Carbon dioxide emissions

Science understanding

Logical/Mathematical

1 **Construct** line graphs on the grid provided below using the data provided in Table 6.3.1.

Table 6.3.1 CO_2 emissions by country

Year	CO_2 emissions (tonnes per head of population)			
	Australia	USA	China	Japan
1960	8.60	16.20	1.20	2.50
1965	10.60	17.70	0.70	3.90
1970	11.40	20.60	0.90	7.10
1975	11.90	19.70	1.20	7.60
1980	14.80	20.30	1.50	7.90
1985	15.20	18.50	1.90	7.50
1990	17.20	19.20	2.10	8.70
1995	17.10	19.50	2.70	9.00
2000	17.10	20.00	2.60	9.50
2005	18.10	19.50	4.30	9.60
2007	18.10	19.50	4.30	9.60

2 **Explain** why *CO_2 emissions per head of population* is used as a measure of energy consumption.

3 **Compare** the CO_2 emissions (and therefore the energy consumptions) of Australia and the United States of America.

4 **Describe** the trend in energy use in China.

5 **Compare** the data for emissions from the United States of America with the data for the other three countries.

6 Japan is often portrayed as a country with a large number of people, all using the latest electronic gadgets.

(a) **Compare** this image with the energy consumption illustrated by your graph.

(b) **Propose** reasons for any differences identified in the comparison.

Ozone

Science as a human endeavour

Verbal/Linguistic

Refer to the Science as a Human Endeavour on page 199 of your student book to answer the following questions.

1 **Explain** what ozone is.

2 **Describe** the importance of ozone to living things on Earth.

3 **Name** the naturally occurring chemicals that can damage the ozone layer.

4 **Name** the manufactured chemicals that can destroy the ozone layer.

5 **Explain** what the Montreal Protocol is and why it is considered a very significant agreement.

6 **Describe** the natural annual cycle of change in the ozone layer.

7 **Explain** what is meant by a *hole* in the ozone layer.

8 Is *layer* a good explanation of the distribution of ozone in the atmosphere? **Explain** your answer.

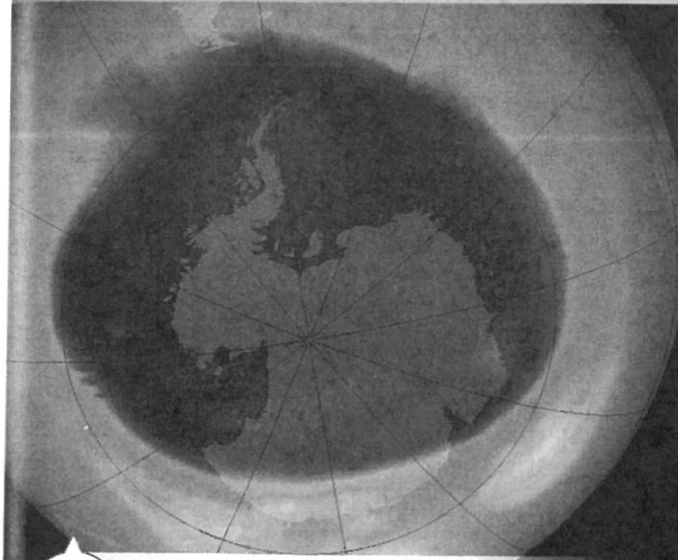


Figure 6.3.11 The hole in the ozone layer over Antarctica (shown in purple)

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Ozone

Ozone (O_3) occurs naturally in the atmosphere, mostly in the stratosphere. It is vitally important to life on Earth because it absorbs ultraviolet (UV) radiation emitted by the Sun (Figure 6.3.12). Too much exposure to UV radiation can cause skin cancers and eye disease.

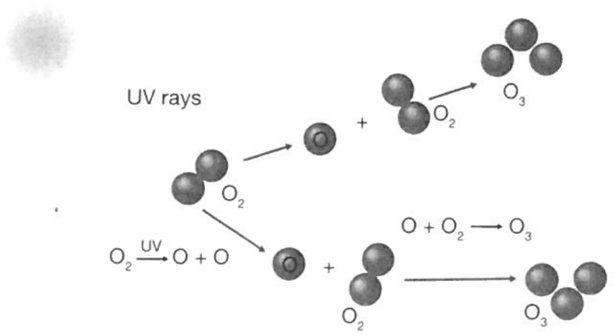


Figure 6.3.12 Ozone is formed when UV light strikes an oxygen molecule (O_2) and splits it into individual atoms, which then combine with O_2 molecules to form O_3 molecules.

