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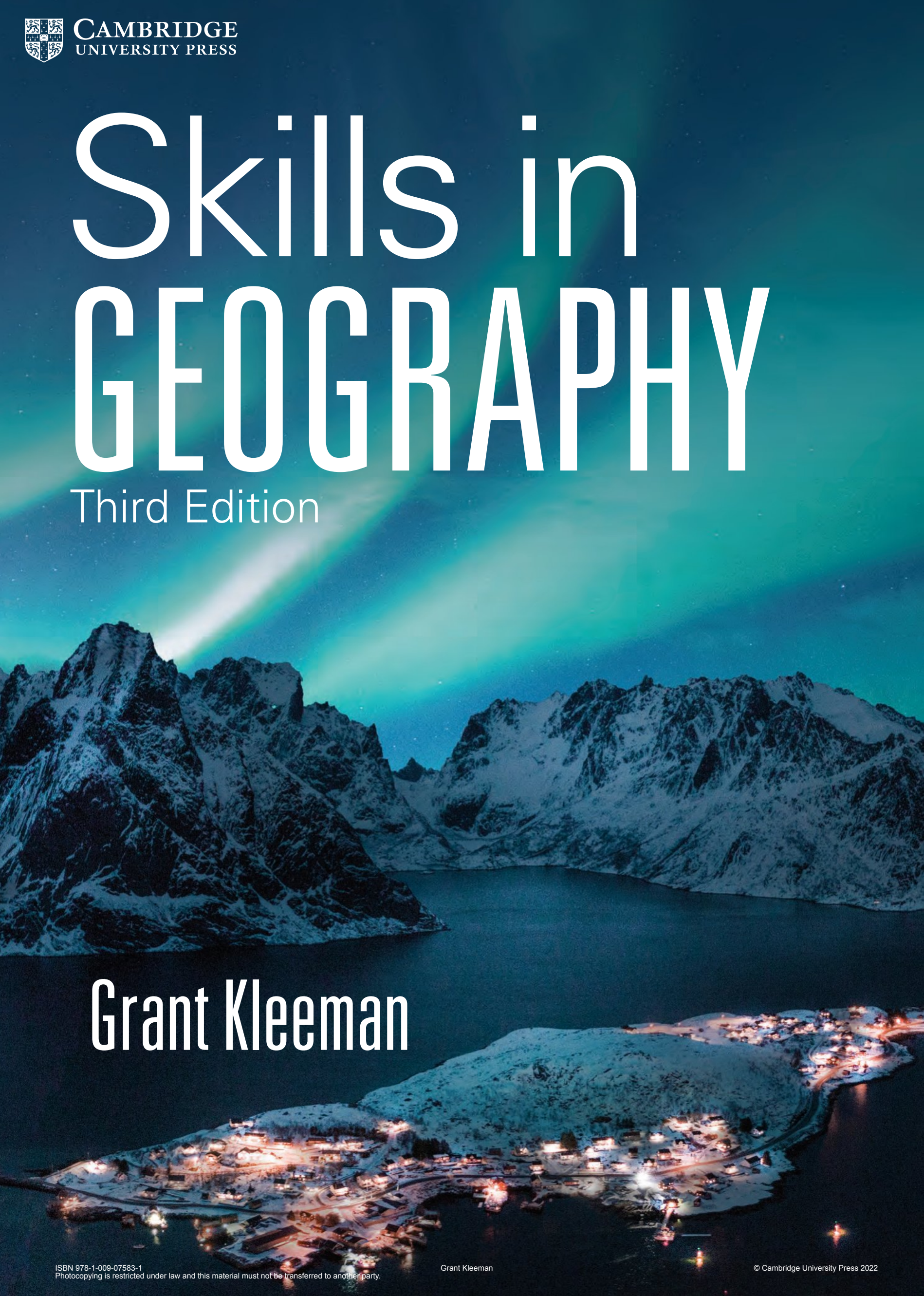
Skills in GEOGRAPHY

Third Edition



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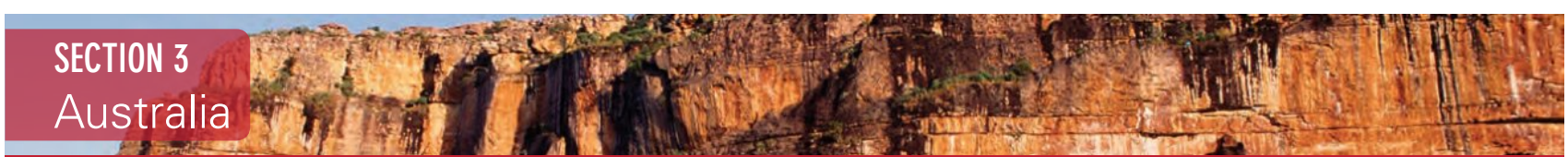

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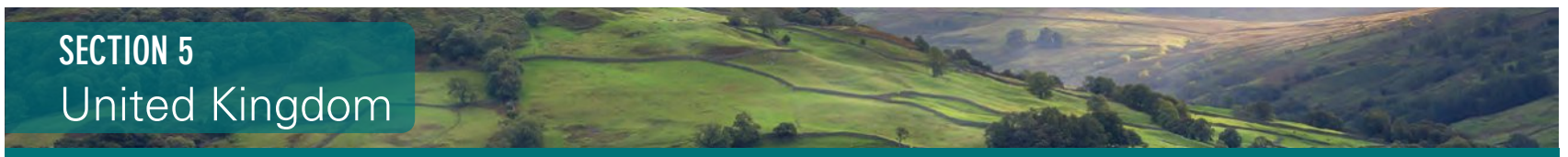

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PREFACE

Skills in Geography Third Edition has been prepared for Australian students studying Geography in Years 7–10.

Featuring more than 400 items of stimulus material, the text guides students to a thorough understanding of the geographical tools and skills they are required to master, and provides them with opportunities to practise these skills. There is also an opportunity for students to develop their geography skills within the context of the geographical themes addressed in Years 7–10.

A detailed glossary is provided to help ensure that students know and understand the geography skills-based terminology used throughout the text.

The text is divided into nine sections:

- **Section One: Key skills in geography** provides comprehensive coverage of the geography tools and skills students are expected to master in Years 7–10. Each skill is explained in clear, direct language. Examples are provided where appropriate. For more complex skills, step-by-step instructions are included along with illustrative examples.
- **Section Two: Key themes in geography** provides students with a skill-based approach to the themes addressed in Geography Years 7–10. The themes addressed are landscapes and landforms, place and liveability, water and the world, interconnections, sustainable biomes, changing places, environmental change and management, and human wellbeing.

Sections Three to Seven provide students with the opportunity to apply their geography skills. Each section contains large-format topographic map extracts plus related stimulus material (including climate data, satellite images, aerial and ground-level photographs, and videos) presented in an easy-to-use double-page format. Each map extract is accompanied by a graded set of activities.

- **Section Three: Australia** includes 23 topographic map extracts from different locations around the country. A special feature of this section is a focus on Gallipoli, a place that is special to many Australians.
- **Section Four: New Zealand** features eight topographic map extracts and associated activities. Of special note is the emphasis given to New Zealand's volcanic and glacial landscapes and landforms. Also included is a focus on New Zealand's climate.
- **Section Five: United Kingdom** features eight topographic map extracts highlighting the country's diverse urban and biophysical landscapes.
- **Section Six: Iceland** features four topographic map extracts focusing on mountain landscapes.
- **Section Seven: North America** includes seven topographic map extracts and associated activities focusing on mountain and river landscapes.

The text is designed to supplement content-based geography textbooks, thus providing a balanced geography course focusing on both knowledge and skills. The text can be used in a variety of ways. Teachers can elect to integrate the skills and thematic material covered in the text into the content of their lessons, or they may opt for short, skills-based units of work at various stages of the course. The text also lends itself to student-directed forms of instruction and would be an ideal resource for home-based study and revision. This text can help students develop a sound understanding of the skills central to the study of geography in secondary school.

Grant Kleeman

About the author

Dr Grant Kleeman is one of Australia's leading geography educators. He is an experienced teacher educator, geography teacher, award-winning author, curriculum writer and examiner. Grant has been closely involved in the development of the *Australian Curriculum: Geography* (7–10) and Senior Secondary Geography Curriculum. He has been active in professional associations for more than 30 years and is currently a director and immediate past Chairperson of the Australian Geography Teachers Association (AGTA). In 2007, the Geographical Society of NSW and the Geography Teachers Association of NSW (GTA NSW) awarded Grant the McDonald Holmes Medal for his 'Distinguished contribution to Geographical Education in Australia'. Grant is a Fellow of the Royal Geographical Society and the GTA NSW & ACT.

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SECTION 1 Key skills in geography

1.1 Maps

A map is one of the most important tools used by geographers. Maps provide us with information about places (including their location) and help us to identify patterns and changes in the landscape.

A map is a graphic representation of a place – an illustration of part of the Earth's surface drawn to scale on a sheet of paper or stored electronically as a computer database (for example, a GPS app on your phone).

The amount and type of detail shown on a map depends on the scale and purpose of the map. Maps can range from the simple to the highly complex, but no map can show every feature of the Earth's surface. The features shown on maps are usually selected to meet a specific purpose. *Cartographers* (map makers) use colours, symbols and shading to illustrate how features of the Earth's surface are arranged and distributed.

Figure 1.1a Maps – you would be lost without them.

Map essentials

Map essentials usually include a title, direction indicator, scale, legend, grid and an indication of latitude and longitude. (See Figure 1.1b.) When drawing your own maps make sure that you include each of these map essentials.

Types of maps

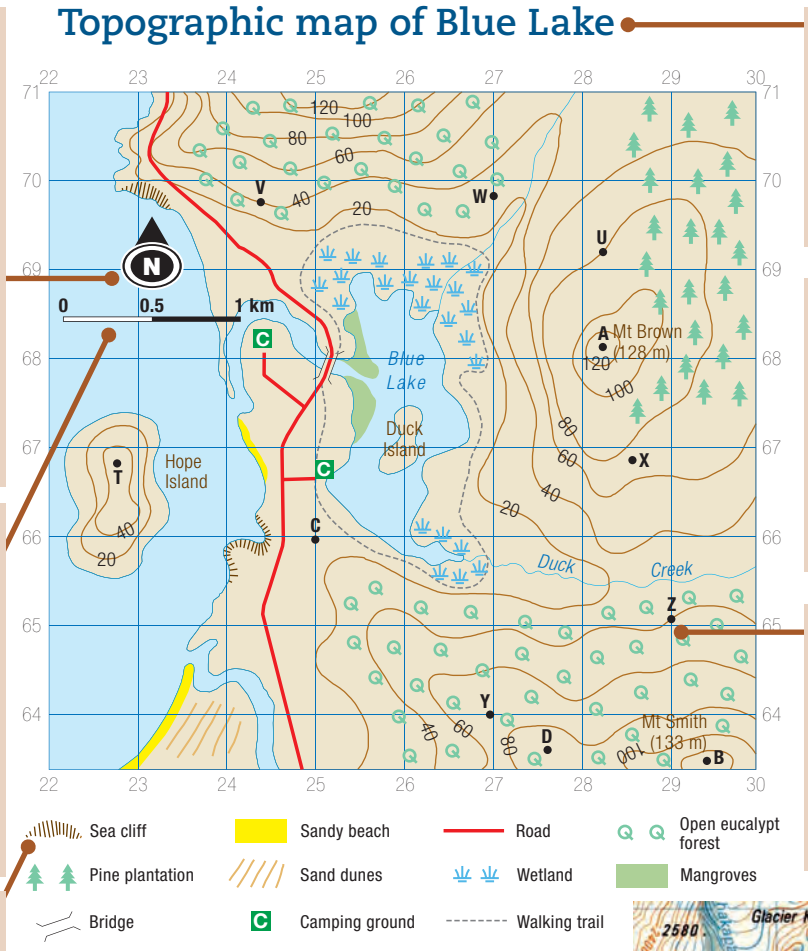
There are many different types of maps. Each type is used to show or highlight a particular set of geographical features. The most common types of maps are shown in Figures 1.1c–1.1g.

The typical school atlas includes most, if not all, of these map types. Each is carefully selected by the cartographer as the best map type for communicating the required information.

Direction indicator. To use a map we need to have an understanding of direction. To help us orientate the map the cartographer includes an arrow to show us where north is. Once we know where north is, we can work out other directions. Direction makes it easier to describe the location of places. (See Unit 1.4 Direction, bearings and quadrants, pages 8–9.)

Scale. Every map is smaller than the actual area it represents. The scale of the map tells us by how much it has been reduced in size. This, in turn, allows us to work out the distance between the features and places shown on a map. (See Unit 1.2 Scale, pages 4–5.)

Legend. A legend (or key, as it is sometimes called) tells us what the symbols used on the map represent.



Title. Map titles provide us with two important pieces of information: the name of the region or place shown on the map and what features are being shown.

Latitude and longitude. When latitude and longitude are indicated on a map they allow us to accurately locate the place on the Earth's surface. (See Unit 1.3 Locating places, pages 6–7.)

Grid. A grid, made up of a series of vertical and horizontal lines, makes it easy to find the location of a particular place or feature on a map. (See Unit 1.2 Scale, pages 4–5.)

Figure 1.1b Map essentials

Figure 1.1c *Physical map showing selected features of the physical environment of south-eastern Australia.* Physical maps show selected features of the physical environment, including mountains, plains, rivers, lakes, seas and oceans. Colour shading is often used to show height above sea level.

Figure 1.1d *Political map of south-eastern Australia.* Political maps show different political units (for example, countries and states), including their borders and capital cities.

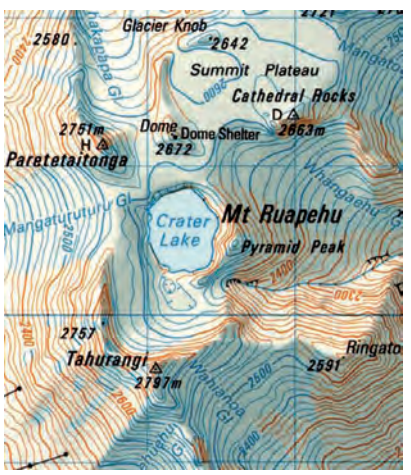


Figure 1.1e *Extract from the topographic map sheet for Mt Ruapehu, New Zealand.* A topographic map is a detailed, large-scale map of part of the Earth's surface, showing selected features of the biophysical, managed and constructed environments. It shows the height, relief and slope of the land; drainage patterns; and vegetation. It also indicates a range of built features, such as settlements and transport linkages. The ability to read, interpret and analyse topographic maps is a useful skill. It allows us to locate features of the biophysical, managed and constructed environments, describe distributions and patterns, and identify relationships between features.

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Weather maps

Weather maps (or synoptic charts) are commonly seen in newspapers and in television news programs. These maps show the weather conditions over part of the Earth's surface at a particular point in time. They show air pressure, temperature, wind direction and strength, and the rainfall received in the previous 24 hours. They also show the location of cold fronts. Being able to interpret weather maps allows us to make predictions about the weather that a place will experience over the following few days. (See Unit 1.10 Climate graphs and weather maps, pages 22–23.)

Flowline maps

Flowline maps show the movement of information, goods and people between places, and the quantity of such movements. Movements are shown by lines or arrows that link the place of origin with the destination. The amount of information, goods or people being moved between places is indicated by the width of the line or arrow. The map's legend indicates the value of the flowlines.

Map symbols

Map symbols are used to show the location of selected features of the biophysical and constructed environments. Many symbols look like the features they represent. The colour(s) used for a symbol may also provide a clue to its meaning.

The importance of a feature may be shown by the size of the symbol or the thickness of the line. The meaning of each symbol is explained in the map's legend. (See the legend on page 2.)

The legend is an important feature of any map. It allows us to interpret the features shown on the map, and it provides us with information relating to the scale to which the map is drawn (see Unit 1.2, pages 4–5) and the contour interval used (see Unit 1.5, pages 10–12). When working with maps always check these details. Never assume that the cartographer has used a particular scale or contour interval.

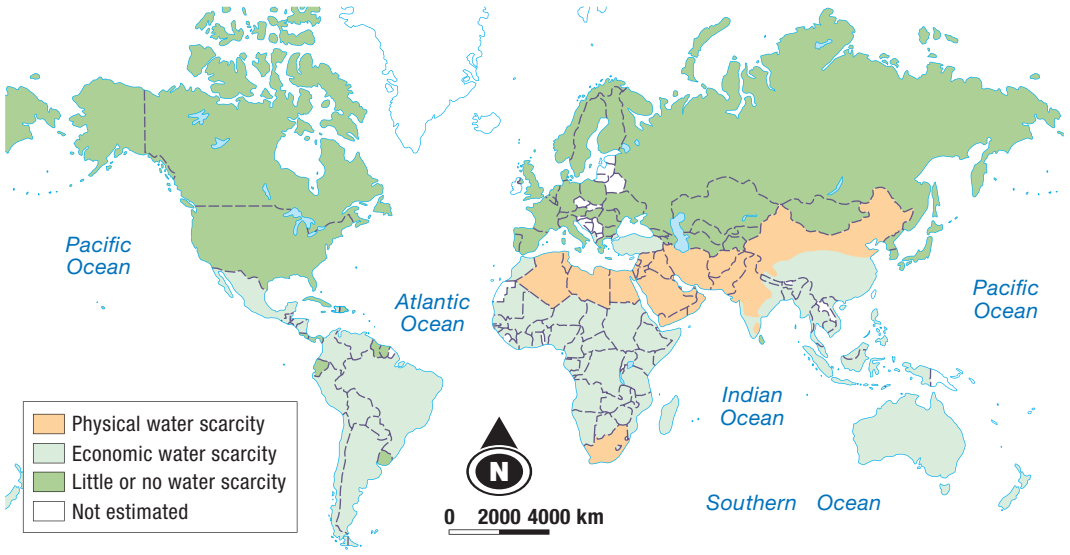

Figure 1.1f *Thematic map showing projected water scarcity, 2025.* A thematic map illustrates a particular theme or issue. Thematic maps may be used to show the distribution of one or more of the following: climate, vegetation types, average rainfall, average temperature, various development indicators, population and agricultural land uses. Thematic maps can be compared to identify links, or associations, between different sets of geographical information.

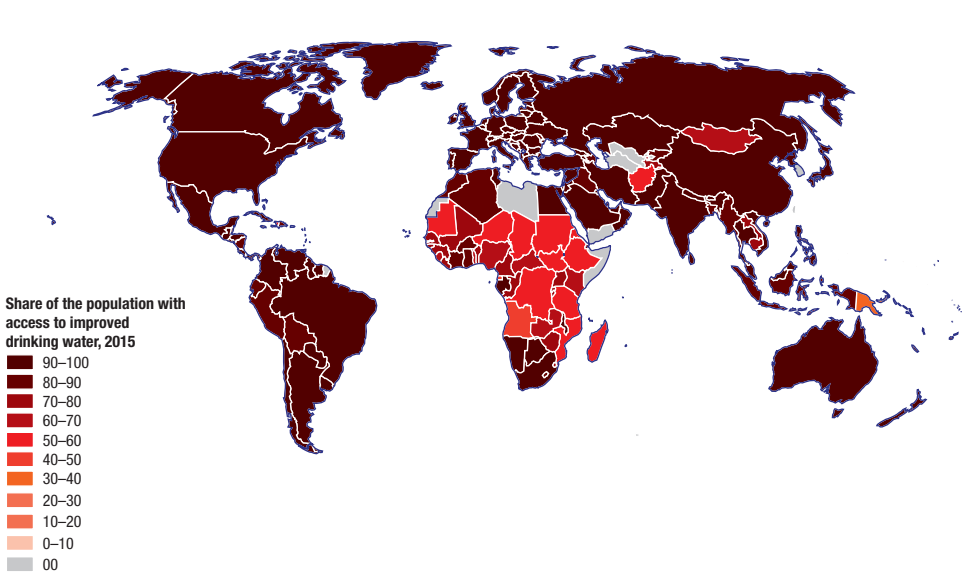

Figure 1.1g *Choropleth map showing access to safe drinking water, 2015.* Choropleth maps are often used to show thematic material. They use different shades of the one colour to show a pattern. The darker shades show the highest values and the lighter shades show the lowest values.

Constructing and interpreting choropleth maps

To construct a choropleth map, follow the steps below:

1. Examine the data and decide on the categories you will use. Make sure they are logically spaced; for example, 1–10, 11–20 and 21–30.
2. Ensure you have at least three categories of data.
3. Select a different shade of the one colour for each of your categories.
4. Colour in your map.
5. Include a legend that shows the value range for each colour used.

When interpreting choropleth maps it is important to remember that considerable differences can exist within a single area, even though the area may have only one colour or type of shading. World maps, for example, usually present data for particular countries. In these maps a whole country is shaded in one colour. This means that national borders often become the boundaries between different ranges of values. This can result in generalisations as it neglects to show localised variations in the feature being mapped.

ACTIVITIES

1. Explain, in your own words, what a map is and the purpose of maps.
2. List the 'essentials' of a map.
3. Using an atlas, find examples of the types of maps described on pages 2–3.
4. Outline the role of a cartographer.
5. Distinguish between physical and political maps.
6. Explain the principal purpose of topographic maps.
7. Using this textbook, identify three thematic maps and three choropleth maps. Write down the figure number, caption and page reference of each map you identify.
8. *Political borders.* Some political (or geometric) boundaries follow straight lines while others follow natural features, such as rivers and mountain ranges. Find examples of each type of boundary on a map of the world. Which type of boundary is more common?
9. *Maps and literature.* Every story has a physical setting or location. Think of a book you have read recently. Identify the book's setting. Use an atlas to locate the places or features mentioned in the book. The places might include countries, states, cities, rivers, mountainous areas, lakes or oceans. If the book includes a journey, trace the route of the trip on the map in the atlas.
10. Use the legend for the topographic maps in Units 3.2 and 3.5 (pages 82 and 94) to complete the following task. Draw the symbol used to show each of the following features:
    a. railway station
    b. embankment
    c. mine
    d. bridge
    e. cliff
    f. small dam
    g. exposed wreck
    h. swamp
    i. lighthouse.
11. Design your own symbol for each of the following features of the built environment:
    a. fast-food outlet
    b. shopping mall
    c. skateboard park
    d. playground
    e. movie theatre
    f. bicycle track
    g. surf club
    h. indoor sports complex
    i. school.
12. Draw a map of your school. Construct a legend using appropriate symbols and colours to locate the prominent features of the biophysical and constructed environments.

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1.2 Scale

Figure 1.2a 'I've been scaled!'

To draw a map of any part of the Earth's surface, the area must be reduced in size, or scaled down, so that it can fit on a sheet of paper. There is, therefore, a direct relationship between the size of features on a map and their actual size on the ground. In other words, maps are actually a scaled-down representation of part of the Earth's surface. To determine how large the real area is, it is always necessary for the map to indicate the scale at which it has been drawn.

Scale is expressed as the ratio of distances on the map to distances on the ground.

Scale can be expressed in three ways:

1. as a statement (in words); for example, '1 cm represents 100 000 cm' or '1 cm represents 1 km'
2. as a ratio or representative fraction; for example, 1:100 000 or $\frac{1}{100000}$
3. as a linear scale (see Figure 1.2b).

Maps drawn at progressively smaller scales increase the area of the Earth that can be shown, but reduce the amount of detail that can be included. Maps drawn at progressively larger scales decrease the area that can be shown, but allow more detail to be shown. This means, for example, that a map drawn to a scale of 1:20 000 covers a smaller area of the Earth's surface but shows much more detail than a map drawn to a scale of 1:100 000. (See the box 'Large-scale maps vs small-scale maps'.)

The most common scales used for topographic maps are:

- 1:25 000, which is the same as 4 cm = 1 km, 1 cm = 0.25 km or 1 cm = 250 m
- 1:50 000, which is the same as 2 cm = 1 km, 1 cm = 0.5 km or 1 cm = 500 m
- 1:100 000, which is the same as 1 cm = 1 km or 1 cm = 1000 m
- 1:250 000, which is the same as 0.4 cm (4 mm) = 1 km, 1 cm = 2.5 km or 1 cm = 2500 m.

The scale of a map shows the relationship between distances on the map and distances on the ground. This means the scale can be used to calculate distances and areas.

Figure 1.2c shows two maps of the Camden Haven area. At a scale of 1:100 000 (top map) we can see all of the Camden Haven township. At a scale of 1:25 000 (bottom map) only part of the township can be seen.

Figure 1.2b Linear scale

Calculating distances

The distance between two points on a map can be found by measuring the distance on the map and then converting it from centimetres to kilometres and/or metres. Most students do this by using the map's linear scale, which will work for both print and digital documents.

There are several ways to measure the distance between two points on a map. Some students use a length of string, while others use a pair of dividers. The following methods are more likely to be accurate because they make it easier to work around curves and sharp corners.

