customs and beliefs. The Nyungar people of south-western Western Australia, for example, throw a handful of sand into streams and lakes as they approach, in order to warn the spirit of the water of their approach.

For more information on the key concept of interconnection, refer to section GT.1 of 'The geographer's toolkit'.
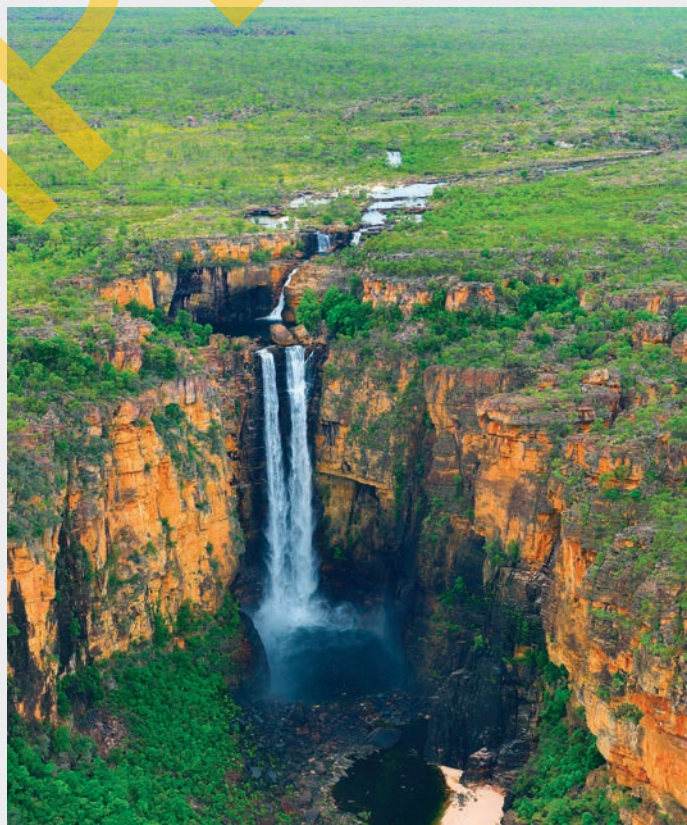
Source 1.64 According to the traditional beliefs of the Gagudju people of Kakadu, a creator-being, known as Almudj, created the waterholes of the region. Almudj brings the wet season every year, may appear as a rainbow, can punish people by drowning them and lives in a pool beneath a waterfall.

Case study: The Police Lagoons

The views of Indigenous Australians with regard to the management of water can, at times, conflict with the views of non-Indigenous Australians, many of whom believe that water is a commodity that can be bought, sold and traded. There are, however, many examples of communities who have been able to take into account both sets of views when developing water management strategies.

One of these is the town of Dirranbandi and the nearby Police Lagoons, a series of wetlands beside the Balonne River in southern Queensland. The Police Lagoons are ephemeral wetlands which means they only fill with water during the rainy season. Before European settlement, the lagoons filled with water once a year and provided an important habitat for plants and animals. The lagoons were also an important meeting place for ceremonies, including burials, for the Kamilaroi and Kooma Indigenous peoples, as well as a source of food. With the development of large-scale farming in the region, including the establishment of Cubbie Station, the largest cotton farm in Australia, the Balonne River floods less often and the lagoons are without water for longer periods of time.

Source 1.65   Satellite image of the Balonne River floodplain in southern Queensland

Following consultation with local Indigenous people, a new management plan for the lagoons will be developed that will take into account the cultural needs of the Indigenous population and emphasise sustainability. Information and knowledge will also be shared between the Indigenous community and government geographers. This will lead to a healthier wetland and see more frequent flooding of the lagoons.

Check your learning 1.19

Remember and understand

1   Why do the views of Indigenous and non-Indigenous Australians sometimes conflict?

2   Why do you think that Indigenous views are often ignored when decisions about water use are made?

Apply and analyse

3   How might the Indigenous concept of interconnection help non-Indigenous Australians to better manage scarce water resources in arid regions of Australia?