The 'thickness' of the ozone layer is measured in Dobson units (DU). Ozone is spread throughout the stratosphere, so the term *thickness* is misleading. If all the ozone in the world could be concentrated into a pure layer at ground level, it would be 5 mm thick or 500 DU.

A value of less than 220 DU is considered a 'hole'.

The concentration of ozone in the atmosphere varies throughout the year and around the world. Measurements over Antarctica show that the values are lowest during September to October, when daylight returns after the long dark winter. At this time chlorine is most effective at breaking down ozone molecules. In November, prevailing winds carry ozone-rich air from other regions and repair the hole. But lower ozone levels still remain over Australia and New Zealand.

An increase in the rate of ozone destruction was linked to the release into the atmosphere of manufactured compounds such as chlorofluorocarbons (CFCs) (Figure 6.3.13) and halons. CFCs are very stable compounds that scientists now know react with UV radiation to release chlorine, which destroys ozone. Halons were developed to fight fire.

Figure 6.3.13 CFCs were developed in the 1920s as propellants in spray cans and coolants in refrigerators and air conditioners. They were used to make the bubbles in foam packaging and were included in industrial cleaners.

When the destructive powers of CFCs and halons were recognised in the 1970s, the use of CFCs was banned in the United States, Canada and Norway. However, it took until 1985 and the identification of a hole in the ozone layer over Antarctica, to convince the rest of the world that there was a serious problem. In 1987, 196 countries agreed to stop producing CFCs. This treaty (known as The Montreal Protocol) demonstrates the contribution that science can make to environmental protection agreements. Scientists predict that the ozone layer will recover to its pre-1980 concentrations by the middle of the 21st century.

6·4

6.5 Climate change

Science as a human endeavour

Visual/Spatial **Logical/Mathematical**

There is discussion in the media, in parliament and in scientific circles about the effect of human activities on the world climate. Climate is not static. World climate has changed in the past and will continue to change.

Scientists cannot know what the world climate is going to be like in the future, nor can they know for certain what the effect of human activities will be on future change. However, they can use their knowledge to construct models of what they think will happen. These models can help governments plan for the future.

Computer models of climate use quantitative data relating to interactions between the atmosphere, oceans, land surface and ice. Models are used to study ways present climates change as well as to make projections of future climate.

All climate models take into account the balance between the energy entering the Earth's atmosphere and the outgoing energy. If these values are not balanced, there will be a change in average world temperature.

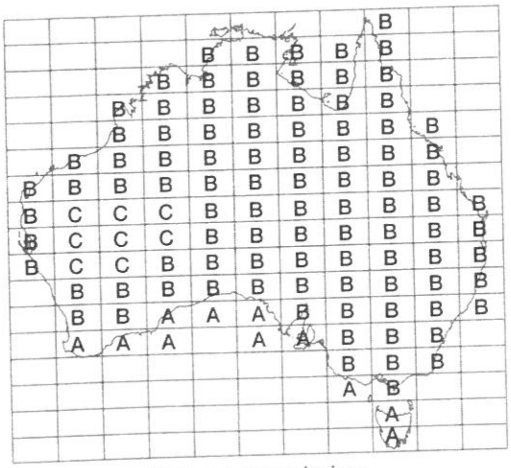
The most discussed models of recent years are those projecting possible changes to average world temperatures caused by changes to the atmosphere. The models predict the effects of increased amounts of greenhouse gases in the atmosphere. All the models project an upward trend in temperature. However, not all models predict the same amount of change.

Models can take into account different levels of greenhouse gas emissions.