Measuring a straight-line distance

To estimate a straight-line distance, place the edge of a sheet of paper between the two points and mark on the paper the distance between the points. Place the paper along the map's linear scale. Read off the distance on the scale. (See Figure 1.2d.)

Measuring a distance along a curved line

To estimate a distance along a curved line, place a sheet of paper on the map and mark off the starting point. Carefully move the paper so that its edge follows the curve, marking each section with a pencil as you go. Mark the end point and then place your sheet of paper on the linear scale. Read off the distance on the scale. (See Figure 1.2e.)

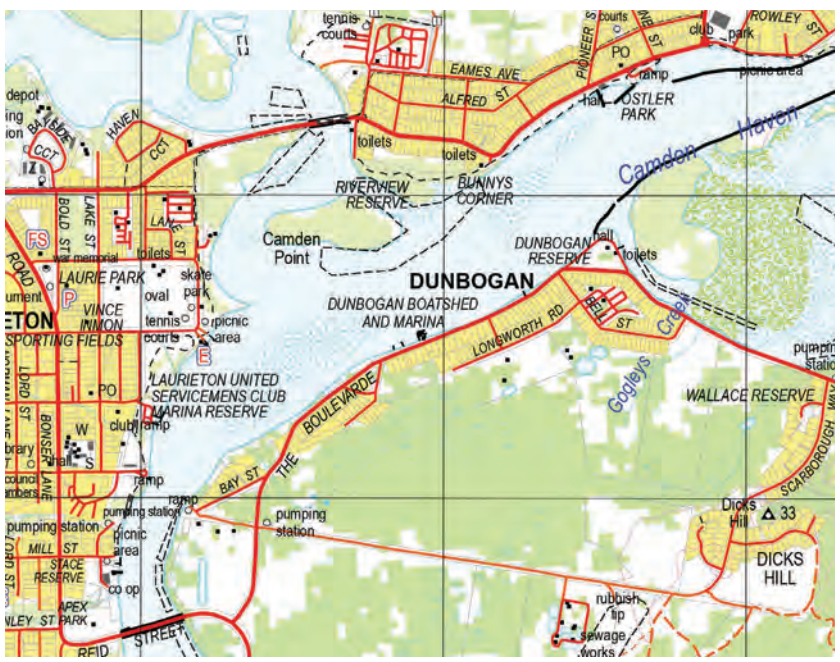

Figure 1.2c Different scales can show different levels of detail. The top map is drawn at a scale of 1:100 000 and the bottom map at 1:25 000.

Large-scale maps vs small-scale maps

A map that shows only a small area of the Earth's surface is referred to as a large-scale map. This is because the area of land being represented by the map has been scaled down less; in other words, the scale is larger. A large-scale map only shows a small area, but it shows it in great detail.

A map featuring a large area, such as an entire country, is considered to be a small-scale map. In order to show the entire country, the map must be scaled down until it is much smaller. A small-scale map shows more territory, but it is less detailed.

To fit a map of the world onto an A4 sheet of paper (measuring 297 mm × 210 mm) you would need to use a scale of approximately 1:135 000 000 (a smaller scale). To fit a map of Australia onto an A4 sheet of paper you would need to use a scale of approximately 1:20 000 000. At a scale of 1:25 000 (a larger scale) it would take 50 000 A4 sheets to map Australia.

Maps in digital documents

If you are using a print map, you can use a ruler to measure distance, and then do a mathematical calculation, using the scale statement or ratio, to calculate the real-world size.

However, if you are looking at a map in a digital document (for example, if you are using the PDF version of this textbook) you will be able to zoom or shrink the map display so that the statement or ratio no longer applies. The amount of area covered in measurements of 1 cm will vary depending on how much you have zoomed in on the display.

Therefore, if you are using a digital document, you should only use the linear scale when working out distances on the map. The linear scale on the map will shrink and grow in the same proportion as the map when you zoom in or out of the page.

Most maps will include a linear scale in addition to, or in place of, a statement or ratio.

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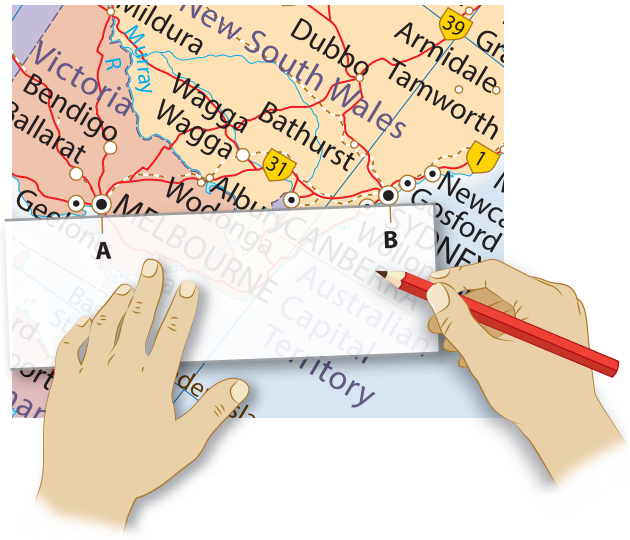

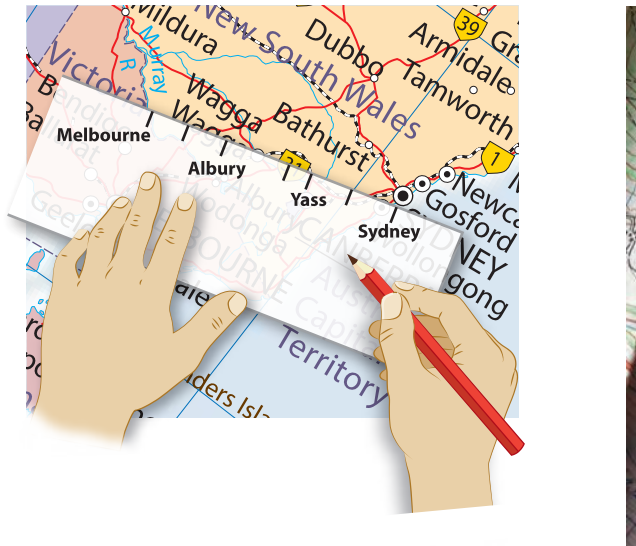

Figure 1.2e Measuring a distance along a curved line on a map

Figure 1.2f Don't get lost!

Figure 1.2d Measuring a straight-line distance on a map

Estimating area

The area of the Earth's surface covered by a map feature can be estimated using the scale of the map. It is possible to find the area of some features by multiplying the length of the feature by its breadth.

If a feature has an irregular shape, its area can be estimated by counting the number of grid squares that the feature covers. To do this, count the number of squares more than half covered by the feature and ignore those squares less than half covered by the feature. Your answer should normally be stated as square kilometres (km^2). (See Figure 1.2g.)

Example

The area of the lake in Figure 1.2g is approximately 42 km^2.

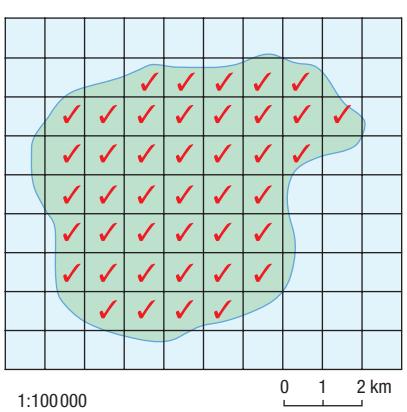

Figure 1.2g Estimating area

Calculating density

The term 'density' refers to the number of people or objects per unit area, usually 1 km^2.

We can work out the density of features on a map by counting how many features are located within the specific area. (See Figure 1.2h.) Answers should be expressed in terms of the number of features per square kilometre.

Example

The density of buildings in the central grid square is 7/km^2. (This central grid square should be referred to as AR 2736 – see Unit 1.3, pages 6-7.)

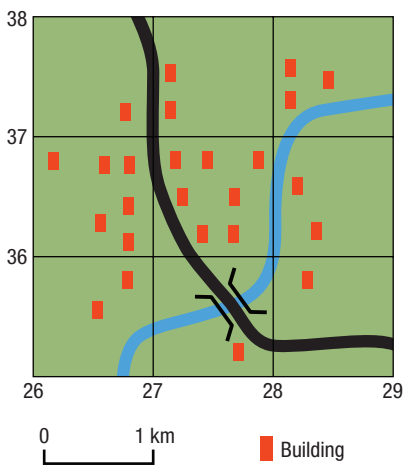

Figure 1.2h Calculating density

Advanced skill: calculating time–distance relationships

When working with topographic maps you may be required to calculate how long it would take to travel a specific distance at a certain speed.

Example

How long would it take to travel 30 km at 80 km/h?

1 Calculate the time by dividing the distance by the speed. (Note: units should be consistent with each other, e.g. distance in km and speed in km/h.)

time (h) = distance (km) ÷ speed (km/h)
= 30 ÷ 80
= 0.375 h

2 It may be helpful to convert this time from hours to minutes, by multiplying by 60.

time (min) = time (h) × 60 (min/hr)
= 0.375 × 60
= 22.5 min

ACTIVITIES

1 Why is scale used when drawing maps?

2 List the three ways in which scale can be expressed.

3 Copy the following table and complete it by adding the correct type of scale.

Statement	Representative fraction or ratio	Linear
a One cm represents 250 m		
b	$\frac{1}{50000}$ or 1:50 000	
c		0 1 2 km

4 Using the linear scale in Figure 1.2b determine the length of each of the following lines.

a _____
b _____
c _____
d _____

e

5 What is meant by the term 'area'?

6 What is meant by the term 'density'?

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1.3 Locating places

Figure 1.3a You are here.

Location

'Where is it?' is one of the most important questions asked by geographers. Every feature and place on the Earth's surface has a specific location. This location can be expressed in a number of ways. It can, for example, be expressed in terms of its distance and direction from other features or places. We call this relative location. It can also be expressed in terms of its absolute location. This is the location of a point on the Earth's surface that can be expressed using a grid reference, such as latitude and longitude. The absolute location of a feature or place can be determined by using an alpha-numeric grid; grid and area references; or latitude and longitude.

Alpha-numeric grids

Maps using alpha-numeric grids are divided by grid lines into a series of small squares. Along the top and bottom of the map, the squares are labelled with letters of the alphabet. Along the left- and right-hand sides of the map, the squares are labelled with numbers. (See Figure 1.3b.) Using the grid is easy. For example, on the map shown in Figure 1.3b, Queen Victoria Memorial is located where 'G' and '5' intersect.

If you wanted to find a specific suburban street using a street directory you could go to the directory's index. This would give you a page reference and the alpha-numeric grid reference of the street. You then turn to the relevant page and use the alpha-numeric labels on the edges of the grid to locate the street. Practise using alpha-numeric grids by completing Activity 4 on page 7.

Grid and area references

The location of features on topographic maps can be found by using grid and area references. Topographic maps have grid lines, which are a series of equally spaced, numbered vertical and horizontal lines. The horizontal lines are called *northings* and the vertical lines are called *eastings*. (See Figure 1.3d.) Northings are numbered from the south to north (from bottom to top). Eastings are numbered from west to east (from left to right).

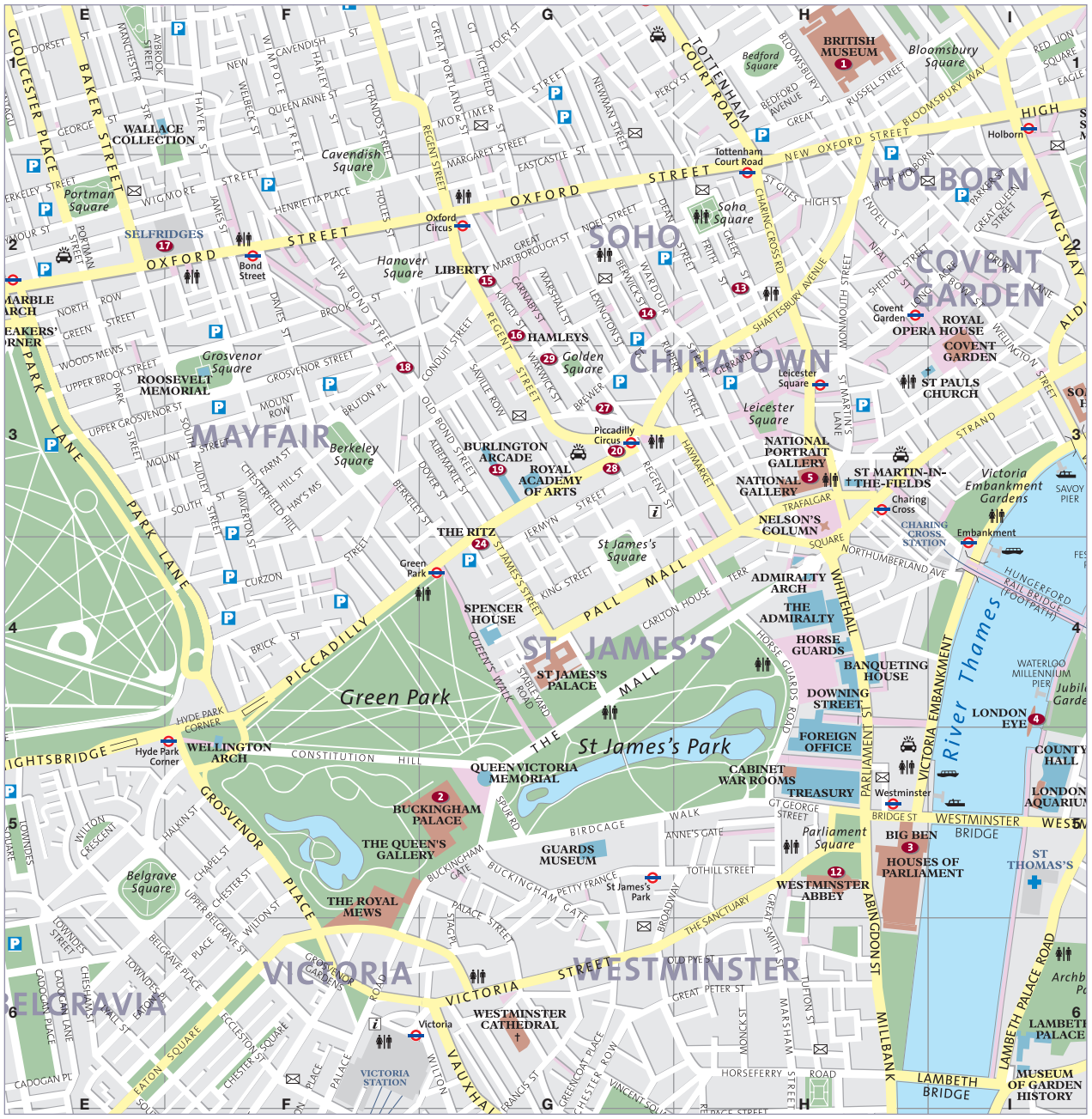
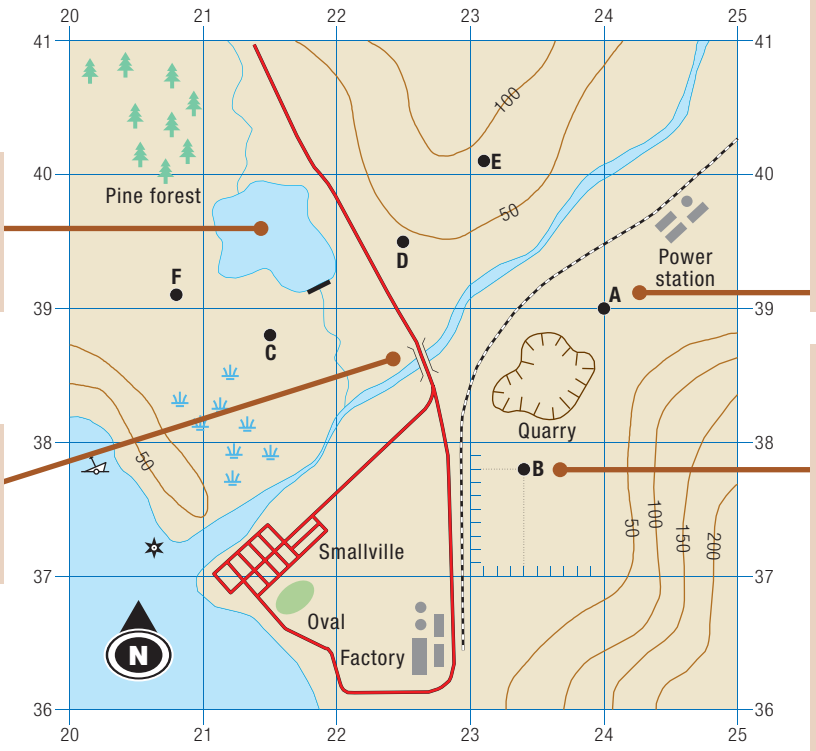


Figure 1.3b Extract from a London street directory



Example 1
Find the grid reference (GR) for point A. Point A is located exactly on the intersection of easting 24 and northing 39. The easting is, therefore, 240 (24 and no tenths towards 25). The northing is 390 (39 and no tenths towards 40). The GR of point A is expressed as 240390.

Example 2
Find the grid reference (GR) of point B. Point B is located four-tenths of the way between eastings 23 and 24. The easting is, therefore, 234 (23 and 4 tenths towards 24). The northing is approximately eight-tenths of the way between northings 37 and 38; therefore, it is 378. The GR of point B is expressed as 234378.

Example 3
Find the area reference (AR) of the dam. The AR of the dam is 2139.

Example 4
Find the area reference (AR) of the road bridge. The AR of the road bridge is 2238.

Figure 1.3c Grid reference and area reference example

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Grid references

To locate quite small features (such as a building or bridge) on a topographic map a six-figure grid reference is used. The first three single numbers (or digits) refer to the eastings and the last three refer to the northings that surround the map. (See Figure 1.3c.) The third digit required for each coordinate is obtained by dividing each easting and northing into tenths.

Area references

Some map features (for example, a lake or small town) can cover quite a large area within a grid square. We usually locate such features using an area reference (AR). An AR has only four digits.

To find the AR of a feature we first identify the easting line just to the left of it and then the northing below it. This means that we refer to the eastings and northings of the lower left-hand corner of the grid square in which the feature appears. (See Figure 1.3c.)

Where a feature extends beyond one grid square, the AR should be based on the lower left-hand corner of the square that contains the main part of the feature. Practise this skill in Activity 6c.

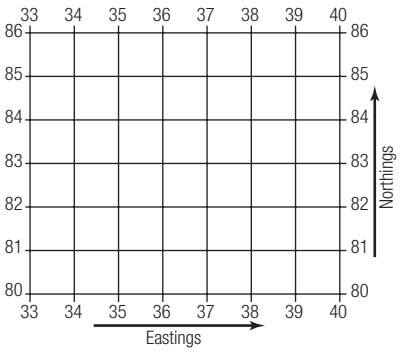


Figure 1.3d Grid lines

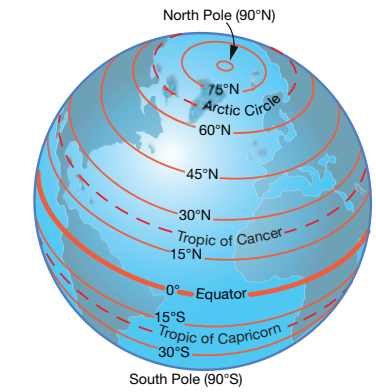


Figure 1.3e Parallels of latitude

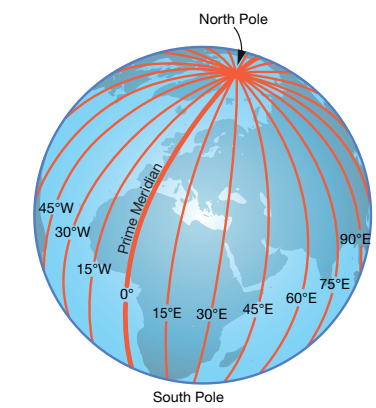


Figure 1.3f Meridians of longitude

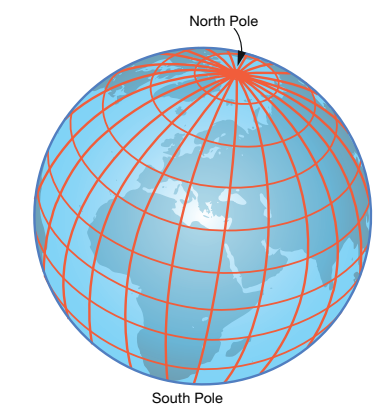


Figure 1.3g The grid pattern produced by lines of latitude and longitude

Latitude and longitude

Most maps include lines of latitude and longitude. These allow us to quickly and accurately locate places and features on the Earth's surface.

Latitude

Lines of latitude (see Figure 1.3e) are imaginary lines that run in an east–west direction around the Earth. Because they are parallel to each other they are often referred to as *parallels of latitude*.

The most important line of latitude is the *Equator* (0°). The Equator divides the Earth into two halves: the *Northern Hemisphere* and the *Southern Hemisphere*. All other lines of latitude are either north or south of the Equator and are given a number between 0° and 90°. The North Pole is 90° north and the South Pole 90° south.

Some of the other important lines of latitude are the Tropic of Cancer (23 1/2°N), the Tropic of Capricorn (23 1/2°S), the Arctic Circle (66 1/2°N) and the Antarctic Circle (66 1/2°S).

Longitude

Lines of longitude (see Figure 1.3f) run in a north–south direction. They are not parallel to one another, but pass through both the North and South Poles. Any number of these lines can be drawn, but they all converge and meet at the poles. These imaginary lines are called *meridians of longitude*.

The most important line of longitude is the *Prime Meridian* (0°), which passes through the Greenwich Observatory just outside London, England. All other lines of longitude are located either east or west of the Prime Meridian.

Another important line of longitude is the *International Date Line*, which is on the opposite side of the world to the Prime Meridian, at 180°. Together, the Prime Meridian and International Date Line divide the Earth into two halves. The half to the west of the Prime Meridian is the *Western Hemisphere*. The half to the east is the *Eastern Hemisphere*.

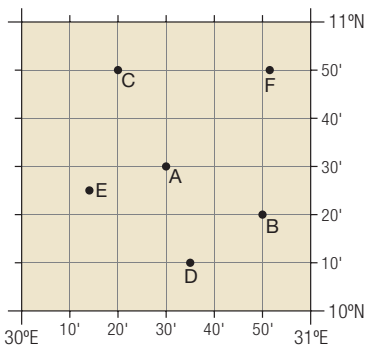


Figure 1.3h A latitude and longitude grid showing minutes

Finding places using latitude and longitude

Put together, lines of latitude and longitude form a grid that allows us to pinpoint places and features on the Earth's surface. (See Figure 1.3g.) To be even more accurate, each degree of latitude and longitude can be divided into smaller units, called minutes. There are 60 minutes in each degree. (See Figure 1.3h.)

When using latitude and longitude to describe the location of a particular place, we always give the latitude first and then the longitude.

If you are given the latitude and longitude of a place and asked to find it, follow these three steps:

1. Using a world map, find a general location of the latitude and longitude you have been given.
2. Turn to a map of the region or continent and locate the latitude and longitude more accurately.
3. You can check your answer by locating the place name in the index of an atlas. Most atlases include the latitude and longitude of each place. (See Figure 1.3i.)

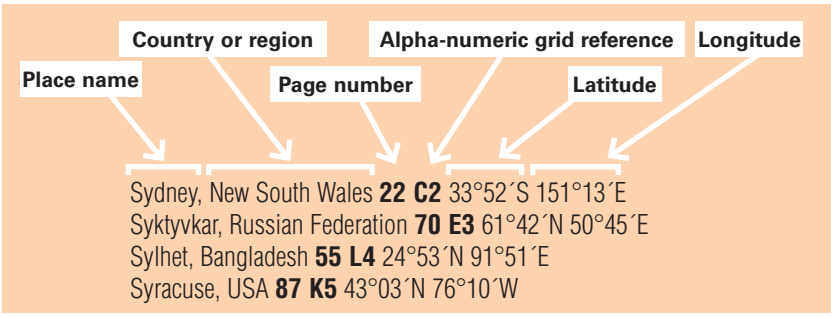
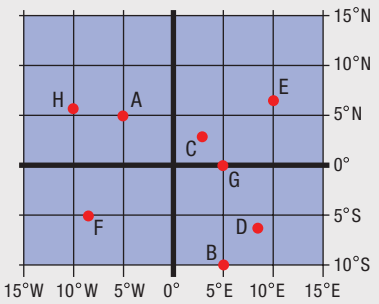


Figure 1.3i Extract from the index of an atlas

ACTIVITIES

1. Explain the difference between relative location and absolute location.
2. State the name given to the grid typically used on maps in street directories.
3. Distinguish between northings and eastings on topographic maps.
4. Study Figure 1.3b and then complete the following tasks:
   - **a** Identify the features located at each of the following alpha-numeric grid references:
     - **i** G4 **ii** H1.
   - **b** State the alpha-numeric grid of each of the following features:
     - **i** Buckingham Palace
     - **ii** Admiralty Arch
     - **iii** Westminster Abbey
     - **iv** Horse Guards
     - **v** Houses of Parliament
     - **vi** Westminster Cathedral.
5. Identify the circumstances in which area references are used instead of grid references.
6. Study Figure 1.3c and then complete the following tasks:
   - **a** State the grid reference of points C to F.
   - **b** State the grid reference of each of the following features:
     - **i** dam wall
     - **ii** roadbridge
     - **iii** oval
     - **iv** shipwreck.
   - **c** State the area reference of each of the following features:
     - **i** pine forest
     - **ii** quarry
     - **iii** factory
     - **iv** power station.
7. Define the terms 'parallel of latitude' and 'meridian of longitude'.
8. Explain the difference between parallels of latitude and meridians of longitude.
9. Describe the location and significance of the Prime Meridian and the International Date Line.
10. Study Figure 1.3h. State the latitude and longitude, in degrees and minutes, of points A–F.
11. State the latitude and longitude of points A–H.