4   What are your beliefs about the natural environment? Where do these beliefs come from?

5   Examine Source 1.65.

   a   Describe the location of the Police Lagoons.

   b   This is an ephemeral wetland. Explain how an ephemeral wetland operates.

   c   Why are these wetlands significant to local Aboriginal peoples?

   d   What land uses can you identify in the satellite image?

   e   How do these land uses put pressure on the water resources in this region?

Evaluate and create

6   Discuss a set of guidelines or rules that could be introduced to help water users and managers use the expertise and knowledge of Indigenous peoples in making decisions about water use in Australia.

7   Research the interconnection between water resources in your local area and Indigenous Australians. How have these interconnections changed over time?

Return to Eden

The region at the **confluence** of the Tigris and Euphrates Rivers in Iraq once supported one of the world's great wetlands – the area where farming was first developed as well as the location of the world's first towns. For this reason, many thought of the area as the Garden of Eden. The wetlands once covered 20 000 square kilometres and supported complex communities of plants, animals, birds and people.

Between the 1970s and 2002, however, the area of the marshes shrunk by more than 90 per cent and the only major marsh that survived was the Al Hawizeh marsh sitting on the Iraq and Iran borders. This was a result of new irrigation dams that drew water from the rivers upstream to support further agriculture. Much of the marshland became dry and the ecosystems collapsed. The numbers of migratory birds declined dramatically and the local people were forced to move to the cities.

Since 2003 many of the drainage structures have been dismantled and the marshes allowed to reflood. By the end of 2006, more than half of the region had been reflooded and much of the original vegetation had recovered. Farmers are also returning to the area.

skill**drill**

Constructing overlay maps from satellite images

One way to show how a place has changed over time is to construct an overlay map of the area. **Overlay maps** allow geographers to show a place at two different times so that they can instantly see any changes that have taken place. To construct an overlay map from two satellite images, follow these steps:

Step 1   Construct a base map of the region using the earlier satellite image. This should be traced rather than drawn freehand to make it as accurate as possible. Draw a rectangle the same size and shape as the satellite image. Add key natural and human features: rivers, canals, towns, and lakes.

Step 2   Add labels to rivers and towns. Add a north arrow, legend and title. Include the date of the image, scale and source.

Step 3   On a plastic sheet or piece of tracing paper construct a map of the same region from a later satellite image. Ensure that the two satellite images you use show the same region at the same scale. This map will sit on top of your base map so line up features such as rivers that have stayed the same.

Step 4   Place the overlay map on top of the base map and use a piece of tape like a hinge along the top to stick them together.

Step 5   Add a title to the overlay map that does not cover the one on the base map. A north arrow, legend, scale and source should not be needed as these are the same as for the base map.

Apply the skill

1   Construct an overlay map of the marshes using the 2000 and 2010 satellite images in Source 1.66.

2   Describe the changes to the rivers and marshes of this region from 2000 to 2010 as shown in your overlay map.

3   Describe the scale of this series of environmental changes. Is this change at the local, regional, national, international or global scale? Give some reasons for your answer.

Extend your understanding

1   The decline and rebirth of the Mesopotamian Marshes is an example of the pressure faced by many of the world's freshwater resources but it is also a beacon of hope as it shows that areas can be restored. Select one of these other examples of water resources under pressure: Aral Sea, tributaries of the Dead Sea, Kara-Bogaz-Gol lagoon, Everglades wetlands, Lake Chad, Lake Balkash, Lake Chapala, Lake Nakuru or the Coorong.