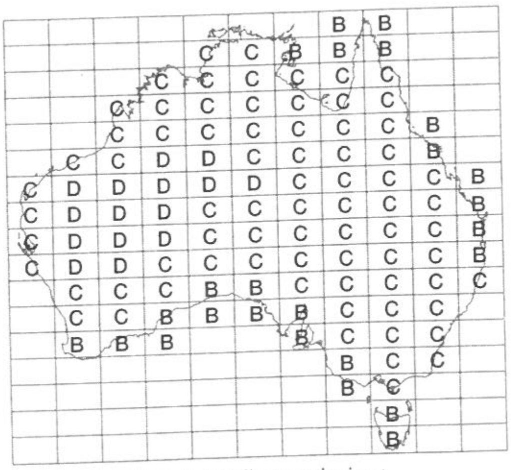
1 **Use** the following three maps 1–3 to **demonstrate** different projected futures for Australia based on low emissions, medium emissions and continued high levels of greenhouse gas emissions.

Use the key to decide on colours for each of the temperature increases A–E.

Colour the maps to show the projected change in average temperature from 1990 to 2050.



Map 1 Low emissions



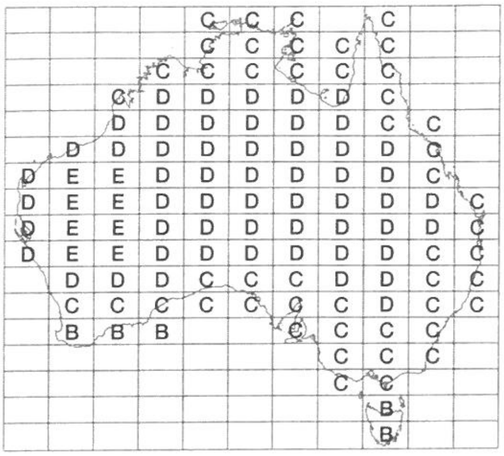
Map 2 Medium emissions

Key:

		A	B	C	D	E			

0.3 0.6 1 1.5 2 2.5 3 4 5

Temperature rise (°C)



Map 3 High emissions

2 Propose reasons for using different levels of greenhouse gas emissions in the models for climate change.

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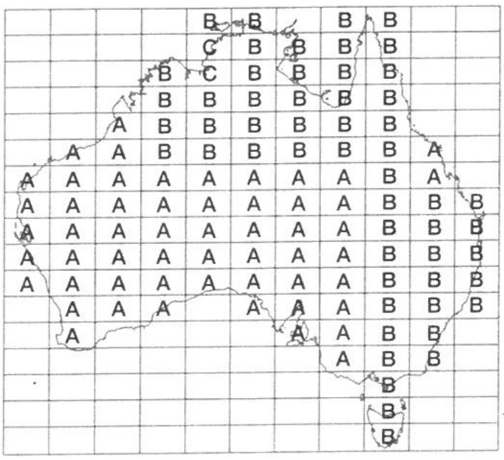
There are many different climate models created by individuals or groups. The people who construct the model emphasise different aspects of the data depending on how important they think it is. The result is a range of scenarios for the future. Most of the models have similar projections but there are some that are different.

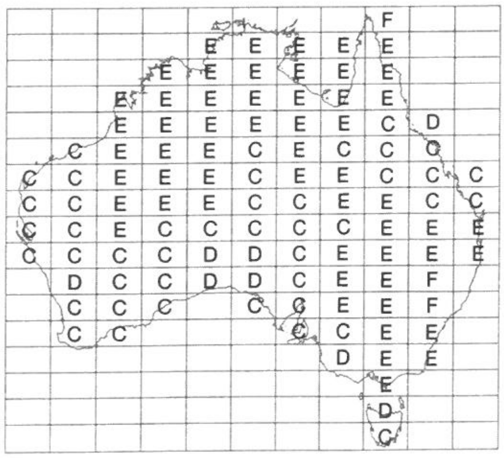
The following three maps (maps 4–6) use medium levels of emissions of greenhouse gases to predict the percentage change in rainfall from 1990 to 2050. Map 5 represents the mid-point of the model results. Maps 4 and 6 represent the extremes of low and high percentage change in rainfall predicted by different models.

3 Use these three maps 4–6 to **demonstrate** how projected changes in average rainfall vary according to different models. Use the key to decide on colours for each of the percentage changes in rainfall A–J.

Colour the maps to show the projected change in average rainfall from 1990 to 2050.