12. With the aid of an atlas, copy and complete Table 1.3a.

Table 1.3a Latitude and longitude of selected landform features

Place/feature	Latitude and longitude
a	17°55´S 25°51´E
b Mt Kilimanjaro, Africa	
c Mt Everest, Asia	
d	5°58´N 62°32´W
e Grand Canyon, North America	
f Uluru (Ayers Rock), Australia	
g	13°08´S 72°30´W
h Denali (Mt McKinley), North America	
i Niagara Falls, North America	
j	78°32´S 85°37´ W

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1.4 Direction, bearings and quadrants

Direction

Direction is important because, together with distance, it shows where one place is in relation to other places; that is, their *relative location*. Direction is usually given in terms of the points on a compass, but it may also be given as a bearing.

North, south, east and west are known as the *cardinal points* of the compass. The points that give us a more specific indication of direction are called the *intermediate points*. Geographers use these points to describe the direction of one place or feature in relation to another. Figure 1.4a shows the 16 points of the compass.

Maps usually have an arrow indicating where north is. Most maps are designed so that north is at the top of the map, and so that one set of grid lines runs north–south. Just to make sure, check the direction arrow, which is usually located near the legend.

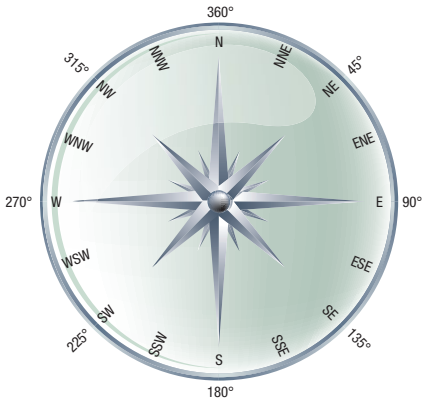

Figure 1.4a The 16 points of the compass

Figure 1.4b A compass helps us navigate with a map.

Magnetic compass

A *magnetic compass* (see Figure 1.4c) can be used in association with a map in a number of ways. If we are observing a landscape during fieldwork, for example, we can lay out the map and then turn it around until the magnetic north arrow on the map is the same as the north point shown on the compass. This is called *orientating* the map. It makes it easy to identify different features, which should be in the same direction as they appear on the map.

Finding direction using a magnetic compass

A magnetic compass is an instrument used to find direction. It has a magnetised needle that will always point to the Earth's magnetic north pole.

To locate north, position the magnetic compass so that the needle points towards the 'N' marked on the face of the compass. You are now facing towards the north. South is behind you, west is to your left and east is towards your right.

Figure 1.4c A magnetic compass

Finding direction without a compass

During daylight you can use your watch to find north. Point the '12' of the watch towards the sun. Halfway between the '12' and the hour hand will be north. (See Figure 1.4d.)

At night the Southern Cross constellation can be used to find direction. Locate the five stars of the Southern Cross and the two bright 'pointers' (Alpha and Beta Centauri). Project a line through the axis of the Southern Cross, and another at right angles to a line joining the two pointers. Where these two lines intersect, extend a line directly to the horizon. You have located south. (See Figure 1.4e.)

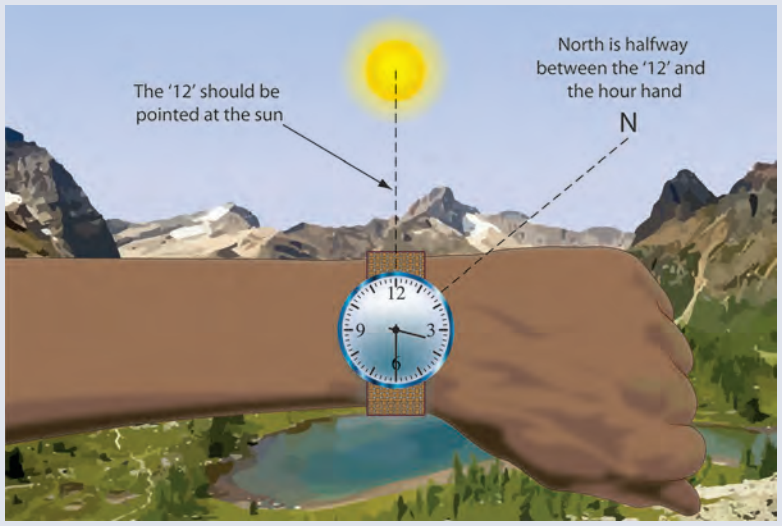

Figure 1.4d Finding north with the aid of a watch

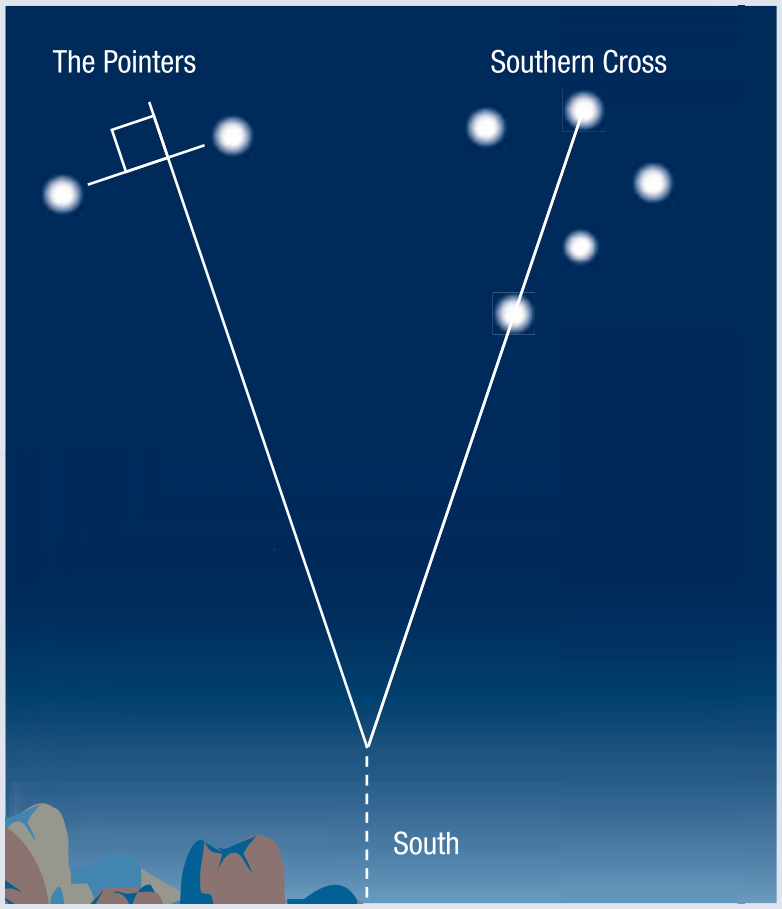

Figure 1.4e Finding direction at night

ACTIVITIES

1. Define the geographical term 'direction'.
2. Identify the cardinal points of a compass.
3. With the aid of a pair of compasses, draw your own 16-point compass.
4. State what a magnetic compass is used for.
5. Explain how you can find north without the aid of a compass in both the day and night.

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Locating north on topographic maps

Topographic maps usually include a reference to several north points:

- True north (TN) – the direction of the Earth's geographic North Pole. Meridians of longitude converge on the geographic North Pole.
- Grid north (GN) – the direction of vertical grid lines on a topographic map. Grid north is used when measuring bearings.
- Magnetic north (MN) – the direction in which the magnetic needle points; that is, towards the magnetic north pole. The MN pole varies slightly from the North Pole; the amount of variation changes from year to year.

When using a map and compass in the field, use the MN arrow. If you are referring to directions from a map, use TN. Topographic maps are generally designed so that north is at the top of the map. (See Figure 1.4f.)

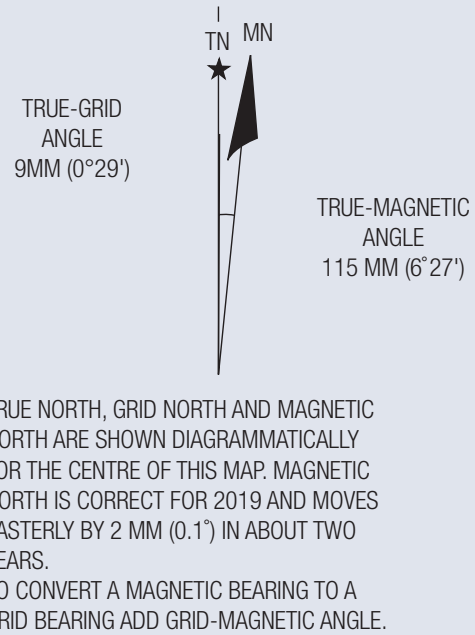

Figure 1.4f Direction indicator from an Australian topographic map sheet

Using direction to describe general location

Direction is often used to identify regions of a country, state or urban area. Figure 1.4g shows how compass points can be used to identify regions of Australia.

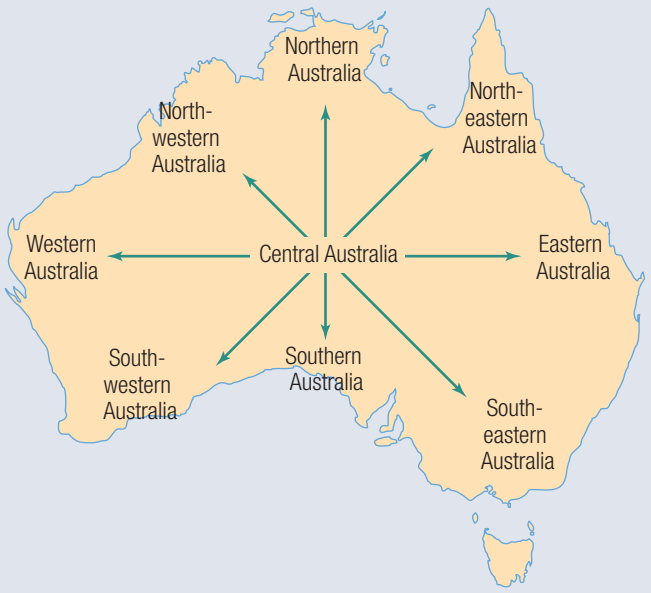

Figure 1.4g The compass points can be used to describe and locate regions of Australia.

ACTIVITIES

6 State why geographers use bearings. Explain how bearings are calculated.

7 Explain what is meant by the term 'quadrant'.

Bearings

Geographers often use bearings to give an accurate indication of the direction of one point from another. A bearing is an angle, measured clockwise, that a line makes with a fixed zero line. Unless stated otherwise, the zero line is always taken to be north.

Bearings are calculated by measuring the angle from north in a clockwise direction. It is important to remember that any bearing to the east of the north–south line falls between 0° and 180°. Bearings of any direction to the west of the north–south line fall between 180° and 360°. (See Figure 1.4h.) In Example 1 the bearing of B from A is 145°, and in Example 2 the bearing of B from A is 205°.

To accurately measure a bearing on a map a protractor must be used. To measure the bearing of point Y from point X in Figure 1.4i follow the steps given below:

Step 1 Using a ruler and sharp pencil join points X and Y. If the distance between the two points is small, extend the line through point Y so that it can be seen.

Step 2 Place a clear plastic protractor on the map. Position the protractor so that the centre point is directly over point X, and 0° is pointing to GN; that is, parallel to the eastings.

Step 3 Read the bearing off the graduated edge of the protractor where it meets the pencil line.

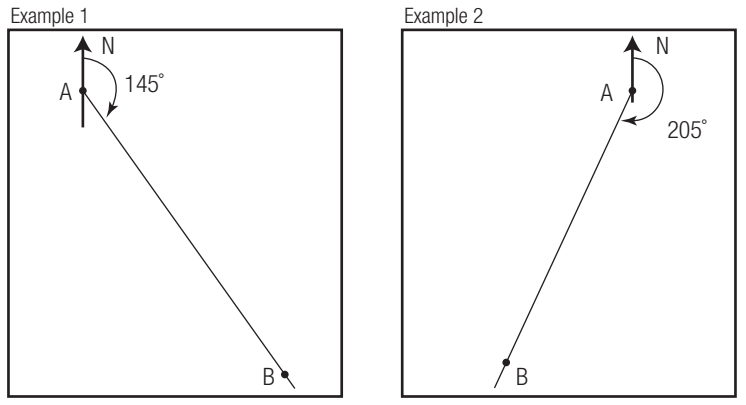

Figure 1.4h Finding bearings

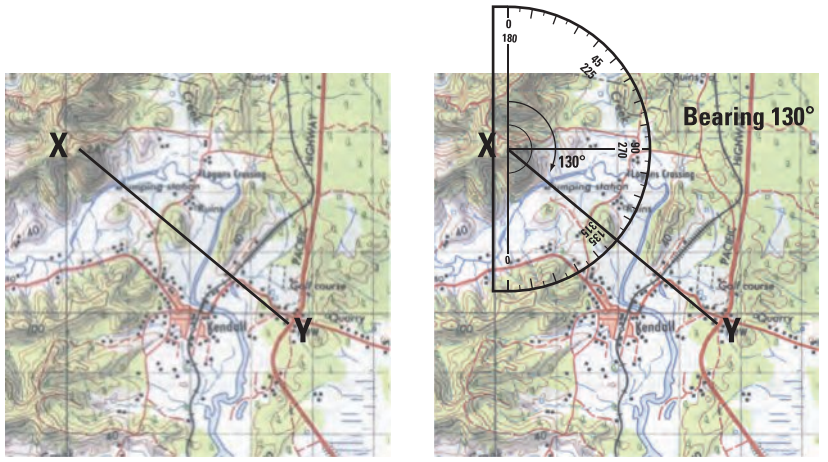

Figure 1.4i Using a protractor to determine the bearing of point Y from point X

Quadrants

To help us find the location of features on topographic maps their relative position is sometimes expressed in terms of *quadrants*. (See Figure 1.4j.) These divide the map into quarters. They get their names from the points of the compass.

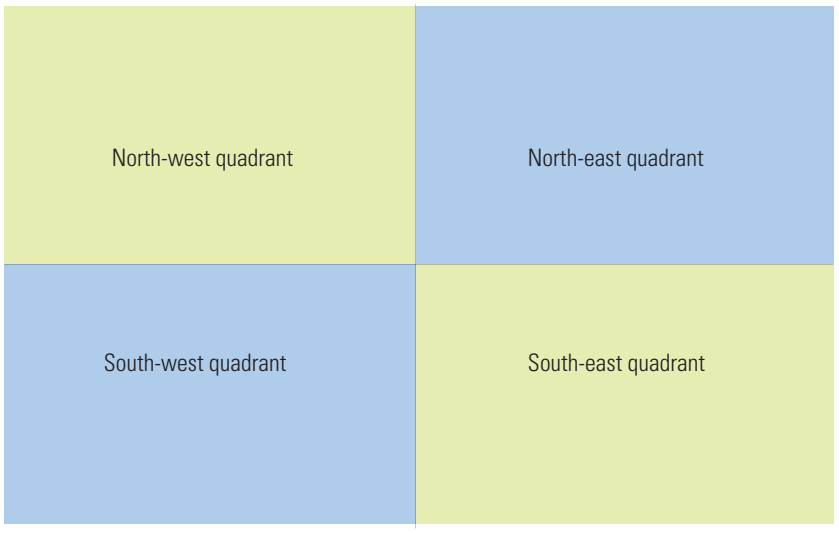

Figure 1.4j The quadrants of a map

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1.5 Relief

Relief is a term geographers use to describe the shape of the land, including its height above sea level (asl) and the steepness of its slopes.

Because maps are usually drawn on flat sheets of paper it has been necessary for cartographers (map makers) to develop ways of showing what the shape of the landscape is like. These techniques include the use of spot heights, shading, colour layering and contour lines.

Figure 1.5a Contoured!

Spot heights

A *spot height* is usually shown on a map as a black dot with the height written next to it. It gives the exact elevation (or height) above sea level of a particular location or feature. Major spot heights are sometimes shown as trigonometric (trig) stations. These are usually found on the top of significant (prominent) landform features and are normally marked with a structure of some kind; for example, a block of concrete and a black disc on a metal pole.

While spot heights are useful in determining the elevation of a landform feature, they do not tell us much about the shape of the land. Contour lines and shading are much more effective at conveying this.

Shading

Map *shading* is a very effective method of highlighting landform features. The shading makes the landform features 'stand out' from the map, creating a three-dimensional effect. (See Figure 1.5b.)

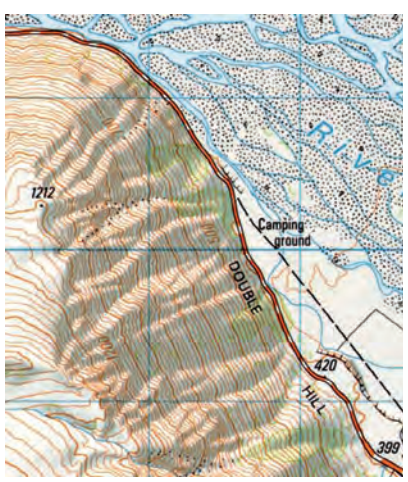

Figure 1.5b Shading on Lake Coleridge topographic map extract. Shading creates a three-dimensional visual effect.

Colour layering

Some cartographers use colour layering to distinguish between different elevations. The legends of these maps include a graded colour scale that enables the user to interpret the map. (See Figure 1.5c.)

Figure 1.5c Colour layering on Dungarvan topographic map extract © Crown Copyright 2013 Ordnance Survey licence number 100043500

Contour lines

The most effective way to show relief on a map involves the use of *contour lines*. Contour lines join places of equal height above sea level. Below sea level the lines are referred to as marine contours (or *bathytherms*). Being able to interpret contour lines provides geographers with information about the:

- *shape* of the land
- *slope* of the land
- *height* of features above sea level.

Each contour line represents a specific height above sea level. Therefore, every point along a contour line has the same value. The spacing of the contour lines on a map indicates the steepness of slopes. Areas where contour lines are close together have steep slopes, and areas where there are only a few widely spaced contour lines are very flat. (See Figure 1.5d.)

The spacing of the contour lines also gives us an idea of the slope's shape. Evenly spaced contours indicate a uniform slope. When the spacing between contour lines (reading from high to low) decreases, the slope is *convex*. When the spacing between contour lines (reading from high to low) increases, the slope is *concave*. (See Figure 1.5e.)

A skilled user of topographic maps can visualise the shape of particular features by studying the patterns created by the contour lines. Some examples of common landform features and their associated contour patterns are shown in Figure 1.5g.

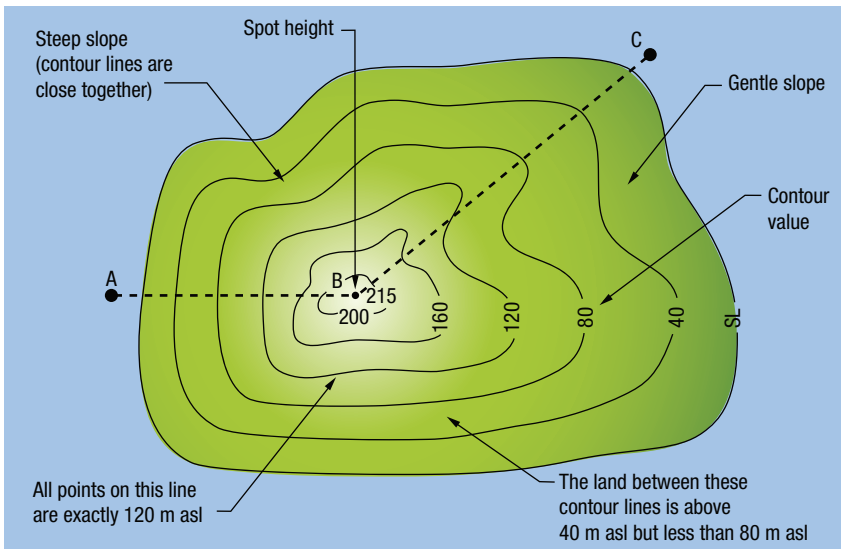

Figure 1.5d Features of a contour line. The cross-sections A–B and B–C show the shape and steepness of selected slopes.

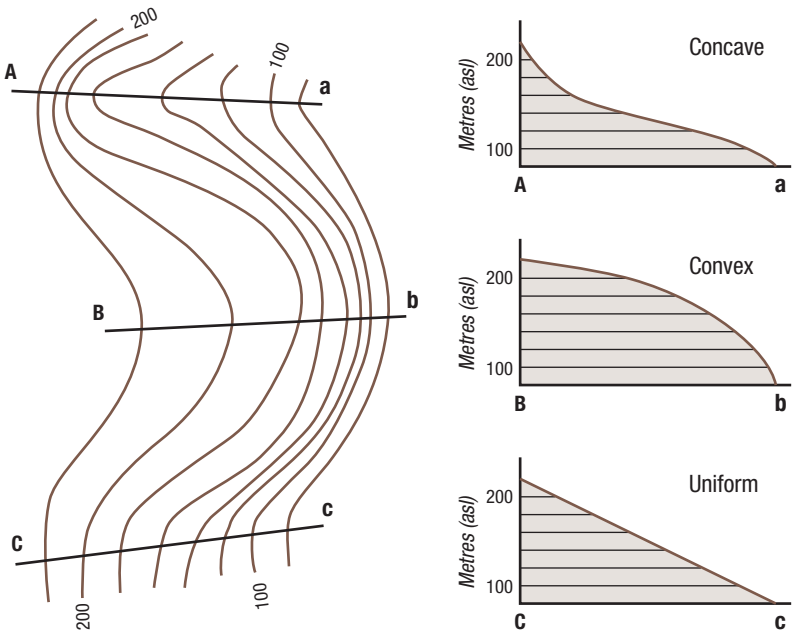

Figure 1.5e Contour patterns and the shape of slopes

The *contour interval* (CI) is the difference in height between two adjacent contour lines. This interval is always constant on any particular map.

Aspect

Aspect refers to the direction in which a slope faces. The aspect of a particular slope can be determined by examining the height and pattern of the contour lines. The slope shown in Figure 1.5f has a north-westerly aspect.