Work in groups to:

a   Research the changes that have occurred over time.

b   Describe the causes of these changes.

c   Describe any attempts that have been made to restore the natural environment and comment on their effectiveness.

d   Present your findings as an Annotated Visual Display (AVD). Use images such as satellite images, maps and aerial photographs in your display.

e   Compare your example to those researched by other groups in your class. What are the similarities between them? What is unique about the one you researched?
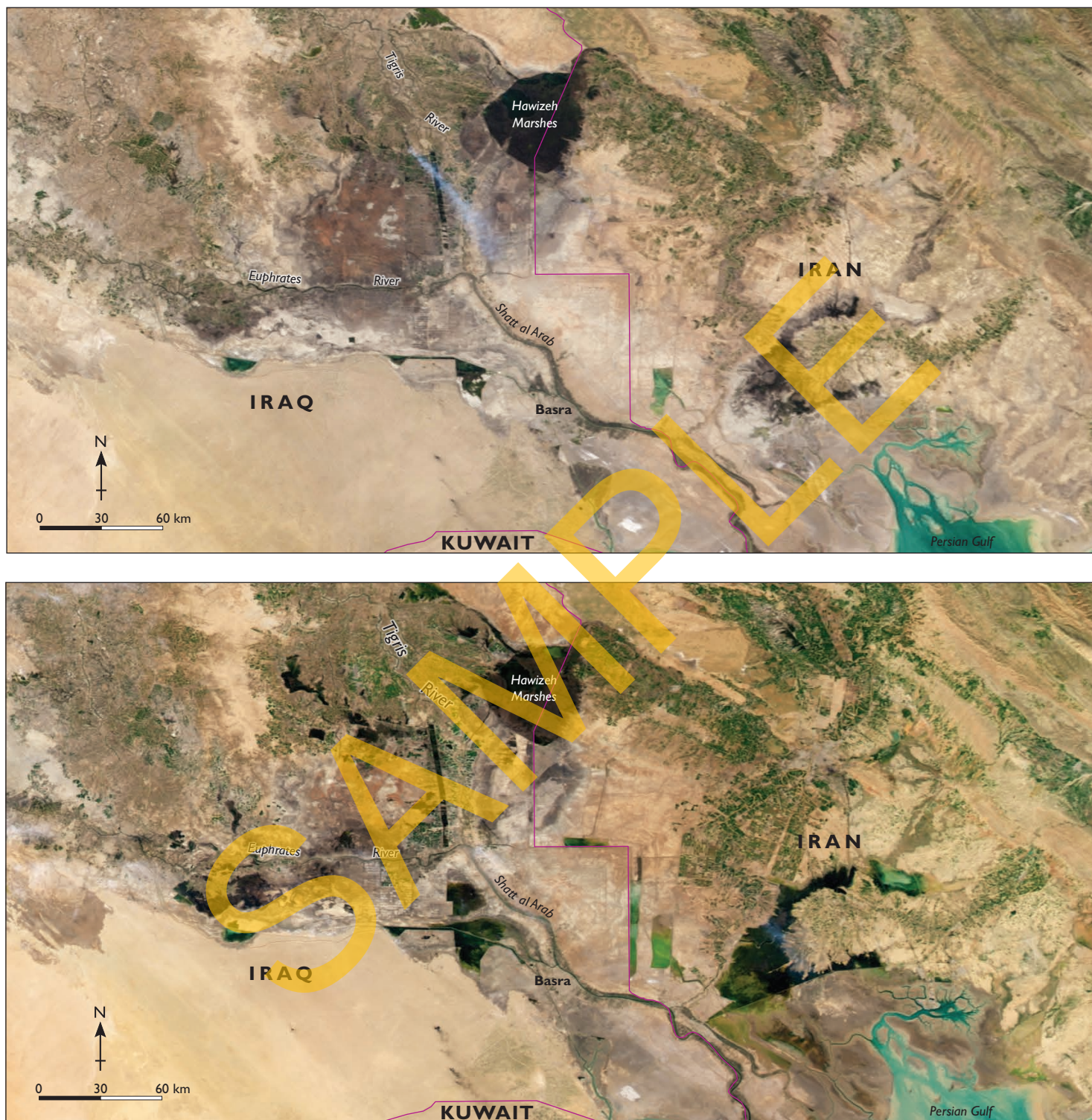
Source 1.66   Satellite images of the Mesopotamian Marshes from 2000 and 2010 (the green areas show the extent of the marshes)