Map 4



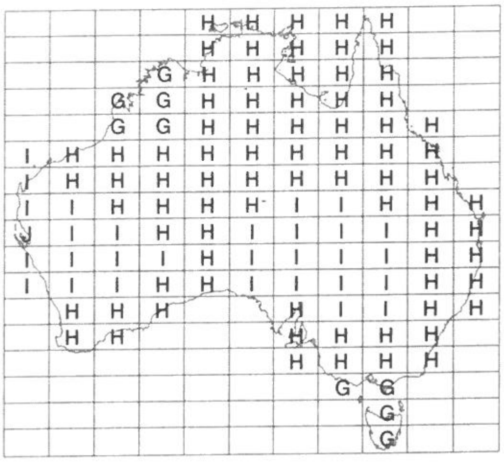
Map 5

Key:

	A	B	C	D	E	F	G	H	I	J

−40 −20 −10 −5 −2 2 5 10 20 40

Percentage change in rainfall (%)



Map 6

4 **Propose** reasons why the different models produce widely different projected changes to rainfall.

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5 **(a)** **Compare** the three maps of rainfall projections.

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(b) **Discuss** problems governments could face when trying to plan future strategies when presented with such different projections.

____

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6 Mark where you live on the maps. **Identify** the projected change in temperature for low, medium and high levels of greenhouse gas emission.

Low ____________________ Medium ____________________

High ____________________

7 Using map 5, **identify** the projected percentage change in rainfall for your area.

____

8 **Construct** a scenario (situation) of how you think the changes in temperature and rainfall would affect life in your area.

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6.6 Sea level changes

Science inquiry

Visual/Spatial **Logical/Mathematical**

Figure 6.6.1 illustrates changes in sea level for the last 450 000 years.

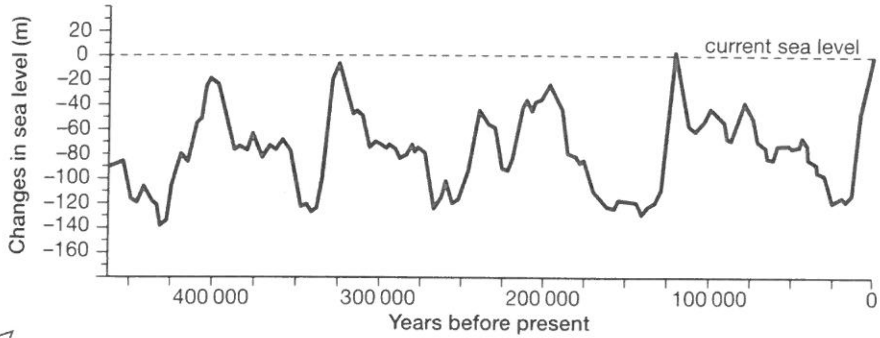

Figure 6.6.1 Historic changes in sea level—late Pleistocene and Holocene

1 **Analyse** the data, then mark on the graph times when ice ages occurred in the last 400 000 years.

2 **Explain** why you chose to mark those times.

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3 **Identify** when the latest rise in sea level started to occur.

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4 (a) **Compare** Figures 6.6.1 and 6.6.2. Both show changes in sea level.

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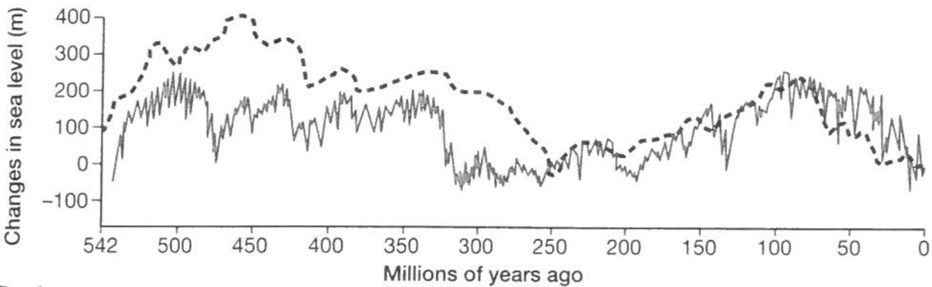

Figure 6.6.2 Global changes in sea level

(b) **Explain** why the curves on the two graphs are so different.