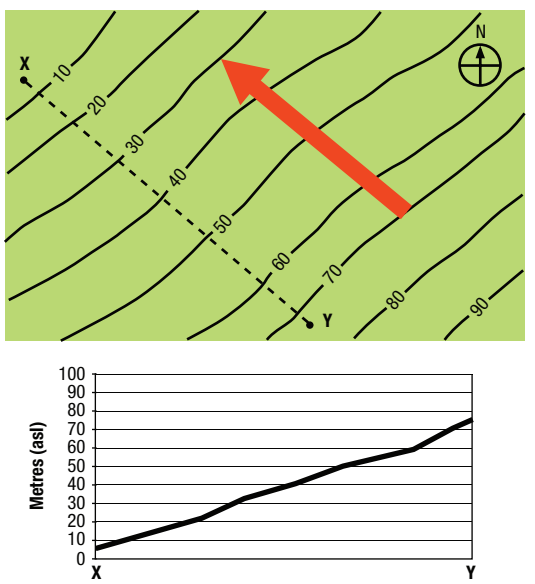

Figure 1.5f Determining aspect

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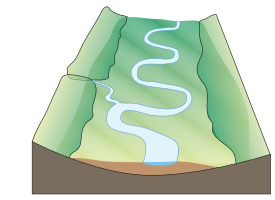
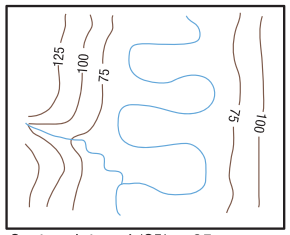
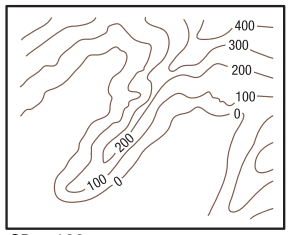


Floodplain

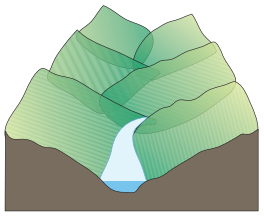


Contour interval (CI) = 25 m

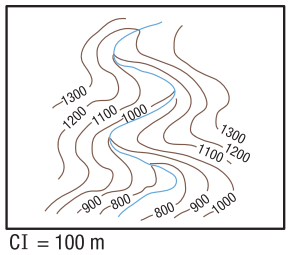
Drowned coastline



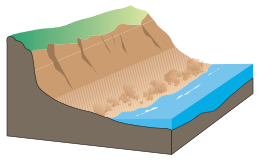
CI = 100 m



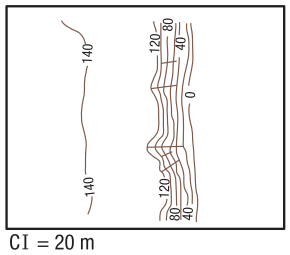
Interlocking spurs



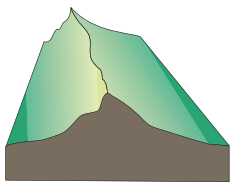
CI = 100 m



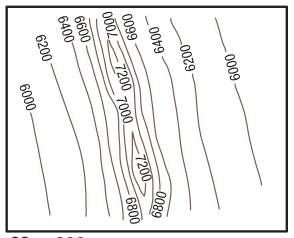
Cliffed beach



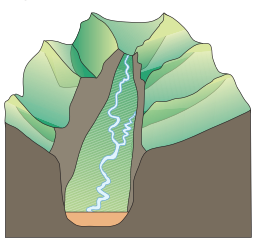
CI = 20 m



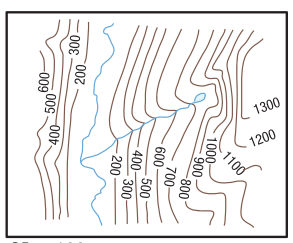
Ridge



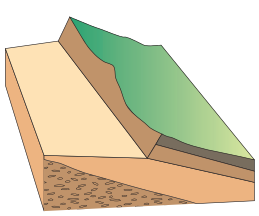
CI = 200 m



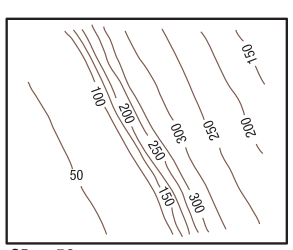
Truncated spurs



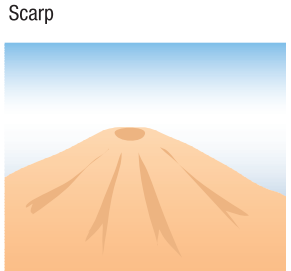
CI = 100 m



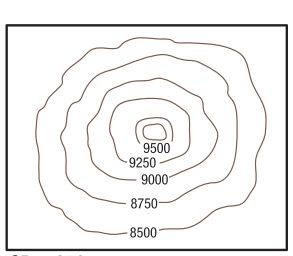
Scarp



CI = 50 m



Conical mountain



CI = 250 m

Figure 1.5g Common landform features and their contour patterns

When a cross-section is drawn from a topographic map, the relief (or shape) of the land is often exaggerated so that relatively small variations in the landscape are clearly visible. To accurately interpret a cross-sectional profile we need to determine how much exaggeration has occurred. To do this we measure the number of times the vertical scale of the cross-section has been exaggerated (or 'stretched') compared with the actual shape. We call this calculation *vertical exaggeration*.

Using contour lines: estimating height above sea level

In the absence of a spot height, it is possible to estimate the height above sea level of a feature by studying the contour lines on a topographic map.

Example 1

Estimate the height of the hill at point A in Figure 1.5h. Point A lies above 200 m but it is obviously less than 250 m. Your answer should be expressed as a statement; that is, 'Point A is more than 200 m but less than 250 m above sea level' or 'Point A is >200 m but <250 m'.

Example 2

Estimate the height of point B in Figure 1.5h. Point B lies between the 50 m and 100 m contour lines. Your answer should be expressed as a statement; for example, 'Point B is >50 m <100 m'.

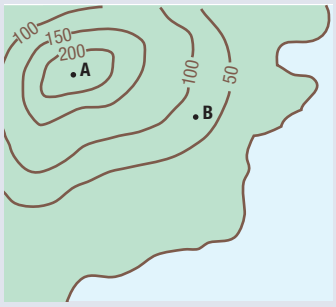


Figure 1.5h Contour sketch

Note: In some cases it may be possible to express your answer as an estimate, but check with your teacher to see whether this method is acceptable. If you can express your answer as an estimate, your answers would be:

- *Example 1.* 'Point A is approximately 225 m' (or any number between, but not including, 200 m and 250 m).
- *Example 2.* 'Point B is approximately 75 m' (or any number between, but not including, 50 m and 100 m).

Advanced skill: calculating local relief

Local relief is the variation in height over a relatively small, defined area. It is determined by calculating the difference in height between the highest and lowest points in the area.

Example

Calculate the local relief between points X and Y in Figure 1.5i.

150 m (Highest point: X)	–	50 m (Lowest point)	=	100 m (Local relief)

Note: Always ensure you include the appropriate unit of measurement with your answer.

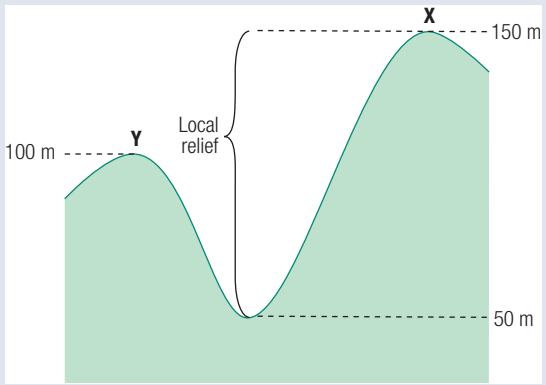


Figure 1.5i Calculating local relief

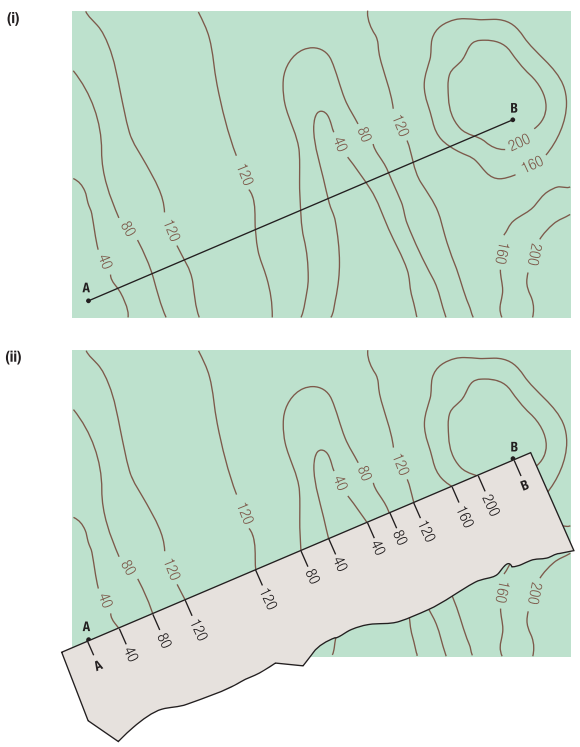


Figure 1.5j Steps in drawing a cross-section

Cross-sections

A *cross-section* is a side view (or profile) of the land. Drawing a cross-section from a topographic map is a useful way of interpreting contour lines and gaining a visual impression of the shape of the land. The following method can be used when drawing a cross-sectional profile between two points; in this case points A and B.

Steps in drawing a cross-section

Drawing a cross-section involves the following steps:

1. Place the straight edge of a sheet of paper along a line joining points A and B. Mark points A and B on your sheet of paper. (See Figure 1.5j (i).)
2. Starting from point A, mark the position where the edge of your sheet of paper cuts each contour line. Write the value of each contour on your sheet of paper. (See Figure 1.5j (ii).)
3. Draw the horizontal and vertical axes for your cross-section. The length of the horizontal axis should equal the length of the line A–B. The vertical axis, showing the height of the land above sea level, should use a scale appropriate to your needs.
4. Place your sheet of paper along the horizontal axis and then plot the contour points and heights as if you were drawing a line graph. (See Figure 1.5j (iii).)
5. Join the dots with a single smooth, curved line and then shade in the area under the line to highlight the relief.

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Advanced skill: calculating vertical exaggeration

The formula used to calculate vertical exaggeration (VE) is shown below.

$$VE = \frac{\text{Vertical scale (VS)}}{\text{Horizontal scale (HS)}}$$

The *vertical scale* is the scale used on the vertical axis of the cross-section. The *horizontal scale* is the scale of the map from which the cross-section was drawn. The most common error students make is not converting the vertical and horizontal scales to a common unit of measurement; for example, metres. Answers must be expressed as a single number. Vertical exaggeration has no units of measurement nor is it expressed as a fraction.

Example

Calculate the vertical exaggeration of the cross-section shown in Figure 1.5j, page 11.

$$VE = \frac{VS}{HS} = \frac{\text{1cm represents 80 m}}{\text{1cm represents 1 km}}$$

Convert the numerator and denominator to the same unit of measurement.

$$= \frac{\text{1cm represents 80 m}}{\text{1cm represents 1000 m}}$$

$$= \frac{\frac{1}{80}}{\frac{1}{1000}}$$

Invert the denominator, then multiply.

$$= \frac{1}{80} \times \frac{1000}{1}$$

VE = 12.5 times

Advanced skill: calculating gradient

Using the contour lines and scale on a map, it is possible to calculate the average gradient, or steepness, of a slope, road or river. The gradient is usually expressed as a fraction or ratio. It is calculated by dividing the difference in height (or vertical interval) between the two points by the horizontal distance between them. Figure 1.5k gives us an idea of how steep a slope is for selected gradients.

Calculating the gradient between two points involves two steps.

Step 1

Determine the two pieces of information required to complete the calculation.

- The first piece of information required is the difference in height between the two points. This is called the *vertical interval*, or *rise*. Find this by subtracting the lowest point from the highest point.
- The second piece of information required is the *horizontal distance* between the two points. This is sometimes referred to as the *run*. Find this by measuring the distance between the two points on the map and then using the scale to determine the actual distance.

Step 2

To calculate the gradient of a slope use the following formula.

$$\text{Gradient} = \frac{\text{Vertical interval (rise)}}{\text{Horizontal distance (run)}}$$

Note: Because the gradient of a slope is expressed as a ratio, the measurements for the rise (numerator) and run (denominator) must be in the same unit of measurement; for example, metres.

Example

Calculate the gradient of the slope between points X and Y in Figure 1.5f, page 10.

$$\text{Gradient} = \frac{\text{Vertical interval (rise)}}{\text{Horizontal distance (run)}}$$

$$= \frac{70}{4500\text{ m}}$$

$$= \frac{7\text{ (numerator)}}{450\text{ (denominator)}}$$

$$= 1 \text{ in } 64 \text{ or } 1:64$$

This means that for every 64 m travelled in a horizontal direction, you go up 1 m. If you refer to Figure 1.5k you will see that this is quite a gentle slope. The average person should be able to cycle up such a slope.

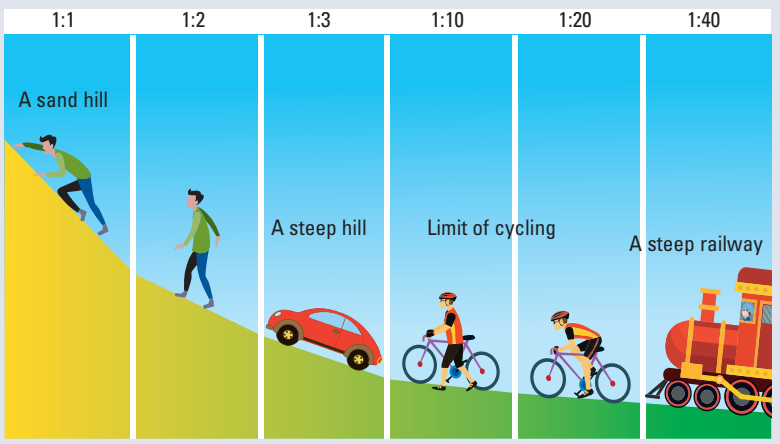

Figure 1.5k Gradients

ACTIVITIES

1 Explain what is meant by the term 'relief'.

2 Identify the technique used to show relief on maps.

3 State what contour lines represent.

4 Explain what the interpretation of contour lines tells us about relief.

5 Explain what is meant by the term 'contour interval'.

6 Explain what is meant by the term 'local relief'.

7 Explain why geographers construct cross-sections from topographic maps.

8 State what is meant by the term 'vertical exaggeration'.

9 Explain what is meant by the term 'aspect'.

10 Explain what is meant by the term 'gradient'.

Study Figure 1.5l and then complete the following tasks.

11 What is the contour interval on the Blue Lake topographic map?

12 Identify the feature of the physical environment located at:
- a GR 283681
- b GR 295635
- c GR 232698
- d GR 260670.

13 Identify the feature of the human or built environment located at:
- a GR 252679
- b GR 251668.

14 What is the physical landform feature located at AR 2363?

15 What is the land use found in AR 2970?

16 What is the vegetation type found in AR 2668?

17 What is the direction of Hope Island from the summit of Mt Smith?

18 What is the direction of Duck Island from the summit of Mt Brown?

19 In what direction is Duck Creek flowing in AR 2865?

20 What is the bearing of Mt Smith from Mt Brown?

21 What is the straight-line distance between the summits of Mt Brown and Mt Smith?

22 What is the difference in elevation between Mt Brown and Mt Smith?

23 What is the elevation of the following locations?
- a U (AR 2869)
- b V (AR 2469)
- c W (GR 270698)
- d X (GR 287669)
- e Y (GR 270640)
- f Z (GR 290650).

24 Calculate the local relief experienced on a traverse from Mt Brown to Mt Smith.

25 What is the aspect of the slope in each of the following locations?
- a AR 2670
- b AR 2766

26 Construct the cross-section between point A (AR 2868) and point B (AR 2963), using a vertical scale of 1:40 m.

27 Construct the cross-section between point C (GR 2566) and point D (AR 2763), using a vertical scale of 1:80 m.

28 Calculate the vertical exaggeration of the cross-section A–B.

29 Calculate the vertical exaggeration of the cross-section C–D.

30 Calculate the gradient of the slope C–D.

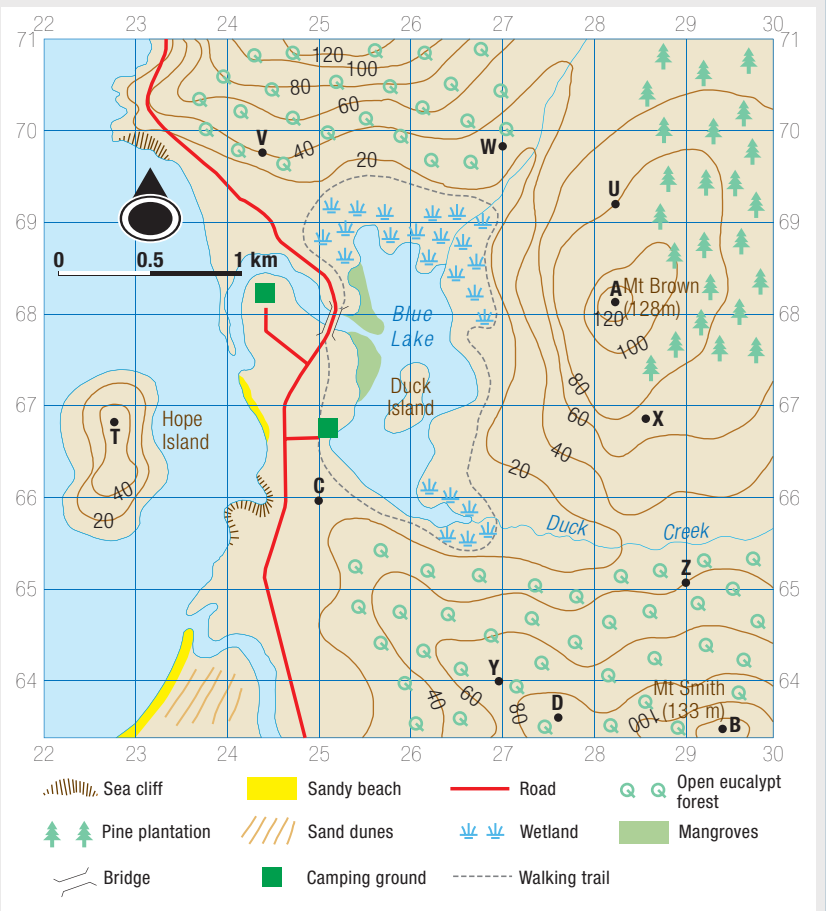

Figure 1.5l Topographic map of Blue Lake. Scale 1 cm = 40 000 cm

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1.6 Digital technologies in geography

The way geographers investigate the world around them has changed. Take maps, for example. Traditionally they were paper-based representations of part of the Earth's surface. Today, however, we are just as likely to access maps in a digital form on our laptops, smartphones or in-car satellite navigation systems. We can also use GIS-based technologies such as Google Earth to investigate places. Drones and a variety of apps can also be used to gather data, especially during fieldwork.

Geospatial technologies

Geospatial technologies are often described as the tools of the modern geographer. The term 'geospatial technologies' can, however, be applied to a range of different technologies. The one you are most likely to be familiar with is a Global Positioning System (GPS).

GPS satellites circle the Earth and allow the user on the ground, with a receiver such as a 'satnav' or smartphone, to locate their position and record locational data. In general, most in-car units and smartphones have an accuracy of plus or minus 5 m.

Another geospatial technology that geographers use is a geographic information system (GIS). A GIS is a database that can be used to present information and view relationships between different layers of data (see Figure 1.6c). If you have used Google Earth you have already used a GIS.

The third geospatial technology of interest to geographers is remote sensing. Remotely sensed data is information collected from space remotely. It includes satellite imagery and aerial photography.

The analysis of satellite imagery is an essential skill in today's world and a whole range of information about a place can be gained using satellites. This includes information about land use, vegetation, the water content of vegetation and soil, and bushfire activity in an area.

Figure 1.6b Smartphone map applications are an increasingly popular way of finding out how to get from place to place.

Google Earth

The US-based technology company Google Inc. has transformed the way people engage with spatial tools. In 2005, Google launched Google Earth. Since then it has developed other spatial technology applications including Google Maps, My Maps and Google Street View.

Google was one of the first providers to make spatial tools free and relatively easy to use. Today, most government agencies and organisations that provide spatial data for public use do so using Google Earth.

Google Earth consists of thousands of satellite images of the Earth's surface of varying resolution. It allows users to get a bird's-eye view of places. The degree of resolution may vary but it allows users to search by address, place or feature.

Google Street View provides a 360-degree panorama of streets in many countries including Australia, France, the United Kingdom, the Republic of Ireland, Italy, Japan, New Zealand, Spain, the United States, Portugal, Brazil, the Netherlands, Taiwan, Switzerland, Canada, Mexico, Sweden, Norway, South Africa and Finland.

Historical imagery can also be accessed via Google Earth. This allows users to look through past images and study the development of a place over time.

Like other GIS-based applications, Google Earth features different layers of data. You can, for example, access topographic maps of the places being studied. There are three different versions of Google Earth available: Google Earth on web, Google Earth on mobile and Google Earth Pro on desktop. Google Earth Pro offers the greatest range of tools.

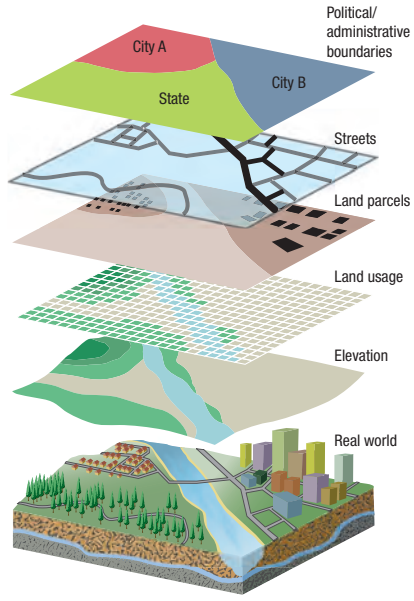

Figure 1.6c A GIS allows layers of data to be analysed in order to identify relationships.

Figure 1.6d Google Earth is a virtual globe, map and geographical information system. Google Earth, image © 2016 TerraMetrics © 2016 Google

Figure 1.6a A GPS-based, in-car navigation system

Figure 1.6e Portofino, Italy

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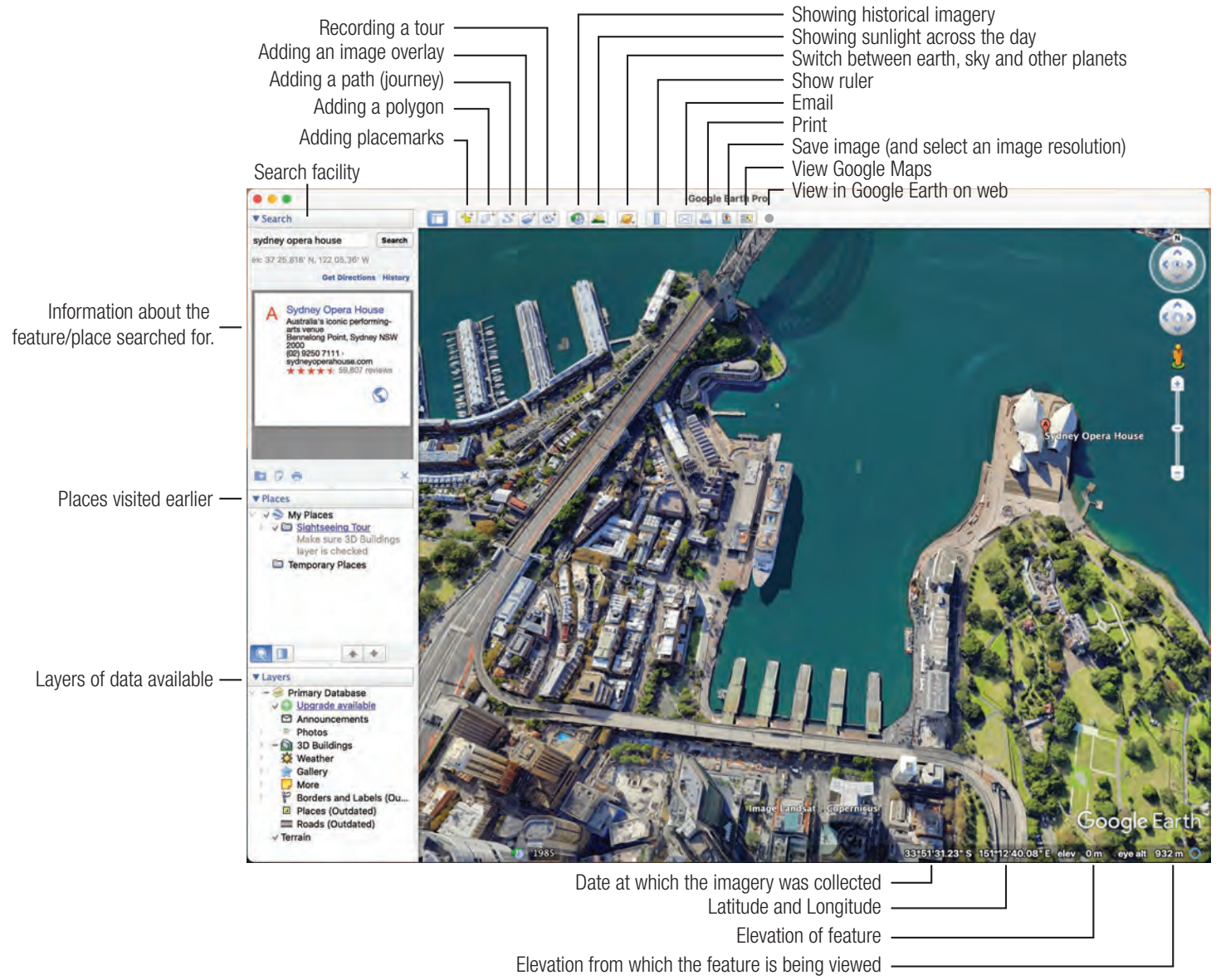

Figure 1.6f Tools on Google Earth Pro © 2021 Google

Things you can do using Google Earth

Listed below are just some of the activities you can complete using Google Earth.