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5 **Propose** what you would say to someone who suggests that the sea levels we are experiencing are among the highest ever.

6 Figure 6.6.2 has two separate curves both representing the same thing but using data from different sources. **Propose** reasons for scientists reaching different conclusions about sea levels in the past.

7 Figure 6.6.3 is also a graph of change in sea level. From the shape of the graph, what would you **conclude** about the changes occurring?

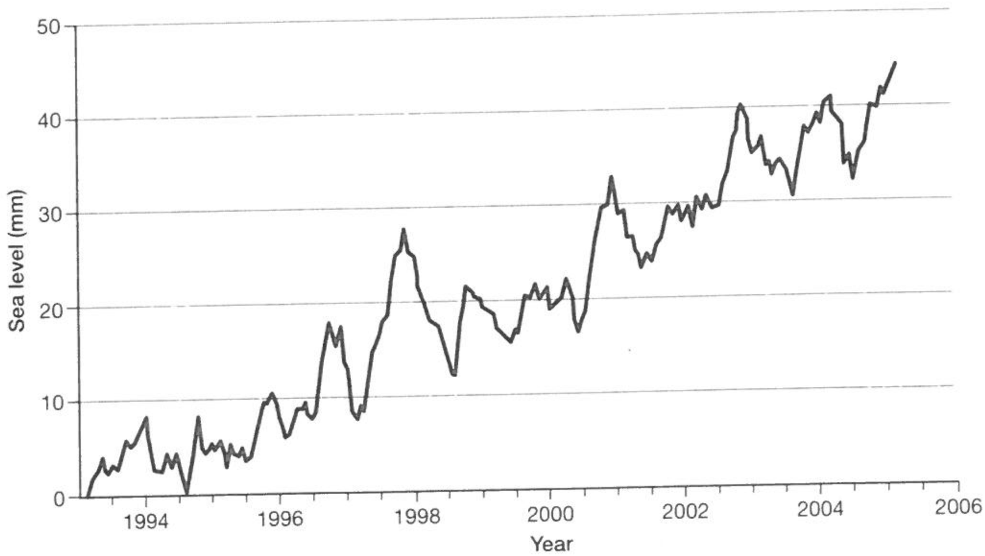


Figure 6.6.3 Changes in sea level for the past 12 years

8 **Explain** how the scale on the graph in Figure 6.6.3 has been used in a way that could make people believe that a fast and large rise in sea level is occurring.

9 **Calculate** the rise in sea level in the 10 years before 2006.

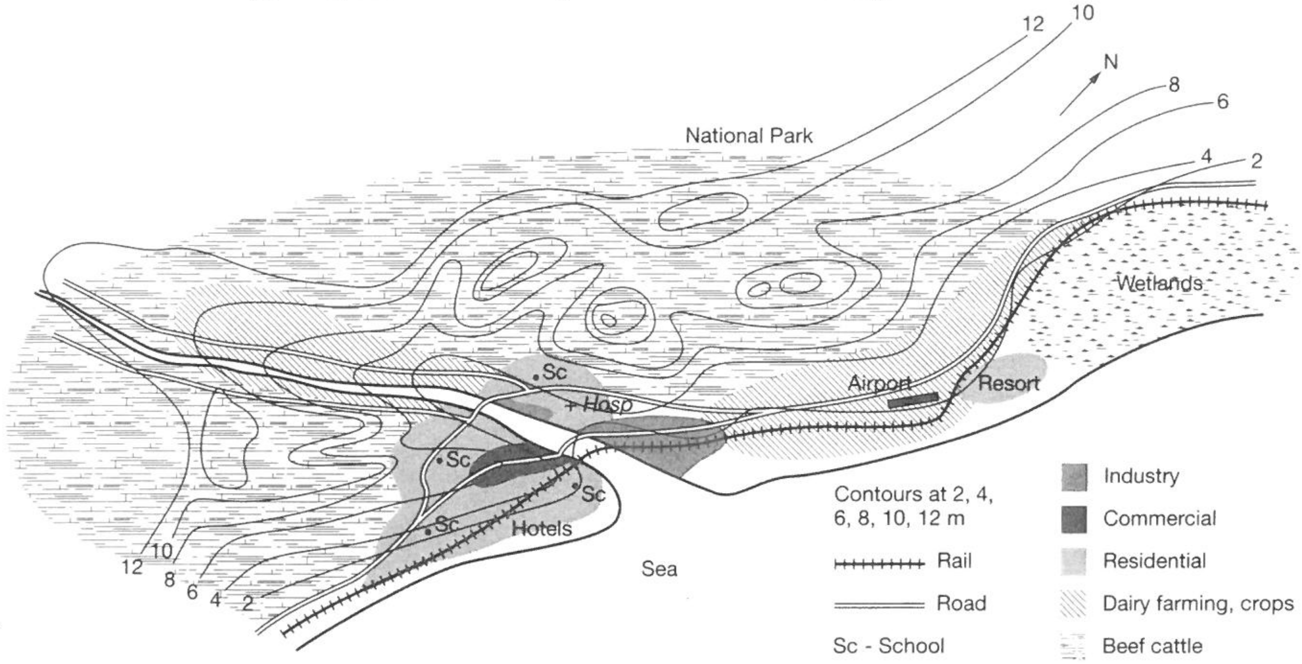
10 **Calculate** the rise in sea level in the 20 000 years since the last ice age.