- Search for the house in which you live by typing in your address into the search facility. Go to Google Street View to look at your house from a ground-level perspective.
- Explore the Earth's continents. Search for vegetation patterns and evidence of climate variation. Identify the continents' major topographical features and drainage patterns.
- Investigate places that are in the news; for example, the site of a natural disaster
- Explore the Earth's terrain in 3D
- Locate and view the world's natural and cultural wonders
- Explore the Earth's different ecosystems
- Travel down the great avenues of famous cities using Google Street View
- Overlay your images with the related Google map
- Conduct a latitude and longitude scavenger hunt. Find the coordinates of your school and important places in your local area. Alternatively, find the coordinates of some of the world's famous landmarks
- Use Google Earth's creation tools to create your projects. Add points, text and rich multimedia content.

Drones

Technological advances are providing us with new ways of viewing, measuring and representing the world around us. Unmanned aerial vehicles (UAVs), or drones with mounted sensors, are able to record a wealth of digital information.

Drones allow geographers to survey the landscape in ways not previously possible.

Examples include:

- plotting the aerial extent of a plant community or habitat
- mapping seasonal changes in vegetation
- identifying stream patterns
- mapping the extent of soil erosion and/or salinity
- assessing the extent of damage following a bushfire
- identifying sources of pollution along a stream
- exploring hard-to-reach and inaccessible places.

Landform features, such as scree slopes, landslides, coastal headlands and wave-cut platforms, can now be examined remotely with little, if any, risk.

In natural systems that change rapidly, such as sand spits, dune fields, eroding cliffs, rivers and estuaries, having several drone missions throughout a year (and even over several years) gives important information on the processes involved and the rate and nature of change. This information can be used to inform management decisions.

Drones are now more reliable and less expensive. As a result, they play an increasingly important role in fieldwork. In doing so, they fill a gap between ground-based data collection techniques and airborne systems (for example, aerial photography). The ability to quickly and easily undertake a remote sensing survey of a relatively small area of the landscape is now possible.

Conducting drone missions

There are a number of mapping apps available to help you manage drone-based data collection. *DroneDeploy*, for example, enables you to manage the entire drone mission from start to finish. It uses cloud-based storage and processing, which means that demands on your laptop are minimal. The app's designers claim that it is compatible with any drone. It is a subscription service, with the first month being free.

While take-offs and landings are fully automated via the app, in order to upload an aerial photograph you will need access to a 3G/4G mobile signal, or to have cached this image before it gets to the fieldwork site. Once the survey area is drawn on the aerial photograph and the drone height is set, the flight path and data resolution are calculated automatically.

Once airborne, the drone follows the mission's flight path, taking geo-referenced images as it goes. With a typical battery life of 20 minutes or more, it is possible to cover about 10 hectares of land.

Flying heights of between 30 and 50 metres are considered the most appropriate for data collection and to minimise the risk of hitting obstacles such as trees. While it is possible to fly at higher altitudes and cover a larger area more quickly, the resolution of images taken at greater heights is reduced.

Most drones can operate in wind speeds of up to 20 kilometres per hour. It is, however, best to avoid gusty conditions. All drones have an emergency 'return home' command, and drones can be manoeuvred and landed manually if required.

There are restrictions on where you can fly drones, with more obvious exclusions being any areas near airports, in national parks or in built-up population centres. Always check that the use of drones is permitted in the area where the fieldwork is being undertaken.

The *DroneDeploy* website allows you to view their processed drone mission data as a two-dimensional detailed aerial photograph mosaic, a three-dimensional model, a plant health map and an elevation map.

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Figure 1.6g Drones enable geographers to investigate a diverse rage of landscapes

Using apps to gather geographical data

There are a range of applications (or apps) that can be used to gather geographical data. The best app to use is one that is available on all devices and is free to download. These apps can be grouped by purpose.

Location apps

All GPS apps essentially do the same thing. They record where you are and where you have been. Some of the more popular apps include *My GPS Coordinates* (iOS and Android), *GPS Essentials* (Android) and *Get Geo-Coordinates* (Android). In the Google Maps app (iOS and Android), you can record a GPS point by holding your finger down on your location on the app. You can then share this information by email.

Recording a path or trip

There are a number of apps available that allow you to record a path taken during activities such as fieldwork. Importantly, these can be exported into mapping tools. Many of these apps are designed for hikers, bushwalkers or mountain bikers but they are also very useful for geographers. Suggestions include *ViewRanger* (iOS and Android), *myTracks—The GPS-Logger* (iOS), *My Tracks* (Android), *GPS Essentials* (Android) and *Simple Logger* (iOS).

Data collection apps

Data collection apps allow you to collect various types of data while undertaking fieldwork. Some are designed to collect one type of data (such as sound, light or temperature), while others allow you to develop a specific survey to collect data in the field.

There are many versions of the apps listed below, available on iOS or Android.

- *Altitude and elevation. Altitude DC* is an app that provides GPS, elevation and location data after taking a photograph of the location through the app; it is available on all devices. *My Altitude* provides current location, altitude, barometric pressure and water boiling point. A benefit of this app is that is does not need an internet connection to work.
- *Area and distance. Geomeasure* measures area and distance using GPS points in the field. Measurements can be made manually or by inputting GPS points as the user moves around the area. Other useful measurement apps include *EasyMeasure* and Apple's *Measure*.
- *Inclination (slope).* There are a number of apps that measure angles in the field. Examples include *iLevelLite* and *SeeLevel* (both free, on iOS only) and *Clinometre*, which is available on iOS and Android devices but has a cost.

Image and sketching apps

The camera on most mobile devices is good enough to take photographs in the field. Useful apps include:

- *Skitch* is a free app but is only available on iOS. It allows the user to annotate an image taken by the device in field. Text, arrows and other symbols can be added to a photo. This can then be exported as an image file for use in a field report or presentation.
- The *Street View* app is freely available on all devices. Users can view images of selected places in 360° 'street view', or can create their own 360° images in the app. These can then be developed into a virtual reality tour using online tools such as *Vortals*.
- *PicSketch* allows you to convert photographs into line drawings which you can annotate.

ACTIVITIES

1. Outline the ways digital technologies have changed the way we investigate the world around us.
2. Study the text 'Geospatial technologies' and Figure 1.6c and then complete the following tasks:
   - **a** Identify the everyday technologies that rely on data sourced from Global Positioning Systems.
   - **b** State what a geographic information system (GIS) is. Name an application that relies on GIS data.
   - **c** Explain what remote sensing is.
   - **d** Using Figure 1.6c, explain the reasons why geographers use GIS.
3. Read the information on Google Earth and then complete the following tasks.
   - **a** Use Google Earth to explore one of the following high-resolution destinations: Melbourne, Victoria, Australia; Las Vegas, Nevada, the United States; or Cambridge, the United Kingdom.
   - **b** Using Google Earth, explore either Portofino or the Amalfi Coast on the Italian west coast. Describe the nature of the relationship between the biophysical and constructed environments.
   - **c** Use Google Earth to explore some of the world's great natural and constructed wonders. For example, Victoria Falls, the pyramids of Egypt.
   - **d** Using Google Street View, explore your local neighbourhood. Try to identify places you are familiar with.
   - **e** Using Google Street View, explore the streets of one of the world's great cities.
   - **f** Use Google Earth to undertake one of the activities listed under the heading 'Things you can do using Google Earth'.
4. Read the information on drones. Investigate the potential of drones to collect geographical data. If you have access to a drone and the associated software, undertake a data collection exercise as described.
5. Access one or more of the applications listed in the section of text dealing with the use of apps to gather geographical data to investigate a selected geographical feature or process. Evaluate the effectiveness of the technology.

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1.7 Interpreting topographic maps

Figure 1.7a What landscape is that?

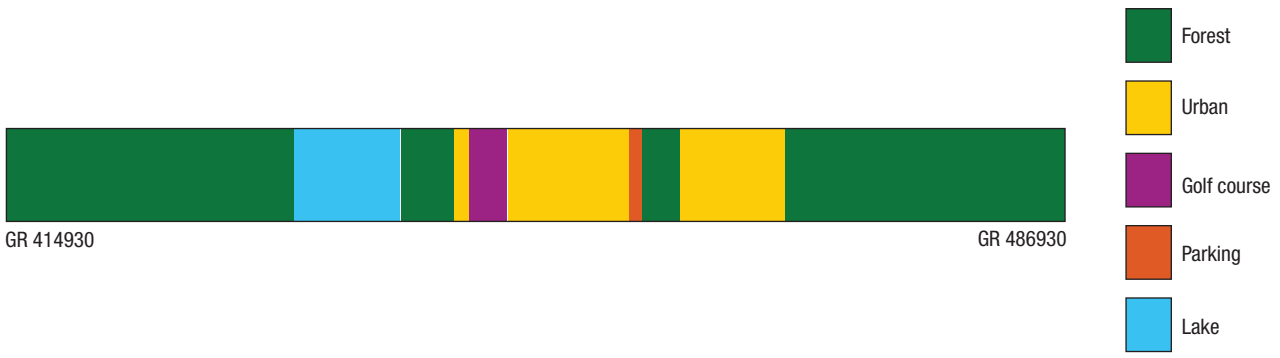

Figure 1.7c Transect along northing 93 between GR 414930 and GR 486930 on the Whistler topographic map extract. (See page 171.)

Precis maps

Topographic maps, aerial photographs and satellite images contain large amounts of detail, so it is often useful to construct a *precis (or single-feature) map* highlighting one particular feature of the map, photograph or image. By comparing precis maps it is often possible to identify the relationship between two features; for example, between landform and settlement patterns or transport networks.

To draw a precis map follow the steps below:

1. Identify the feature or pattern to be studied, such as landforms, drainage, vegetation, settlement, transport or land use.
2. Examine the distribution of the feature on the map, photograph or image and the pattern this distribution creates.
3. Draw a simple outline map of the map, photograph or image.
4. Add the distribution of the feature.
5. Label each area or construct a legend that identifies the features numbered or shaded on the map.

Figure 1.7b illustrates the vegetation pattern on the Cairns topographic map extract. (See page 119.)

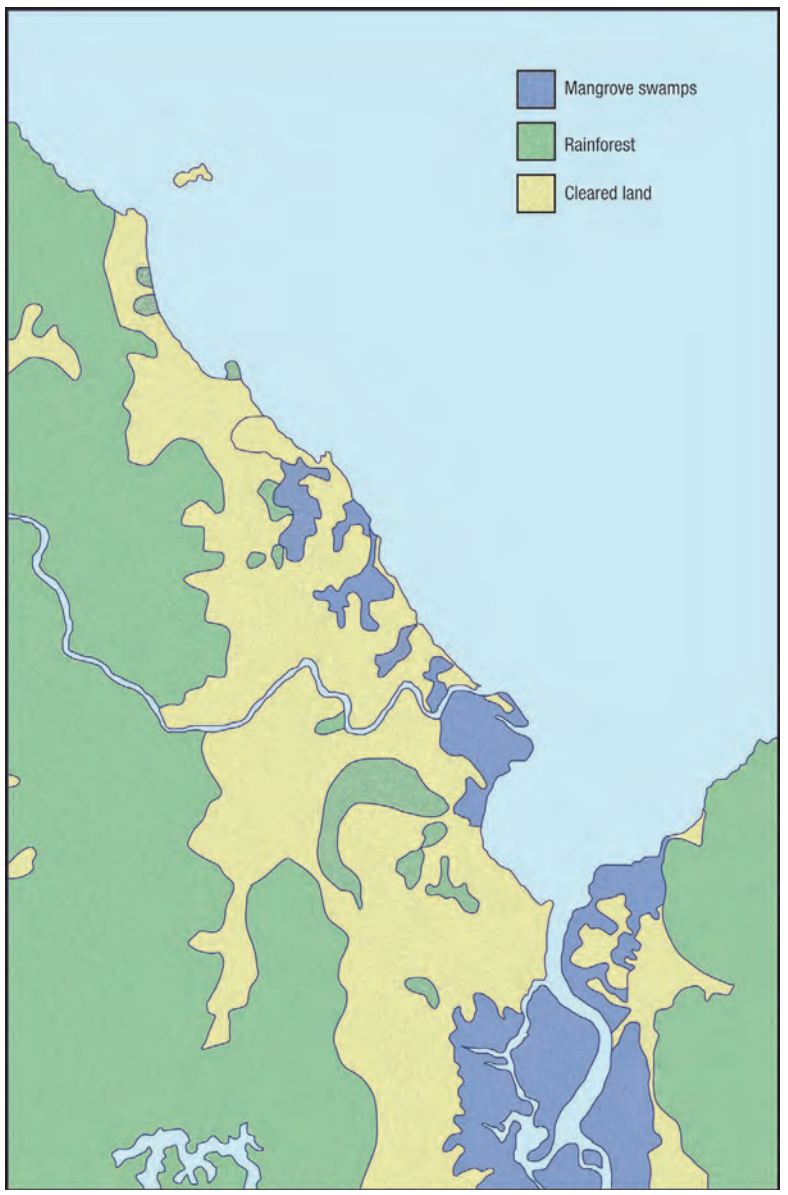

Figure 1.7b Precis map of the Cairns topographic map extract showing the pattern of vegetation

Transects

Transects show the relationship between different features of the physical and built environments along a cross-section or between two points. Once a transect is drawn, you can use it to make generalisations about features, such as landforms, vegetation, soils, geology, transport, settlement and agricultural land use.

Figure 1.7c shows a vegetation transect along northing 93 between GR 414930 and GR 486930 on the Whistler topographic map extract. (See page 171.)

Drainage patterns

A *drainage pattern* is the arrangement of rivers and their tributaries within a drainage basin. Most of these patterns develop over a long period of time and usually adjust themselves to the structure (or geology) of the drainage basin. The most common drainage patterns formed include the following:

- *Parallel*. This is perhaps the simplest of all drainage patterns. It generally occurs on newly uplifted land and where rivers and tributaries flow downhill more or less parallel with each other. The pattern created features a number of parallel rivers. (See Figure 1.7d (i).)
- *Dendritic*. Derived from the Greek word dendron, meaning tree, this is a tree-like pattern. The tributaries converge on the main river channel. Dendritic patterns generally develop in areas that have one rock type. (See Figure 1.7d (ii).)
- *Radial*. In areas dominated by dome-shaped mountains or volcanic cones, rivers radiate outwards from a central point like the spokes of a wheel. (See Figure 1.7d (iii).)
- *Trellis or rectangular*. In areas where there are areas of resistant and less-resistant rock, tributaries will join the main river at right angles. (See Figure 1.7d (iv).)

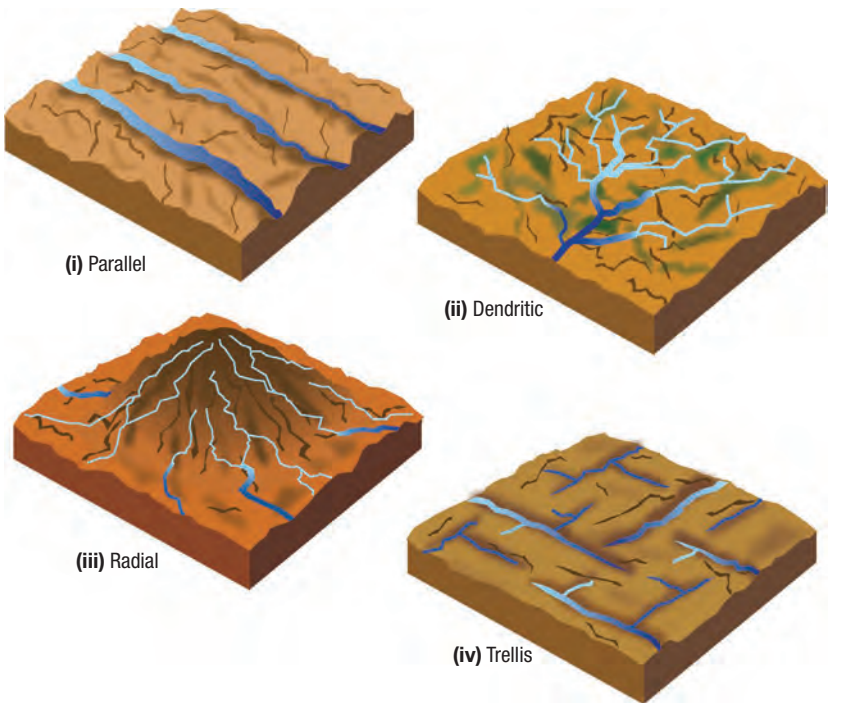

Figure 1.7d Types of drainage patterns

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Settlement patterns

Settlements (hamlets, villages, towns and cities) are built-up areas. No two settlements are exactly alike, but many do have certain features in common. One common feature is *site*. This is the place where a settlement was first established. Another common feature is *layout*, which is the arrangement and spacing of buildings within a community.

Settlement pattern is the term used to describe the distribution and layout of buildings within built-up areas. The main settlement patterns are as follows:

- *Nucleated* – settlements that are compact. Specific examples include the grouped hamlet, cluster village and skeleton grid. (See Figure 1.7e (i)–(iii).)
- *Linear* – settlements that are long and narrow. Examples include the string village and linear hamlet. (See Figure 1.7e (iv) and (v).)
- *Dispersed* – scattered rural homesteads. (See Figure 1.7e (vi).)

Figures 1.7f to 1,7h show a range of French settlements. These include a hilltop village (1.7f), a linear village (1.7g) and a cluster village (1.7h).

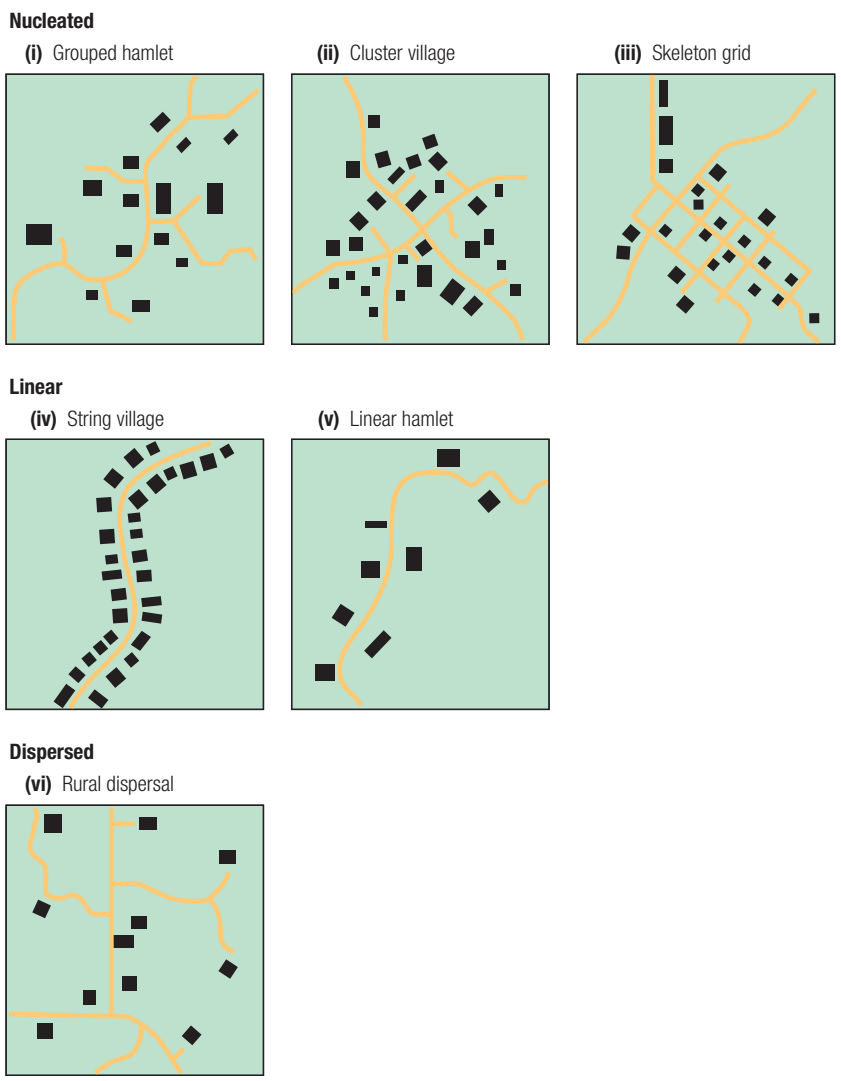

Figure 1.7e Some of the settlement patterns found on maps

Figure 1.7f Hilltop village, Callian, southern France

Figure 1.7g A linear (string) village, Saint Louis, north-east France

Figure 1.7h A cluster village in south-west France

ACTIVITIES

1. Explain why geographers draw precis maps.
2. Outline the purpose of transects.
3. Study the Enard Bay topographic map extract on page 153. Construct a precis map showing the relationship between transport and topography.
4. Study the Wallis Lake topographic map extract on page 93.
   a. Construct a precis map showing the pattern of vegetation found in the area covered by the map.
   b. Construct a transect from GR 390330 to GR 590330.
5. Study the Mt Ruapehu topographic map extract on page 139. Identify the drainage pattern evident on the map extract.
6. Study the Encounter topographic map extract on page 109. Identify the various settlement patterns found on the map.
7. Study the Goolwa topographic map extract on page 111. Identify the settlement type found in AR 0368.
8. Study the Wallis Lake topographic map extract on page 93. Identify the settlement type found at AR 5032.

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1.8 Photographs

Geographers use photographs to gather and record information about features of the Earth's surface. Photographic images provide a visual record of a landscape and allow us to note the relationship between the various elements of the physical and built environments. They also provide a convenient way to examine the rate and nature of environmental change. Photographs taken at different times can be compared and analysed. The different types of photographs are shown in Figure 1.8b.

Figure 1.8a Get the shot!

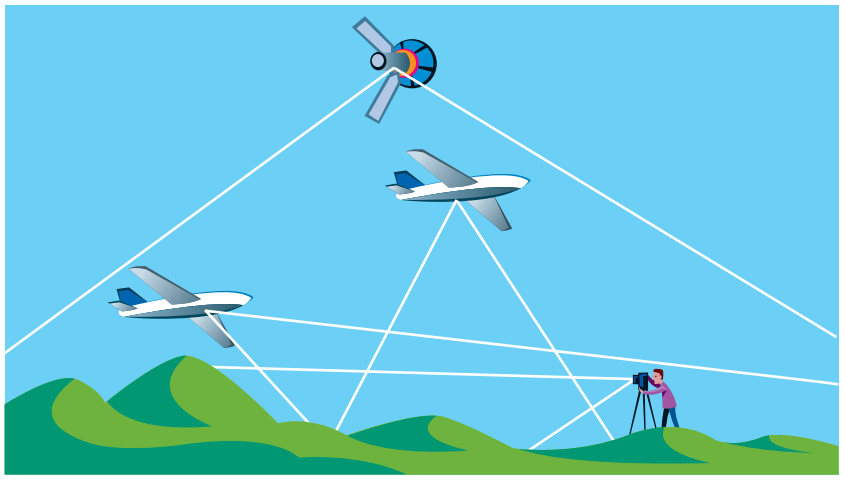

Figure 1.8b Types of photographs

Ground-level photographs

Ground-level photographs are taken from the ground so that a horizontal view is obtained. Features in the foreground appear larger than those in the background. (See Figure 1.8c.)

Aerial photographs

Aerial photographs are photographic images of part of the Earth's surface taken from an aircraft. Aerial photographs are now widely used to update topographic maps.

Types of aerial photographs

There are two types of aerial photographs depending on the angle of the camera: oblique and vertical.

Oblique aerial photographs are taken from an aircraft with a camera pointing at an oblique angle to the Earth's surface; that is, at an angle less than 90°. (See Figure 1.8d.) These photographs are often easier to interpret than vertical aerial photographs because:

- the sides of objects as well as the tops of objects can be seen
- they are usually taken at low altitudes.

The main disadvantage of oblique aerial photographs is that there is no consistent scale. Features in the foreground appear larger than those in the background.

Vertical aerial photographs are taken from an aircraft with a camera pointing directly towards the Earth's surface; that is, at an angle of 90°. (See Figure1.8e.)

Spatial patterns are clearly visible, but specific features may be difficult to identify because we can see only a plan view of them.

Figure 1.8c Ground-level photograph of New York's Central Park in Autumn

Figure 1.8d Oblique aerial photograph of Central Park, New York City, looking South towards Downtown Manhattan.

Figure 1.8e Vertical aerial photograph of Central Park, New York

Satellite images

Satellite images are different from the photographs you take with a digital camera because they are created from data collected by satellites that orbit the Earth. (See Figure 1.8f.) Geographers use remote sensing to study the spatial distribution of biophysical, managed and constructed elements of environments. Remotely sensed images are especially important when investigating change over time.