Impact of rising sea level

Science inquiry

Visual/Spatial

This is a map of a prosperous coastal town. Dairy farming and tourism are the major industries of the town, with large butter and cheese factories in the industrial area. Beef cattle are also important but there is no meat processing in the area. The cattle have to be shipped by road or rail to major centres north of the city.



Propose impacts on this city if the sea level rose by:

(a) 1 metre

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(b) 2 metres

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(c) 6 metres

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Australian Alps and climate change

Science understanding

Verbal/Linguistic

Australian alpine areas cover less than 0.15% of the continent. Figure 6.8.1 shows their distribution through southern New South Wales, eastern Victoria and central western Tasmania. During the winter alpine areas are the coldest environment in Australia.

In the highest parts of the Australian Alps around Mt Kosciuszko (2228 metres), the average temperature of the warmest month is less than 10°C and snow lies there for about 120 days each year. It is too cold there for trees to grow. At these low temperatures and with snow covering their leaves, plants cannot photosynthesise enough carbon to produce woody growth.

Alpine vegetation consists of herbfields, grasslands and heath. The structure of these communities is similar throughout Australia, but the key species differ slightly in Victoria, New South Wales and Tasmania.

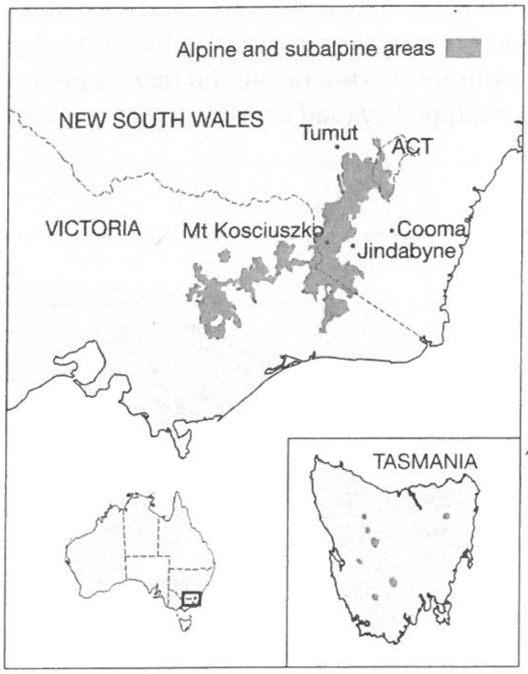

Figure 6.8.1 The alpine areas of Australia

Alpine plants

Most of the plants of the Alps belong to genera growing in other areas of Australia. However, the alpine species have evolved special characteristics in response to the harsh environment. The Kosciuszko alpine area is home to 21 species of plants that live nowhere else in the world.

The uniqueness of the alpine and subalpine vegetation of Kosciuszko National Park is recognised by the United Nations Educational Scientific and Cultural Organisation (UNESCO) as a World Biosphere Reserve. It is one of only 300 Biosphere Reserves listed worldwide.

Unique animals

The unique vegetation creates unique animal habitats and some animals can only live in the Australian Alps.