Remotely sensed images are produced from data gathered by satellite-mounted sensors. These sensors are so sensitive that they can record the radiation given off by features on the Earth's surface. These data are then converted into images. Often, these images are referred to as *false-coloured*

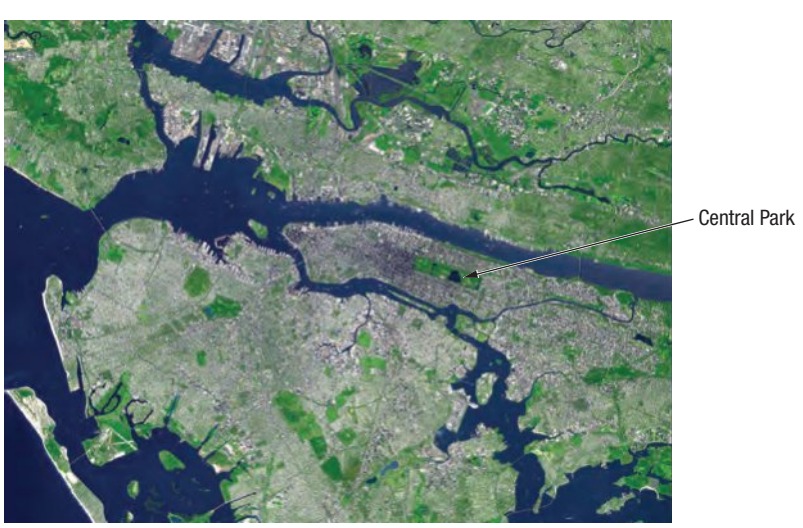

Figure 1.8f Satellite image of New York City

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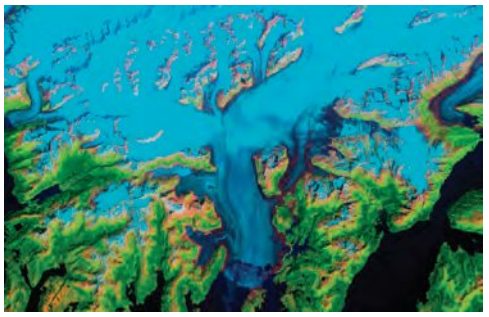
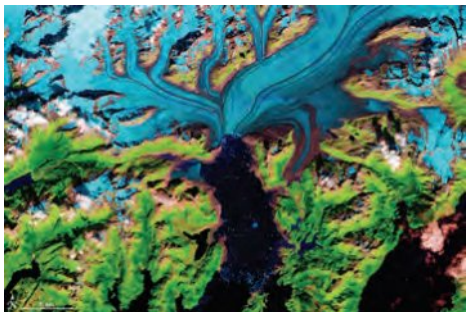
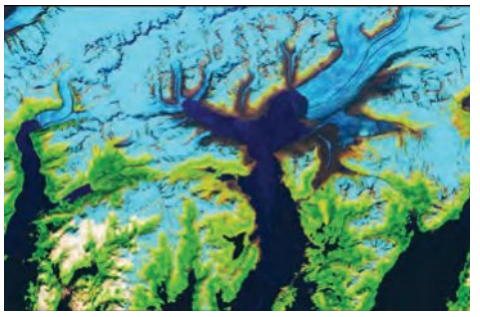


1986



2005



2019

Video 1.8a
Animation of glacial retreat **(00:50)**

Figure 1.8g False-colour satellite images of the Columbia Glacier

Table 1.8a Colour guide for false-coloured images

Colour	Feature
Dark blue–black	Deep water in oceans, lakes and dams
Mauve–steely blue	Urban and industrial areas
Blue–light blue	Arid scrubland; very shallow water
Dark green	Deep muddy floodwaters, clear shallow water
Light green	Moist, ploughed, bare soils; light grass cover
Brown	Drier vegetation such as eucalypts and arid woodlands; bare rock
Red	Healthy growing vegetation; rainforest (deep red); growing crops and pastures; mangroves (deep red)
Pink–red	Early growth of crops and grasslands; suburban gardens, lawns and parks
Yellow	Areas with little vegetation cover, heavily grazed areas, deserts and sand dunes
White–cream	Bare ground; dry sand and salt areas, dunes and beaches; clouds

images, and the observer needs to know what each colour represents in order to interpret the image (see Table 1.8a). The images in Figure 1.8g are examples of *false-coloured* images. Other images look more like photographs because computer programs convert the data received from satellites into *true-colour* images.

The false-colour images in Figure 1.8g, captured by Landsat satellites, show how a glacier and the surrounding landscape has changed since 1986.

As satellites became more sophisticated they were able to capture the data necessary to produce true-colour images. These images feature colours as they appear to the human eye. We still, however, need to know what each colour represents (see Table 1.8b).

Figure 1.8h Grand Plateau Glacier, Glacier Bay National Park, south-east Alaska

Table 1.8b Colour guide for true-coloured images

Colour	Feature
Dark blue–black	Deep, clear water in oceans, lakes and dams
Light blue	Shallow water
Mauve-steely blue	Urban and industrial areas
Brown-light brown	Dry vegetation such as eucalypt and arid woodlands; bare rock
Bright light green	Grassland, growing crops and pastures; suburban parks and gardens
Bright green	Healthy, growing green vegetation; rainforest and mangroves
Light pink–orange–brown	Cleared farming land; early growth in crops and grasslands
White cream	Bare ground; dry sand and salt areas; dunes and beaches; clouds

Interpreting aerial photographs

Interpreting aerial photographs involves the following steps:

1 Determine whether the photograph is a vertical aerial photograph or an oblique aerial photograph.
2 Look for evidence of location and time. Often the caption provides some relevant information about the photograph, especially about the location.
3 Look for a familiar feature of the built environment that will give you some indication of scale.
4 Identify the main features of the photograph. You may find it useful to group them under the following headings.
   - Features of the physical environment:
     - landforms; for example, relief and drainage features
     - climate
     - vegetation.
   - Features of the built environment:
     - land use
     - transport networks
     - settlements – rural and urban.
5 Ask yourself the following questions:
   - Is the area predominantly characteristic of the physical and built environments?
   - What is the physical nature of the environment: fluvial, coastal, arid, glacial, mountainous (and so on)?
   - To what extent has the area been modified by human activity?

Using photographs to record information

Photography is often used to record and illustrate geographical information. It allows us to:

1 record how a place looks at a particular point in time
2 make comparisons between different environments
3 show the relationship between geographical phenomena
4 study change in an area or environment over time.

Taking a photograph that is of use to geographers involves the following steps:

1 Decide what the photograph is going to show.
2 Choose what is to be included and excluded.
3 Include a generally recognised feature that gives the viewer some indication of scale.
4 Choose the appropriate distance between the camera and the object.
5 Ensure the technical aspects of the photograph are correct; for example, that the lighting is adequate and the photograph is in focus.

ACTIVITIES

1 Outline how satellite images differ from photographs.
2 Study Figure 1.8b. Based on your knowledge of the types of photographic images, complete the following tasks:
   - **a** Identify the type(s) of images that result in no distortion of the scale of the objects on the ground.
   - **b** Identify the type of image that is likely to give the greatest distortion of the features in the foreground.
   - **c** Identify the type of image that might block out views of distant features.
   - **d** Identify the type of image that is likely to cover the largest area of the Earth's surface.
3 Use the internet to locate examples of ground-level, oblique and vertical aerial photographs.
4 Use Google Earth to explore some of the landscapes featured in the topographic maps in Sections 3 and 5–9 of this text.
5 Study Figure 1.8g and Video 1.8a. Trace the retreat of the Columbia Glacier.
6 Use NASA's Earth Observatory website to locate examples of satellite images that you find interesting. Mount a wall display that shows the diversity of the images available at the site.

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1.9 Field sketches, line drawings and sketch maps

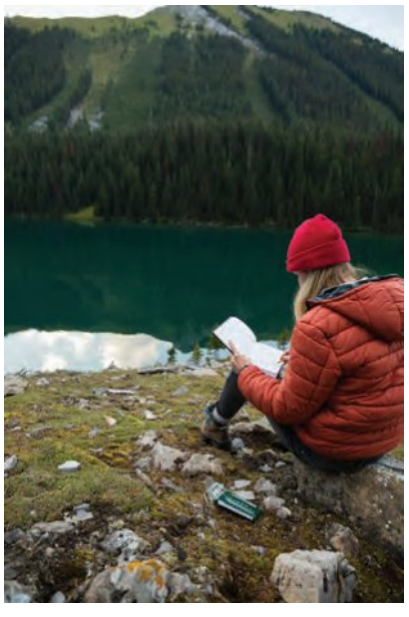

Figure 1.9a Hold that look!

Constructing field sketches

To construct a field sketch, follow the steps below:

1. Study the scene or photograph and select the features to be sketched. It may be helpful to use a viewing frame.
2. Using a soft pencil (it makes it easier to erase mistakes) and a blank sheet of paper, draw a frame the same shape as the scene you wish to sketch.
3. Divide the scene you wish to sketch into three parts: the foreground, middle distance and background. (See Figure 1.9b.)
4. Sketch in the main features or lines of the scene. This may include the horizon and other prominent landform features.
5. Mark in other prominent features or lines, such as roads, railway lines, rivers or powerlines. These will provide reference points for the addition of detailed features.
6. Add detail if appropriate. Details may include buildings, trees and fences.
7. Use shading and/or colour to highlight the key features of your field sketch. Avoid making your sketch too cluttered.
8. Label the main features shown in your sketch.
9. Give your field sketch a heading and note the date of the observation.
10. Highlight your frame with a black felt-tipped pen.

Figure 1.9b Dividing your frame into foreground, middle distance and background will help you to construct your field sketch.

Field sketches and line drawings

Geographers use *field sketches* and *line drawings* to highlight significant features of a particular landscape. If the drawing is based on observations made during fieldwork it is called a field sketch. If it is drawn from a photograph it is called a line drawing or photo sketch.

Field sketches and line drawings are usually done in pencil, but some students find it useful to 'finish off' the sketch with a black pen and colour. The addition of labels or notes around the borders of the sketch can also be used to draw attention to significant features. (See Figures 1.9e and 1.9f.)

You do not need to have artistic ability to draw a field sketch or line drawing. Of greater importance is the geographical understanding you develop from identifying and sketching features of a particular landscape.

Once completed, field sketches and line drawings can be used to classify and explain spatial patterns and relationships.

You could, for example, identify the features of the physical and built environments; note the relationship between landforms, settlement patterns and transport networks; and identify the main physical processes shaping the landscape.

Constructing line drawings from photographs

To construct a line drawing from a photograph, follow the steps below:

1. Study the photograph and select the area to be included in the line drawing.
2. Using a soft pencil and a blank sheet of paper, draw a frame the same shape as the photograph you wish to sketch.
3. When sketching ground-level photographs use soft pencil lines to divide your photograph into three areas: foreground, middle ground and background.
4. Pick out the main features in each area of the photograph and sketch in an outline of their shape.
5. Use shading and/or colour to highlight the key features of your line drawing. Avoid making your line drawing too cluttered.
6. Label the main features shown in your line drawing.
7. Give your line drawing a title and note the source of the image.
8. Highlight your frame with a black felt-tipped pen.

Computer-generated photo sketches

There are now a number of software applications that will transform your photographs into sketches. Figure 1.9d is an example of a sketch generated from a photograph.

Figure 1.9c Yosemite National Park, California, the United States

Figure 1.9d Photo sketch of Yosemite National Park drawn using software

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Figure 1.9e Lake Angus, Banff National Park, Canada

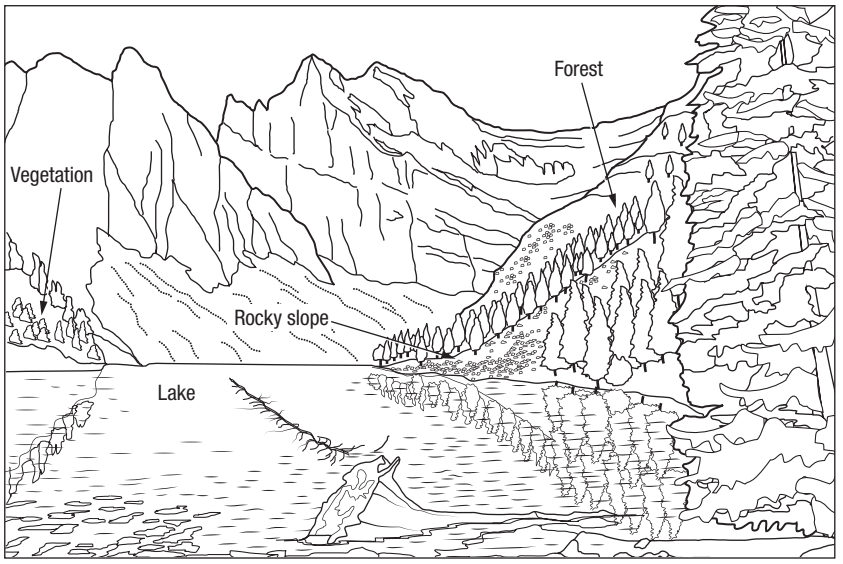

Figure 1.9f A sample field sketch of Lake Angus, Banff National Park. Field sketches such as this are a popular way to record information during fieldwork.

Sketch maps

Just as line drawings can be drawn from ground-level and oblique aerial photographs, it is possible to construct *sketch maps* using vertical aerial photographs. Figure 1.9g is a sketch map of Gallipoli, drawn by Private Sydney Callaghan in 1915.

Here are the steps you should follow to make a sketch map from a vertical aerial photograph:

1. Draw a border the same shape as the aerial photograph.
2. Draw in the main features; for example, roads and coastline.
3. Decide on the amount of detail required and add it to your sketch map.
4. Label the main features on the sketch. Add colour and shading if appropriate.
5. Complete the sketch by adding a title, scale, north point and, if necessary, legend.

A precis map (see Figure 1.7b, page 16) is a type of sketch map. Precis maps are used to illustrate the relationship between elements of a topographic map; for example, landform and settlement patterns.

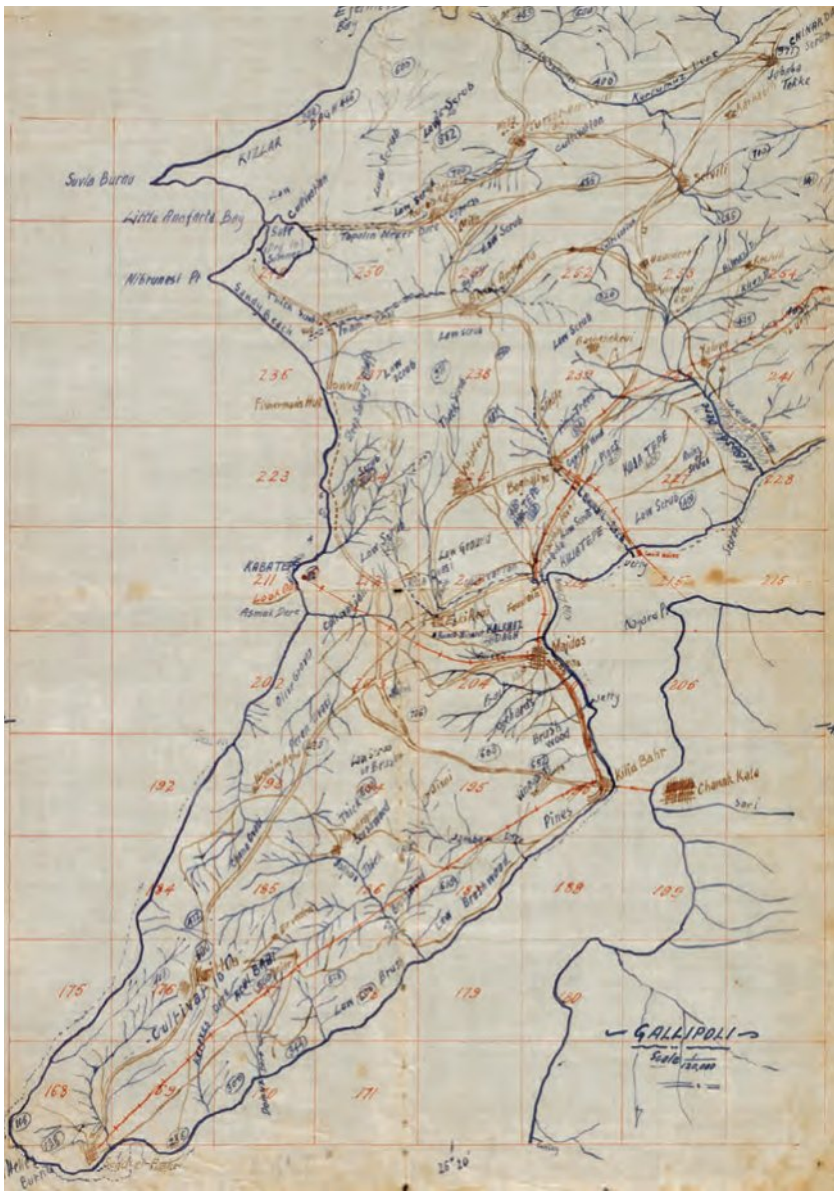

Figure 1.9g This small, 1 inch: 120 000 inch sketch map of Gallipoli was drawn by Private Sydney Callaghan. Callaghan carried the map in his tunic pocket at the landing at Anzac Cove on 25 April 1915 [AWM/RC05680].

ACTIVITIES

1. Explain why geographers construct field sketches and line drawings.
2. Distinguish between field sketches and line drawings.
3. Select one of the photographs in Figure 1.9h and construct a photo sketch of the image. Label the principal features of the biophysical or constructed environment.
4. Undertake fieldwork. Construct a field sketch of a landscape. Annotate your sketch, highlighting prominent landform features and important elements of the biophysical and constructed environments.

Figure 1.9h(i) Matterhorn, Switzerland

Figure 1.9h(ii) Monument Valley, the United States

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1.10 Climate graphs and weather maps

Figure 1.10a Four seasons

Climate graphs

A *climate graph* shows the average temperature and rainfall experienced at a particular place throughout the year. It consists of a line graph showing mean (average) monthly temperature and a simple column graph showing mean monthly rainfall figures.

Climate graphs are constructed using long-term data, such as those collected by the Australian Bureau of Meteorology. You can use the bureau's website to locate climate data for hundreds of locations throughout Australia. Climate data for international locations can be found at the following websites: World Weather Information Service and WorldClimate. The climate data for São Paulo, Brazil, is shown in Table 1.10a.

The main features of a climate graph are shown in Figure 1.10b.

Table 1.10a Climate data for São Paulo, Brazil, elevation 760 m, latitude 23°32'S, longitude 46°37'W

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean min. temperature °C	18.7	18.8	18.2	16.3	13.8	12.4	11.7	12.8	13.9	15.3	16.6	17.7	15.5
Mean max. temperature °C	27.3	28.0	27.2	25.1	23.0	21.8	21.8	23.3	23.9	24.8	25.9	26.3	24.9
Mean total precipitation (mm)	238.7	217.4	159.8	75.8	73.6	55.7	44.1	38.9	80.5	123.6	145.8	200.9	1454.8

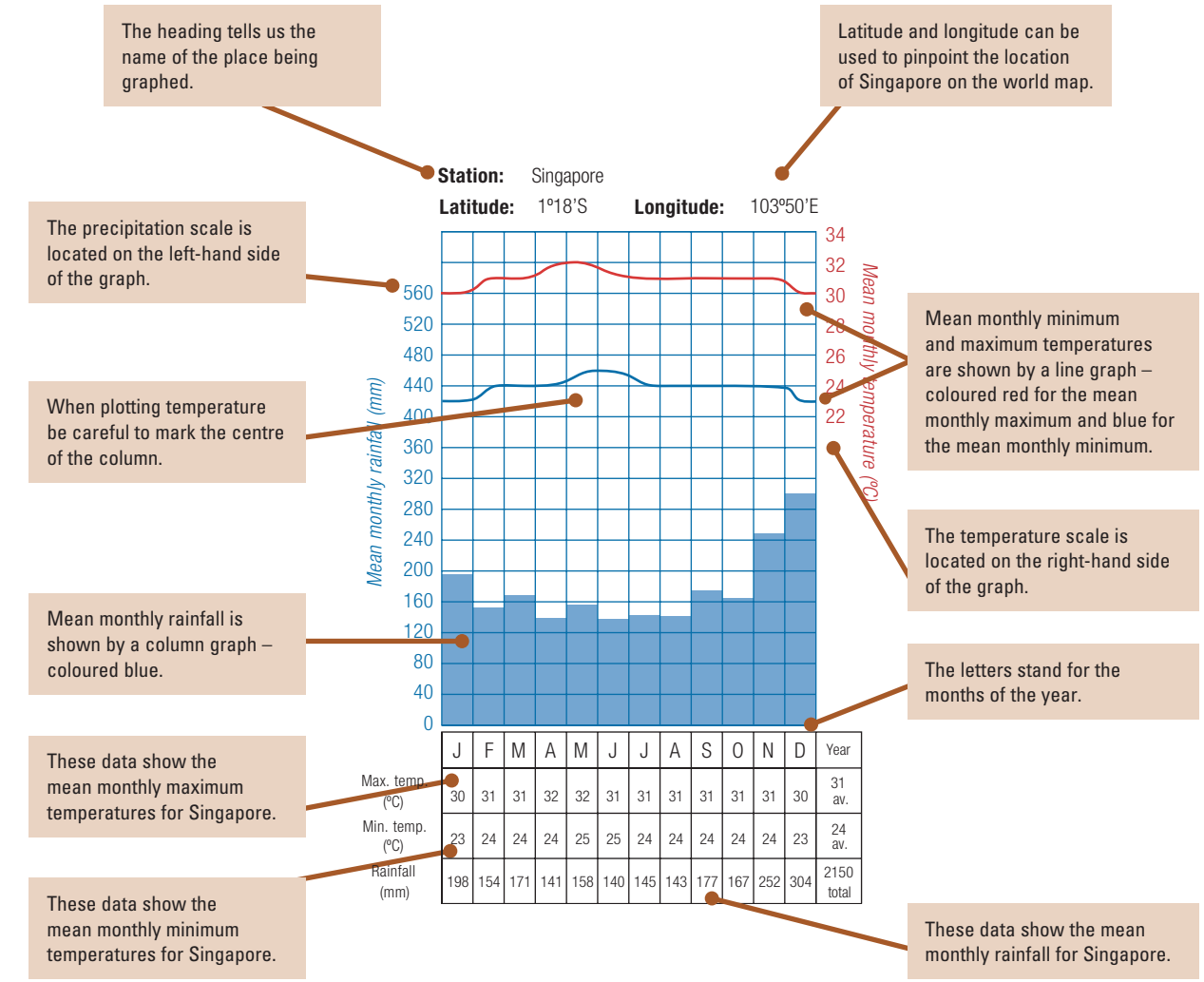

Figure 1.10b Climate graph of Singapore

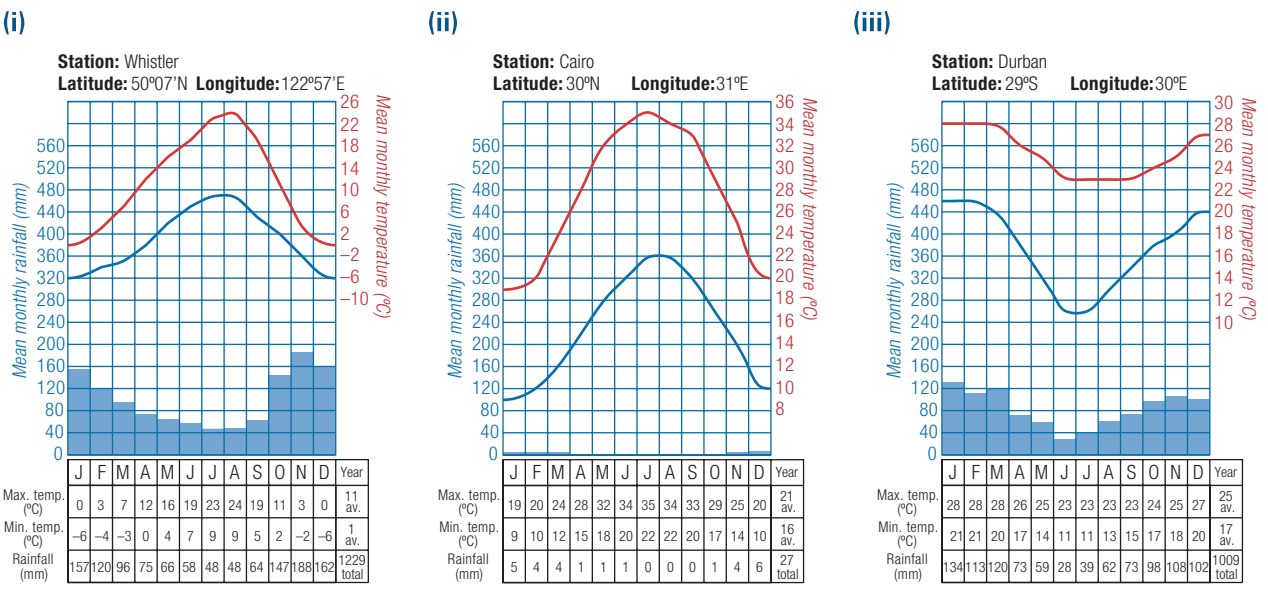

Figure 1.10c Climate graphs for Whistler, Canada (i), Cairo, Egypt (ii) and Durban, South Africa (iii)

Constructing a climate graph

To construct a climate graph, follow the steps below:

1. Transfer the relevant temperature and rainfall data into the table at the base of the climate graph.
2. Study the data to identify the wettest month and the highest and lowest mean monthly temperatures. Use this information to select a suitable scale for both temperature and precipitation.
3. Place the precipitation scale on the left-hand side of the graph and the temperature scale on the right-hand side of the graph.
4. Plot the rainfall figures and then colour the columns blue.
5. Plot the mean temperature data, making sure each dot is placed in the centre of each month. Join the points with a smooth curve.
6. Add a heading that includes the name of the place being graphed together with its latitude and longitude.

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Isobars are lines that join places of equal atmospheric pressure. Air pressure is measured in hectopascals (hPa). Isobars are usually drawn at intervals of 2 hPa.

Air pressure (also known as atmospheric or barometric pressure) is the weight of air pressing down on the Earth's surface. If air is warmed, it expands, rises and creates a low-pressure area on the Earth's surface. If air is cooled, it contracts, descends and creates an area of high pressure on the Earth's surface. Areas of high and low pressure determine much of the Earth's weather.

Low-pressure systems (or cyclones, as they are sometimes known) form when warm air rises. They are associated with unstable atmospheric conditions: cloudy skies, rain and relatively strong winds. Air pressure decreases towards the centre of the pressure system. Air flows in a clockwise direction towards the centre of the low-pressure system.

Rain: areas that have received rain in the previous 24 hours are shaded.

High-pressure systems (or anticyclones, as they are sometimes known) are areas of stable atmospheric conditions: gentle winds, clear skies and little chance of rain. Air pressure increases towards the centre of the pressure system. Air flows out from the high pressure system in an anticlockwise direction. During summer, southern Australia is generally dominated by high-pressure systems (highs) while the north is dominated by low-pressure systems (lows). These lows and a seasonal reversal of wind direction are responsible for the north's 'Big Wet'.

Cold fronts form when a mass of cold air overtakes a slower-moving mass of warm air. As a cold front passes over an area, the temperature is likely to fall, rain may occur and the wind direction changes. (See Figure 1.10e.)

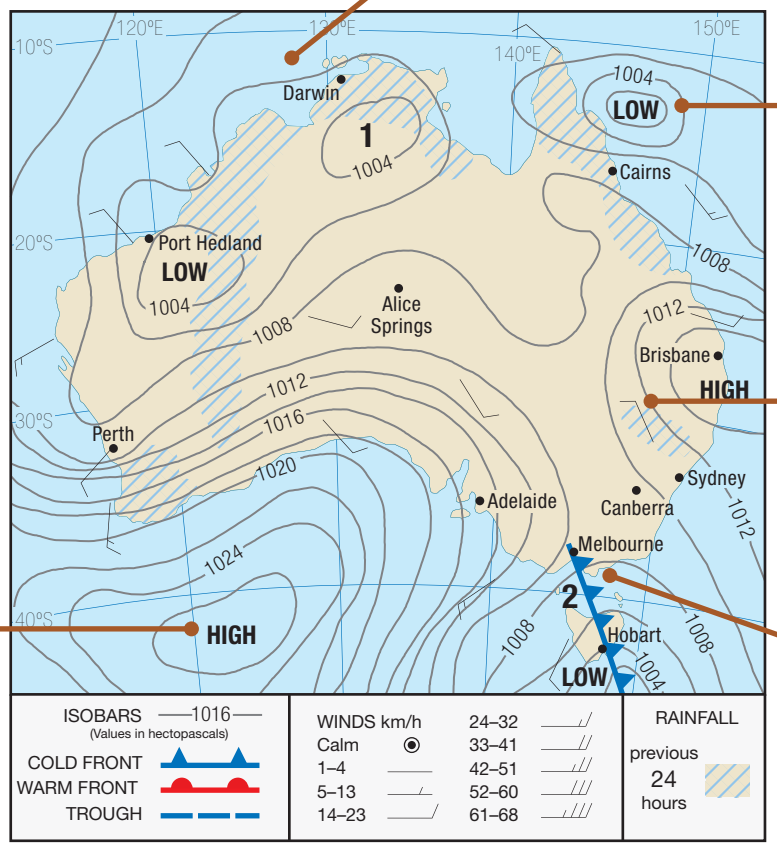

Figure 1.10d A weather map (or synoptic chart)

Weather maps

A *weather map*, or synoptic chart, is a record of the weather conditions being experienced across part of the Earth's surface at a particular point in time. (See Figure 1.10d.) It provides information about air pressure, wind speed and direction, and the distribution of rainfall. It enables us to predict the weather we are likely to experience over the forthcoming two or three days. Being able to read weather maps is an important skill to master. Farmers, for example, use weather maps to help them plan their farming activities. It also enables people to plan their recreational activities, such as going to the beach and playing sport.

When interpreting weather maps it is important to remember that weather systems tend to move from west to east across southern Australia and from east to west across northern Australia.

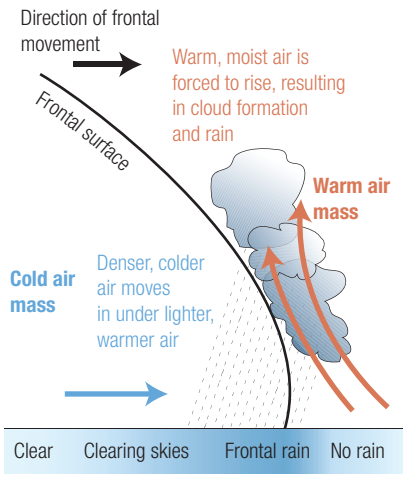

Figure 1.10e Cold front

Predicting weather using a synoptic chart

How warm will it be?

Seasonality is the main factor affecting temperature. It is, on average, warmer in summer than it is in winter. Other factors to take into account include:

- extent of cloud cover
- frontal activity
  - after the passing of a cold front, the temperature falls
- wind direction
  - winds blowing from the south usually bring cooler weather
  - winds blowing from the north generally bring warmer conditions
- proximity to large bodies of water, which has a moderating effect on temperature; that is, results in a smaller diurnal range. Diurnal range is the difference between the highest and lowest temperature experienced during the day.

Will it rain?

- Areas in which rainfall has occurred in the previous 24 hours are shaded.
- Low-pressure systems and fronts are associated with rising air. As air rises it cools and condenses. This may produce precipitation.
- Highs tend to be associated with sinking air. As the air sinks it becomes warmer and is better able to retain moisture.
- Winds blowing from central Australia bring dry conditions.
- Winds blowing onshore are more likely to bring rain.

Will it be windy?

- The closer the isobars, the stronger will be the wind.
- Strong winds are normally associated with low-pressure systems.
- To determine wind direction:
  - Draw a dotted line through the place, parallel to the adjacent isobars.
  - Place a faint arrowhead on this line, indicating an anticlockwise direction if a high is influencing weather conditions, or clockwise if a low is present.
  - Deflect the arrow (10–20° away from a high, or 10–30° towards a low) and draw a new, clearer arrow to give an indication of wind direction.

ACTIVITIES

1 What types of graphs are featured on a climate graph?

2 What elements of climate do climate graphs typically show?

3 Study Figures 1.10b and 1.10c and then answer the following questions:
- a Which station has the highest mean monthly temperature?
- b Which station has the lowest mean monthly temperature?
- c Which station has the greatest annual range in mean maximum temperature?
- d Which station has the smallest annual range in mean maximum temperature?
- e What is the warmest month in Whistler?
- f What is the coldest month in Cairo?
- g Which station is located in the Southern Hemisphere?
- h Which station has the highest mean annual precipitation?
- i Which station has the lowest mean annual precipitation?
- j Which station has the greatest seasonal variability in precipitation?
- k Which station has the smallest seasonal variability in precipitation?

4 Study Figure 1.10d and then complete the following tasks:
- a Identify the synoptic features labelled 1 and 2.
- b What is the atmospheric pressure at Adelaide?
- c What is the atmospheric pressure at Cairns?
- d What is the wind speed and direction at Perth?
- e What is the wind speed and direction at Port Hedland?
- f What weather conditions is Darwin experiencing?
- g State the season of which this weather map is typical.
- h Describe the likely weather conditions being experienced in Melbourne.
- i Describe the weather Perth is likely to experience over the following day or so.

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1.11 Graphs

Figure 1.11a Now that's a trend!

Line graphs

Simple *line graphs* provide an effective way to show values that change over time. Figure 1.11b, for example, shows the annual (actual and projected) rate of growth of the world's population between 1950 and 2050.

Bar and column graphs

Bar graphs use horizontal bars to make comparisons. Simple *column graphs* use vertical bars to make comparisons. Figure 1.11c shows a simple bar graph, while Figure 1.11d is an example of a simple column graph.

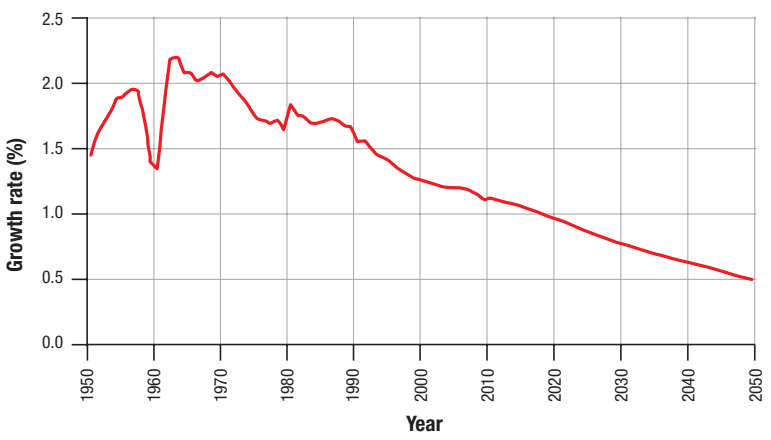

Figure 1.11b Simple line graph showing the annual growth rate in the world's population between 1950 and 2050 (actual and projected)

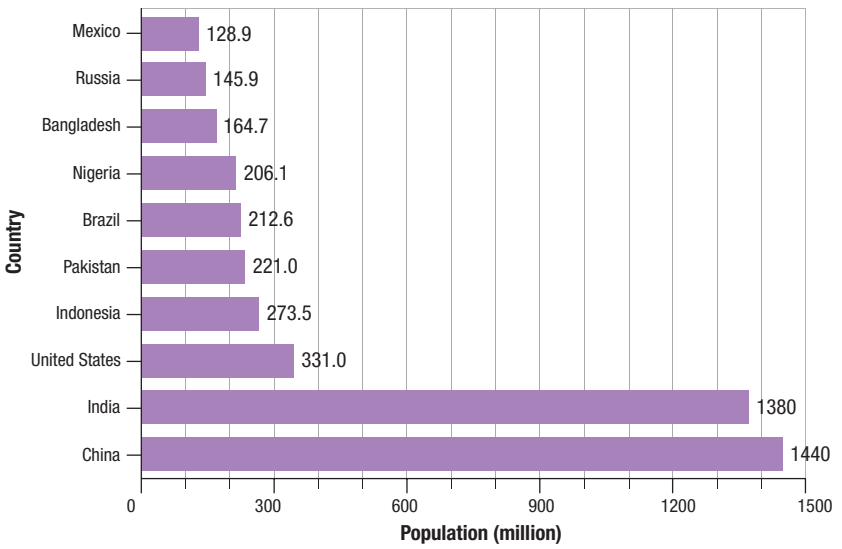

Figure 1.11c Simple bar graph showing the population of the world's most populous countries, 2020

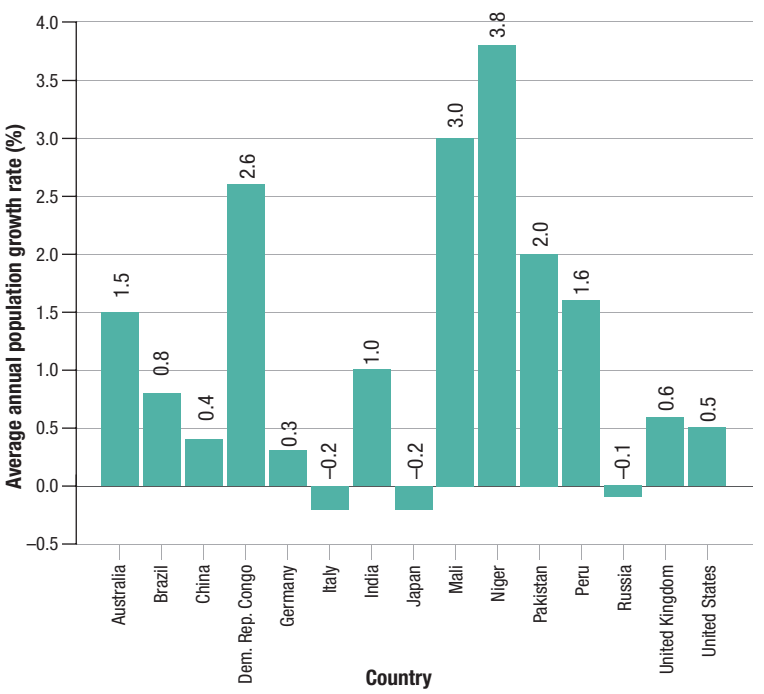

Figure 1.11d Simple column graph showing the average annual population growth rate for selected countries, 2019

Constructing line graphs

To construct a line graph, follow the steps below:

1. Select the set of information or variable you wish to plot on the horizontal axis. The variable that causes the change (usually in time) is generally plotted on the horizontal axis.
2. Select the variable to plot on the vertical axis. In most cases this will be the variable that changes over time.
3. Note the highest value to be shown on each axis and work out an appropriate scale.
4. Rule up the horizontal and vertical axes and mark on the appropriate divisions.
5. Neatly label each axis and give the graph a title.
6. Plot each value on the graph and then join these points with a straight ruled line or a continuous hand-drawn curve.

Constructing bar and column graphs

To construct a simple bar or column graph, follow the steps below:

1. Select the set of information to be represented on the horizontal axis; for example, the year, country or age group in the case of column graphs, or the quantifiable variable in the case of bar graphs. (See Figures 1.11c and 1.11d.)
2. Select the variable to be plotted on the vertical axis. For column graphs this is usually the data that have a quantitative value and tend to rise and fall. For bar graphs is it usually the non-quantifiable data; for example, the year, country or age group.
3. Decide on the width and spacing of the bars or columns to be located along the horizontal or vertical axis.
4. Draw the horizontal and vertical axes, ensuring they can accommodate the range of data to be graphed. Label each axis and give the graph a title.
5. Draw in the bars or columns in pencil, making sure the value of each is accurately plotted.
6. Colour each bar or column and label each if appropriate.

Proportional graphs

Proportional graphs provide an effective way to present geographical data. They have good visual effect and are easy to interpret. They can be analysed to obtain a more detailed understanding of the data presented. The two main types of proportional graphs are pie graphs and proportional circles.

Pie graphs

Pie graphs are also known as divided circles, pie diagrams or sector graphs.

In a pie graph, a circle is divided into segments by radiating out from its centre.

Each segment of the graph is proportional to the value the segment represents. (See Figure 1.11e.)

A complete pie graph (360°) represents 100 per cent. Therefore, each percentage point equals 3.6°. Knowing this statistic will help you to construct and interpret pie graphs.

Constructing pie graphs

To construct a pie graph, follow the steps below:

1. Draw a circle and then extend a line from its centre to the 12 o'clock position.
2. Convert the percentage value of each value or variable to degrees by multiplying it by 3.6. For example, if the percentage was 20%, this would represent 72° on the pie graph; that is, $20 \times 3.6 = 72°$.
3. List your converted values from the largest to the smallest. Place categories such as 'others' at the end of your list.
4. Starting at 12 o'clock, mark in each segment using a protractor. Work in a clockwise direction, starting with the largest segment.
5. Shade in and label each segment. It may be useful to provide a legend. If a legend is included it is not necessary to label the segments.
6. Add an appropriate title.

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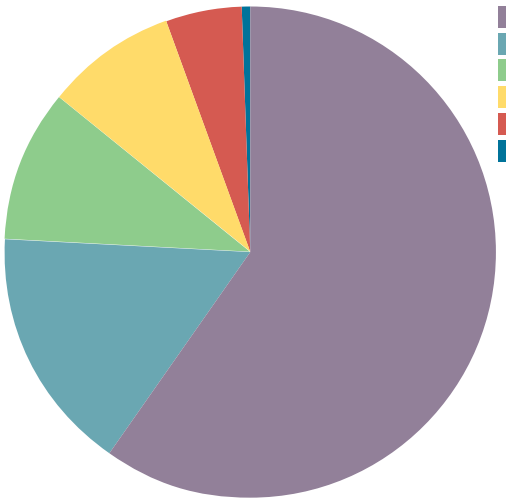

Region	Population (million)
Asia	4 626
Africa	1 338
Europe	747
Central and South America	651
North America	368
Oceania	43
Total	7 773

Figure 1.11e Pie graph showing the distribution of the world's population, 2020

Proportional circles

Proportional circles are used to show the relative size of selected data; for example, the relative size of the Earth's continents.

In Figure 1.11f, the values represented are proportional to the area of the circle. Therefore, the greater the value, the larger the circle.

Constructing proportional circles

To construct proportional circles, follow the steps below:

1. Rank the values being represented from the largest to smallest. For example:
   - the area of Asia: 44 614 000 km^2
   - the area of Africa: 30 319 000 km^2
   - the area of North America: 24 710 000 km^2
   - the area of South and Central America: 18 036 127 km^2.
2. Calculate the square root of each value.* Write the value of the square root to the nearest whole number. For example:
   - Asia: the square root of 44 614 000 ≈ 6679
   - Africa: the square root of 30 319 000 ≈ 5506
   - North America: the square root of 24 710 000 ≈ 4971
   - Central and South America: the square root of 18 036 127 ≈ 4247.

   *You can use an internet-based square root calculator to complete this step.
3. Determine a scale that allows the circles to be a suitable size. In this example 1 mm = 100 units.
4. Use the scale to determine the radius of each circle. Write the radius to the nearest millimetre. For example:
   - Asia: 6679/100 ≈ 67 mm
   - Africa: 5506/100 ≈ 55 mm
   - North America: 4971/100 ≈ 50 mm
   - Central and South America: 4247/100 ≈ 42 mm.
5. Draw four circles that have a radius of 67 mm, 55 mm, 50 mm and 42 mm.
6. You can, of course, scale down your graph. For example, by dividing each value in Step 5 by two you significantly reduce the space occupied by the graph.
7. Label each circle and record the actual area of each continent in brackets next to each name.
8. Give your graph an appropriate title.

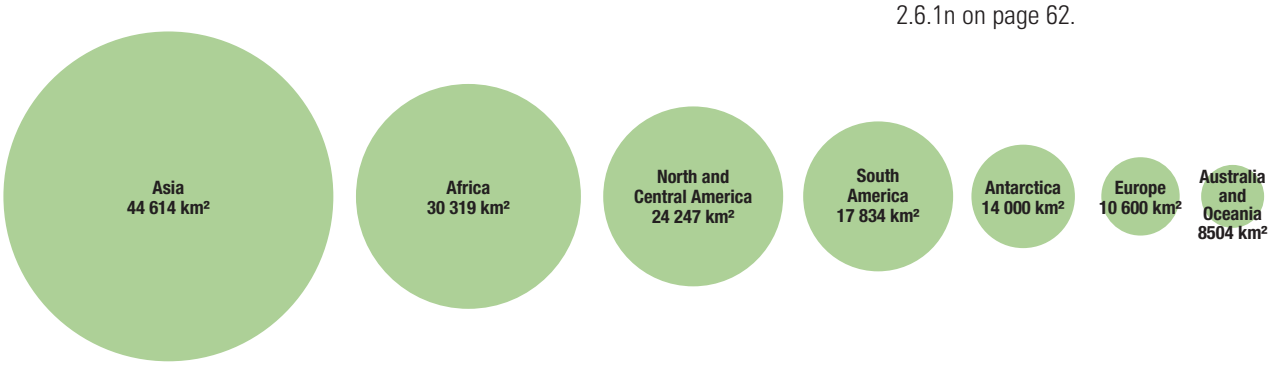

Figure 1.11f Proportional circles showing the relative size of the Earth's continents (in '000s km^2)

Picture graphs

Picture graphs are used to present information in a way that is both visually appealing and informative. In Figure 1.11g, a column graph showing the proportion of the population living in urban centres by continent in 2020, pictorial elements have been used to communicate information.

In other instances, pictorial symbols are used to represent a particular value or quantity. In such graphs, you need to multiply the total number of symbols by the value each symbol represents. For example, half symbols represent half the value. When reading such graphs it is important to read the legend.

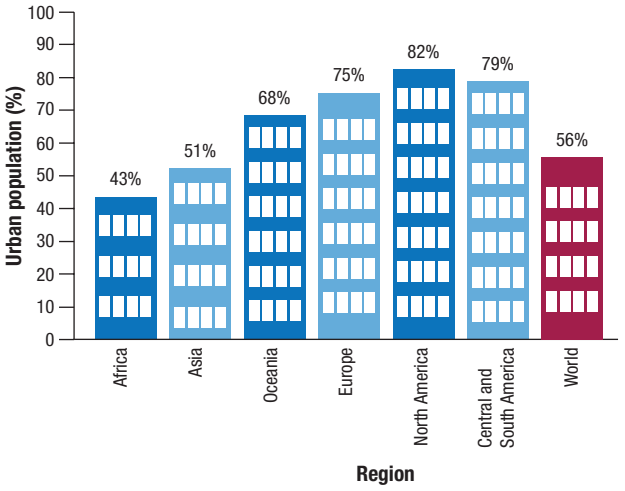

Figure 1.11g Picture graph showing the percentage of the population living in urban centres by continent, 2020

Population pyramids

Population pyramids are bar graphs used to show the male/female breakdown of each age group in a population. The vertical axis of the graph represents the various age groups of the population. The horizontal axis shows either the actual number or the proportion of the population for both males and females.

Each population pyramid represents 100 per cent of a particular population. This allows comparisons to be made with the population pyramids of other populations.

To assist in these comparisons, population pyramids can be drawn on top of each other. This enables us to compare the population structure of a population with another or the changes that occur in a population over time. Figure 1.11h (page 26) compares the structure of the German population in 2020 and 2050.

The shape of the pyramid is also important because it tells us a lot about the particular population. For example:

- If the base of the pyramid is wide, then the population is said to be 'young'. An example is the population pyramid for Nigeria shown in Figure 2.6.1n on page 62.
- If the upper part is relatively wide, then the population is said to be 'old' or 'ageing'. An example is the population pyramid for Italy shown in Figure 2.6.1n on page 62.
- Events such as war, famine, diseases or large-scale emigration may explain why there are fewer people in a particular age group.
- The effects of a 'baby boom' and/or immigration may explain why there are more people than expected in a particular age group.

Figure 1.11j (page 26) shows a series of pyramid shapes with an explanation of the conditions under which such population structures develop.

Interpreting statistical data: percentage

When analysing statistics it is often useful to compare a new value with the original value. This is called the percentage (or proportional) change. To calculate the percentage change, apply the following formula.

$$\text{Percentage change} = \frac{\text{Difference}}{\text{Original}} \times \frac{100}{1}$$

(Difference: the difference between the two values; Original: the original value)

Example

In 1950, the world's population was 2.55 billion. In 2016, it was 7.4 billion. Calculate the percentage increase between 1950 and 2016.

Difference: 7.4 billion – 2.55 billion
= 4.85 billion
Original value: 2.55 billion

$$\text{Percentage change} : \frac{4.85}{2.55} \times \frac{100}{1}$$
$$\approx 190.2\%$$

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Grant Kleeman

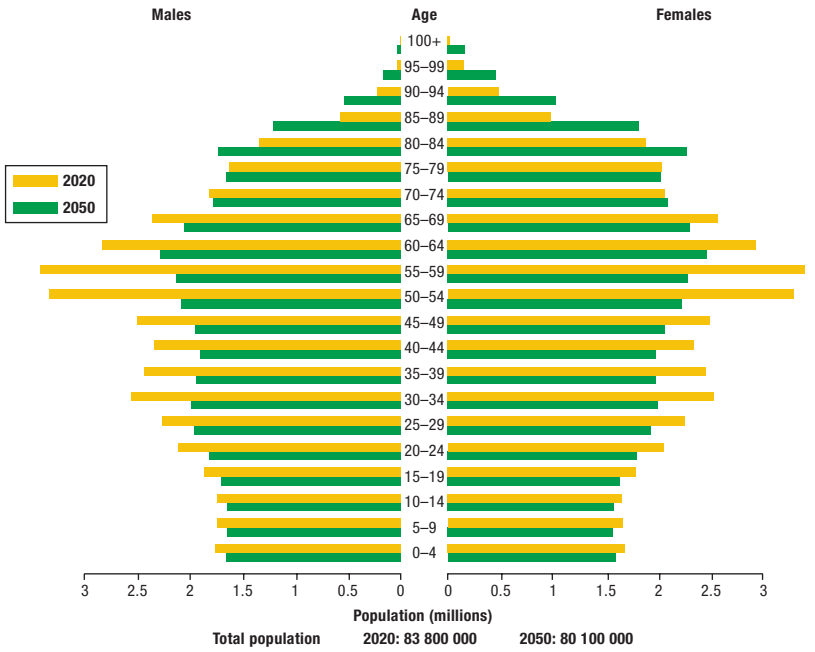

Figure 1.11h Population pyramid comparing the age and male/female structure of the German population in 2020 and the projected structure for 2050

Populations are often divided into broader age groups based on their level of independence. The dependent parts of the population are usually defined as the 14 years and under age group and the 65 years and over age group. The changing proportion of the population in each of these age groups provides us with valuable information about future population trends.