The mountain pygmy possum (*Burramys parvus*) (Figure 6.8.2) is the only marsupial that hibernates properly over the winter. Other marsupials may sleep and be inactive but they don't lower their body temperature to nearly zero and stop their metabolism, the signs of full hibernation. Fossil records show that in the past when Australia's climate was cooler, the mountain pygmy possum had a much greater range. It is now restricted to living in the mountains above 1400 metres. The possum shares these high altitudes with four other mammals including the broad-toothed rat.

The broad-toothed rat (*Mastacomys fuscus*) remains active under the snow during winter. It feeds on grass, eating 50–70% of its body weight in grass each day. It also sleeps in nests of shredded grass.

An amphibian found only in the New South Wales and ACT Alps is the black-and-yellow-striped corroboree frog (*Pseudophryne corroboree*) (Figure 6.8.3). It is only 3 cm long and hibernates under the snow in winter. It lays its eggs in a burrow in sphagnum moss.

Figure 6.8.2 The mountain pygmy possum feeds on stored seeds when it comes out of hibernation and before migrating Bogong moths arrive. The possum then feeds on the moths, building up a fat store that lasts it through hibernation.

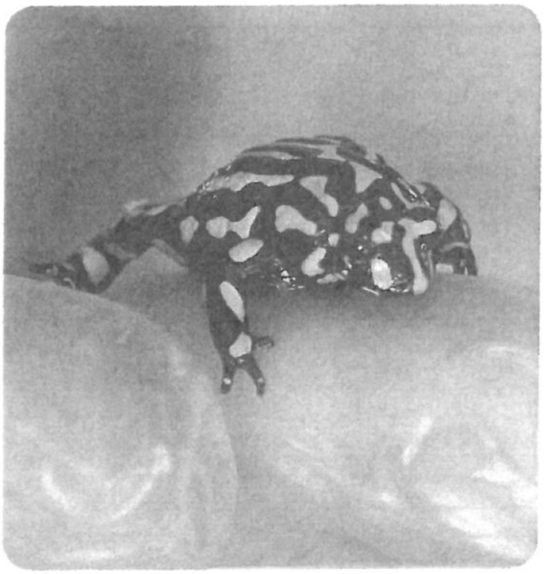

Figure 6.8.3 The corroboree frog has black and yellow strips. It is well camouflaged in the sphagnum moss where it lays its eggs.

Climate change

Recent modelling of climate change predicts that the average temperature of the warmest month in the Australian Alps will be greater than 10°C. This means that trees will be able to expand up into the area now occupied by alpine vegetation. Whether trees expand their range into an area depends on dispersal of the seeds to these new areas, and suitable growing conditions that allow the seedlings to grow and eventually produce seeds themselves.

Even where trees do not expand their range, woody shrubs will move in. The leaves of these shrubs will shade the herbs and grasses of the alpine communities and prevent their growth. The result will be a loss in biodiversity.

Changes in the Australian Alps have already been recorded. Over the last 30 years, as temperatures have warmed slightly, kangaroos, hares and wild horses are being found in larger numbers at high altitudes. These animals graze on the fragile alpine vegetation, putting pressure on it. Seven out of 11 species of migratory birds that fly to the Alps annually are arriving earlier. Foxes are moving uphill into the Alps. Bogong moths are arriving later, forcing the mountain pygmy possums to travel more widely to find food. This increases the opportunities for foxes to prey on the already endangered possums. Foxes also eat Bogong moths. Now that the foxes and possums live in the same area, they are in direct competition for the moths as a food source.

6.8

1 There are areas at the top of high mountains where no trees grow. **Explain** why trees are not found at these high altitudes.

2 **Propose** what changes could occur to these areas as the world temperature increases.

3 **Deduce** the effect on the broad-toothed rat if there was a reduction in the amount of grassland in the Alps.

4 There are many unique plant species in the Mt Kosciusko National Park. **Propose** what would happen to them as the climate changes.

5 (a) **Identify** the effect on the mountain pygmy possum of climate change in the past.

(b) **Propose** the effect on this animal of current and future climate change.

6 **Explain** how increasing temperatures could cause a reduction in biodiversity worldwide.