If the proportion of the population aged 65 years and over is growing, the population is said to be ageing. If the proportion of the population aged 14 years and under is decreasing, we can conclude that the birth rate is declining, as is the rate of population increase.

Note: Sometimes the horizontal scale shows the actual number of people in each age group. Before you try to interpret a graph always check the units of measurement used.

Figure 1.11i Japan has the highest proportion of people aged 65 and over in the world.

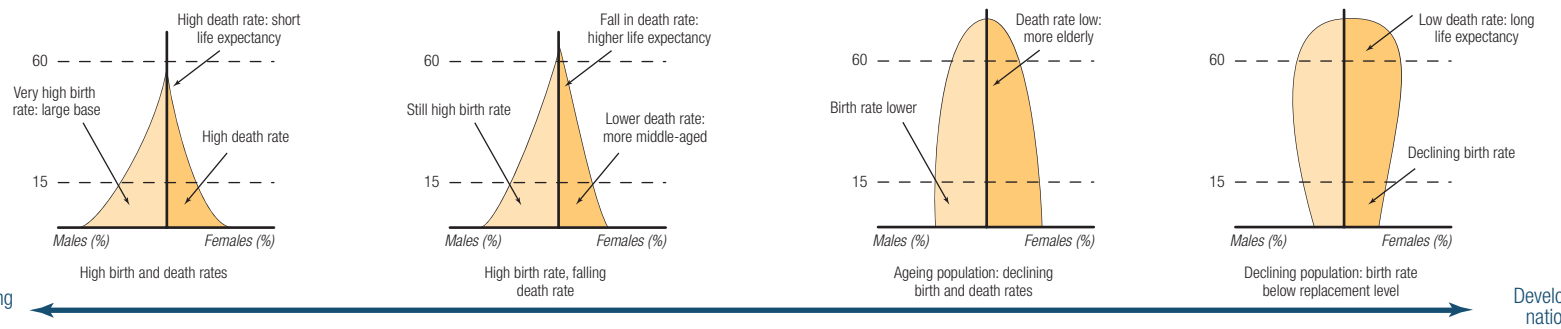

Figure 1.11j Common population pyramid shapes and the conditions under which they develop

ACTIVITIES

1 Name the graph best suited to showing values that change over time.

2 Distinguish between bar and column graphs.

3 Name the two types of proportional graphs.

4 Outline the key features of a pie graph.

5 Explain what proportional circle graphs are used to show.

6 Outline why picture graphs are commonly used to present information.

7 State what population pyramids show.

8 Explain what the shape of a population pyramid tells us about a population.

9 Study Figure 1.11b (page 24) and then complete the following tasks:
- **a** State the year in which the annual rate of world population growth rate peaked.
- **b** Identify the trend in the annual rate of world population increase since the late 1980s.

10 Study Figure 1.11c (page 24) and then complete the following tasks:
- **a** State the population of China.
- **b** Estimate the number by which the population of China exceeded that of India in 2020.

11 Study Figure 1.11d (page 24) and then complete the following tasks:
- **a** Name the country with the greatest annual rate of population increase.
- **b** Name the countries with a negative annual rate of population increase.

12 Study Figure 1.11e (page 25) and then complete the following tasks:
- **a** State the proportion of the world's population found in Asia.
- **b** State the number of people living in Africa.

13 Study Figure 1.11f (page 25) and then complete the following tasks:
- **a** State which has the larger area: South America or Antarctica.
- **b** State the area of Asia.

14 Study Figure 1.11g (page 25). Identify the continents with the percentage of their population living in urban centres below and above the world's average.

15 Study Figure 1.11h and then complete the following tasks:
- **a** Estimate the number of Germans under the age of 15 years in 2020 and 2050.
- **b** Estimate the number of Germans aged 75 years and over in 2020 and 2050.
- **c** Estimate the proportion of the German population under the age of 15 years in 2020 and 2050.
- **d** Estimate the proportion of the German population aged 65 years and over in 2020 and 2050.

16 Use the data in Table 1.11a to construct a line graph showing the growth in the world's population since 1800.

17 Use the data in Table 1.11b to construct a bar graph showing the projected population of the world's most populous countries in 2050.

18 Use the data in Table 1.11c to construct a column graph showing the rate of natural population increase for selected countries in 2020.

19 Use the data in Table 1.11d to construct a pie graph showing the proportion of the world's population living in the developed and developing worlds in 2020.

Table 1.11a Actual and projected world population, 1800–2050

Year	Population (billion)
1800	1.00
1850	2.55
1900	1.60
1950	2.55
2000	6.00
2050	9.20

Table 1.11b Projected population of the world's five most populous countries, 2050

Country	Population (million)
India	1663.0
China	1366.1
USA	385.7
Nigeria	401.3
Pakistan	347.8

Table 1.11c Rate of natural increase (%), 2020

Country	Rate of natural increase (%)
Australia	0.6
Germany	–0.2
India	1.4
Mali	3.6
Russia	–0.2
World	1.1

Table 1.11d Number of people living in developed and developing worlds, 2020

Region	Population (million)
More developed	1272 million
Less and least developed	6501 million
Total	7773

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1.12 Specialist maps

Choropleth maps

Choropleth maps use shading, symbols and colour to show the average density, or concentration, of features such as population and rainfall. Figure 1.12a, for example, shows the population density of Indigenous Australians in 1788 using four shades of the one colour.

When drawing choropleth maps, each area that falls within a particular range is allocated the appropriate colour or shade until the overall pattern is revealed.

Shadings should be graded from the deepest colour for the highest value down to the lightest colour for the lowest value.

Usually, shades of one colour are used; for example, dark red down to light red.

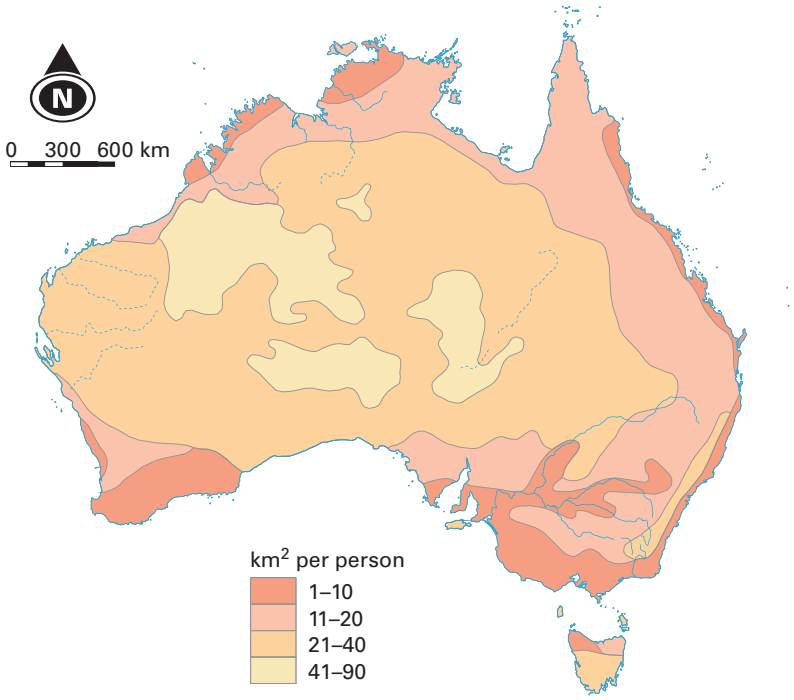

Figure 1.12a Choropleth map showing the population density of the Indigenous Australian population, prior to the beginning of European colonisation in 1788

Dot maps

Dot maps are used to illustrate the distribution and density of a particular feature.

Figure 1.12d shows the distribution of Indigenous Australians at the 2011 Census. The map consists of a number of dots representing a specific value (1 dot = 100 people). It is also possible to have dots of different sizes representing different values or quantities.

Figure 1.12b Aerial view of the remote iron ore mining town of Newman, Western Australia.

Figure 1.12c Maps can be used for many different purposes.

Steps in constructing choropleth maps

To construct a choropleth map, follow the steps below:

1. Examine the data and decide on the categories that you will use. Make sure that they are logically spaced; for example, 1–10, 11–20, 21–30.
2. Make sure that you have at least three categories of data.
3. Select a different shade of the one colour for each of your categories.
4. Colour in your map.
5. Include a legend that shows the value range for each colour used.

When interpreting choropleth maps it is important to remember that considerable differences can exist within an area, even though areas may have the same colour or type of shading. World maps, for example, usually present data for particular countries. National borders often become the boundaries between different ranges of values, resulting in generalisations and the neglect of localised variations in the feature being mapped.

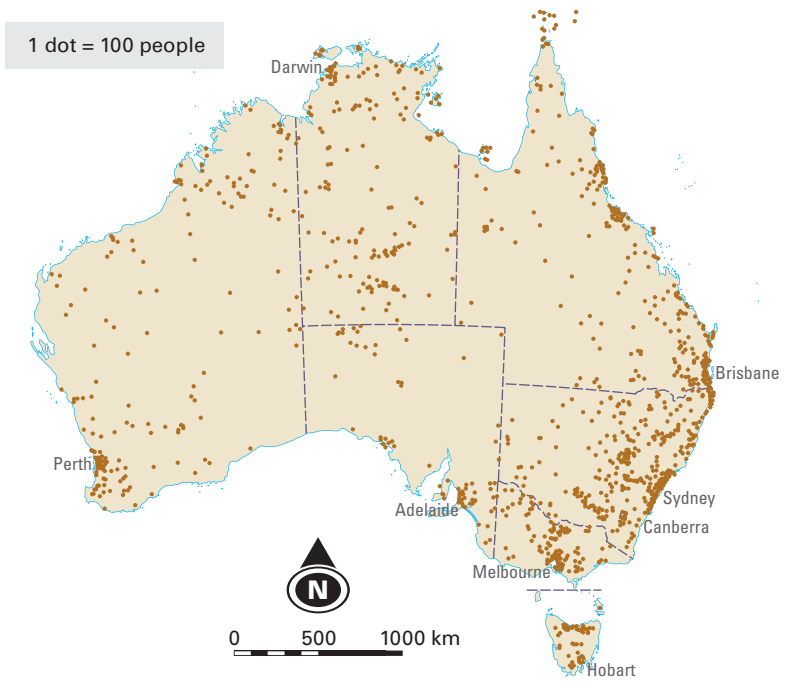

Figure 1.12d Dot map showing the population distribution of Indigenous Australians, 2011 Census

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Flowline maps

Flowline maps show the movement of information, goods and people between places, and the quantity of such movements. Movements are shown by lines or arrows that link the place of origin with the destination. The quantity moved between places is indicated by the width of the line or arrow. The map's legend indicates the value of the flowlines. (See Figure 1.12e.)

Steps in constructing flowline maps

To construct a flowline map, follow the steps below:

1. Arrange the data from the largest to smallest units.
2. Select suitable categories and use a ruler to draw lines of varying thicknesses; one line for each category of data. The thickness of the line should reflect the quantity that it represents; for example, use a 2-mm thick line for 0–20 units, a 4-mm thick line for 21–40 units, a 6-mm thick line for 41–60 units, and so on.
3. Using a pencil, mark on the information you are mapping. Make sure that the thickness of the line represents the category of data being mapped.
4. Make any adjustments to the position of your lines to avoid them crossing over and being too close to one another.
5. Add arrow heads if necessary.
6. Go over your lines, or arrows, in ink and add colour if considered necessary.
7. Add suitable labels and give your map a title.

Cartograms

A *cartogram* (value-by-area map) is a special kind of thematic map that resizes each territory according to the variable being mapped. Figure 1.12f shows population by country. The map illustrates the relative sizes of the populations of the countries of the world by scaling the area of each country in proportion to its population; the shape and relative location of each country is kept to as large an extent as possible, but inevitably a large amount of distortion occurs.

ACTIVITIES

Distinguish between choropleth, dot, flowline and cartogram maps. Using the internet, find examples of each type of map featured on pages 27 and 28.

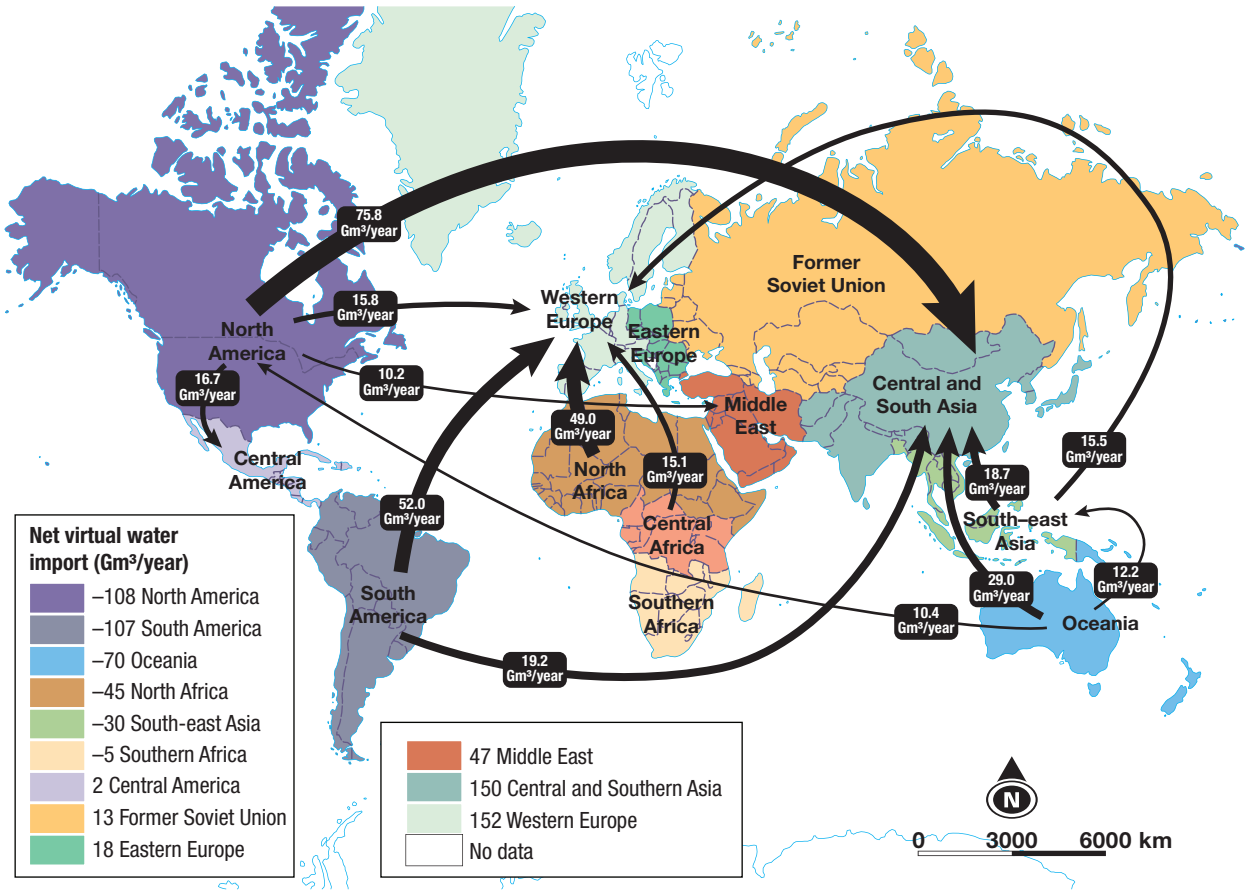

Figure 1.12e Flowline map showing net importers and exporters of virtual water. Virtual water is water 'hidden' in other commodities. For example, if a country imports a crop that takes a lot of water to grow, then it is importing the 'virtual water' as well.

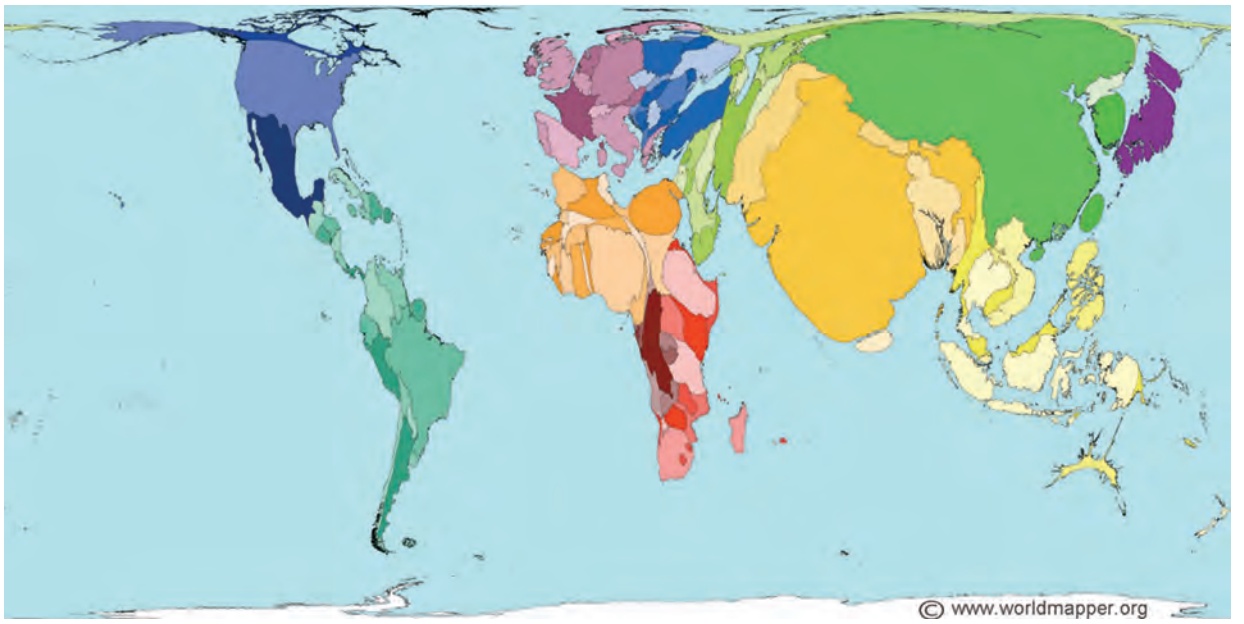

Figure 1.12f Worldmapper cartogram: population by country

Figure 1.12g The population of India is predicted to exceed that of China by 2027.

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SECTION 2 Key themes in geography

2.1 Landscapes and landforms

2.1.1 LANDFORMS

Figure 2.1.1a Matterhorn, Switzerland

The landforms and landscapes featured on topographic maps have been shaped by the processes of weathering and erosion. *Weathering* involves the chemical and physical breakdown of rock into smaller fragments. Running water, wind and ice (the *agents of erosion*) then erode, transport and deposit large amounts of weathered material. The landform features created by weathering and erosion can be classified as either *erosional* or *depositional*. Being able to identify and name these landform features is an important geographical skill.

Common landform features

Figure 2.1.1b illustrates some common landform features that are shown on topographic maps and can be observed during fieldwork. These features include the following:

- *Basin* – an area of relatively level ground surrounded by hills or an area drained by a river and its tributaries.
- *Crest* – the highest part of a hill or mountain range.
- *Escarpment* – the steep hillside formed by a sudden drop in elevation, usually from a plateau.
- *Gorge or canyon* – a deep ravine, usually with very steep sides.
- *Knoll* – a low, detached hill.
- *Plateau* – a large, elevated area of relatively flat land.
- *Ravine* – a long, deep valley carved out by a stream.
- *Re-entrant* – a valley or ravine, usually between two spurs, running inwards towards the hill or mountain top.
- *Ridge* – the line along a hill or range of hills or mountains from which the water flows in opposite directions; sometimes referred to as a 'watershed'.
- *Saddle* – a depression between the tops of adjacent hills or mountains.
- *Spur* – a ridge running out from a hill or mountain.

Arid landform features

Figure 2.1.1c shows the distinctive landform features of arid lands. Running water is the most important agent of erosion in arid (desert) environments. Although it does not rain there often, when it does the rain is often very heavy and results in flash flooding. Because there is no vegetation, run-off is very rapid and can erode large amounts of weathered material.

Surface run-off is channelled into dry riverbeds (*wadis*) that cut through plateaus, forming canyons or gorges. As plateaus are eroded, *mesas* (sometimes known as outliers) and *buttes* (see Figure 2.1.1d, page 30) are left isolated from the retreating *escarpment*. Mesas are wider than they are high, while buttes are higher than they are wide.

The eroded material is often deposited onto lowlands, forming *alluvial fans*. These spread out across the desert basin (or bolson), where the fine particles can be shaped into dunes by the wind (see Figure 2.1.1e, page 30).

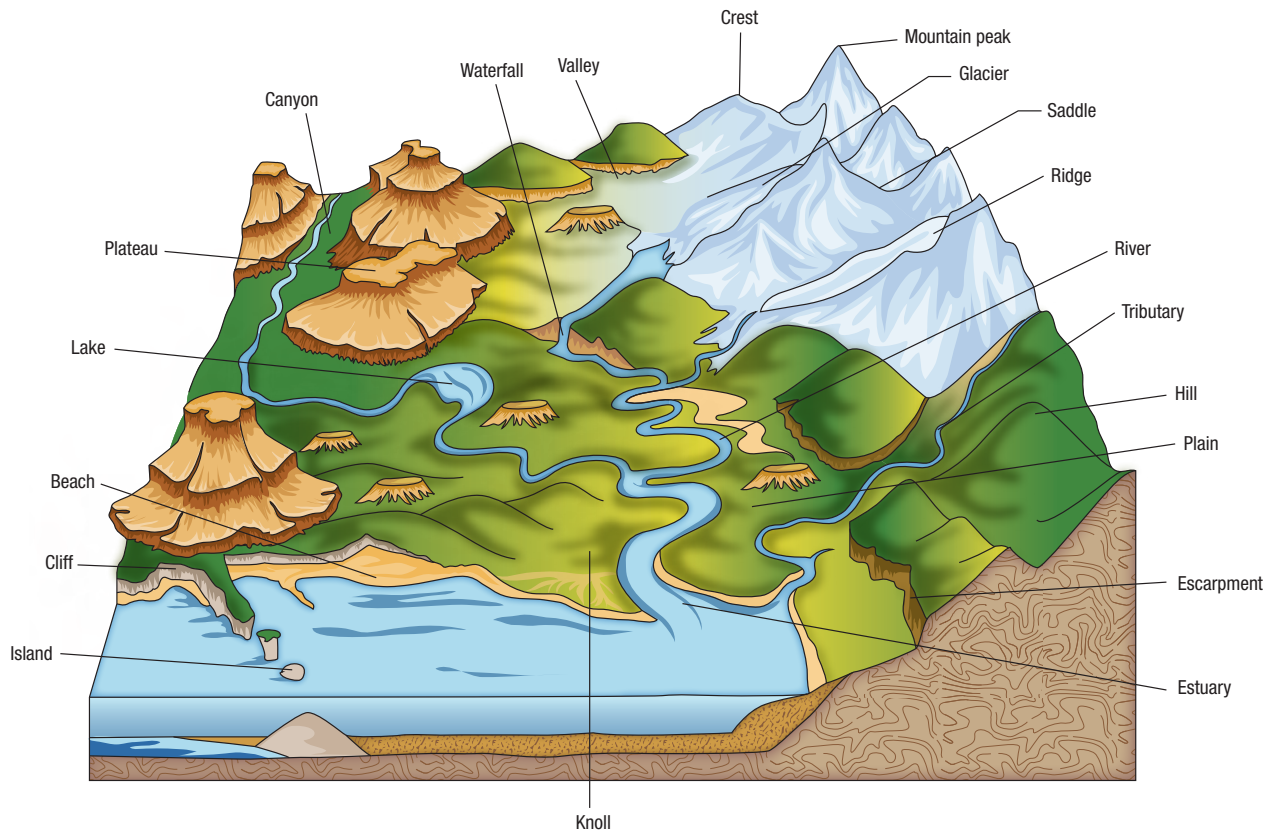

Figure 2.1.1b Some common landform features

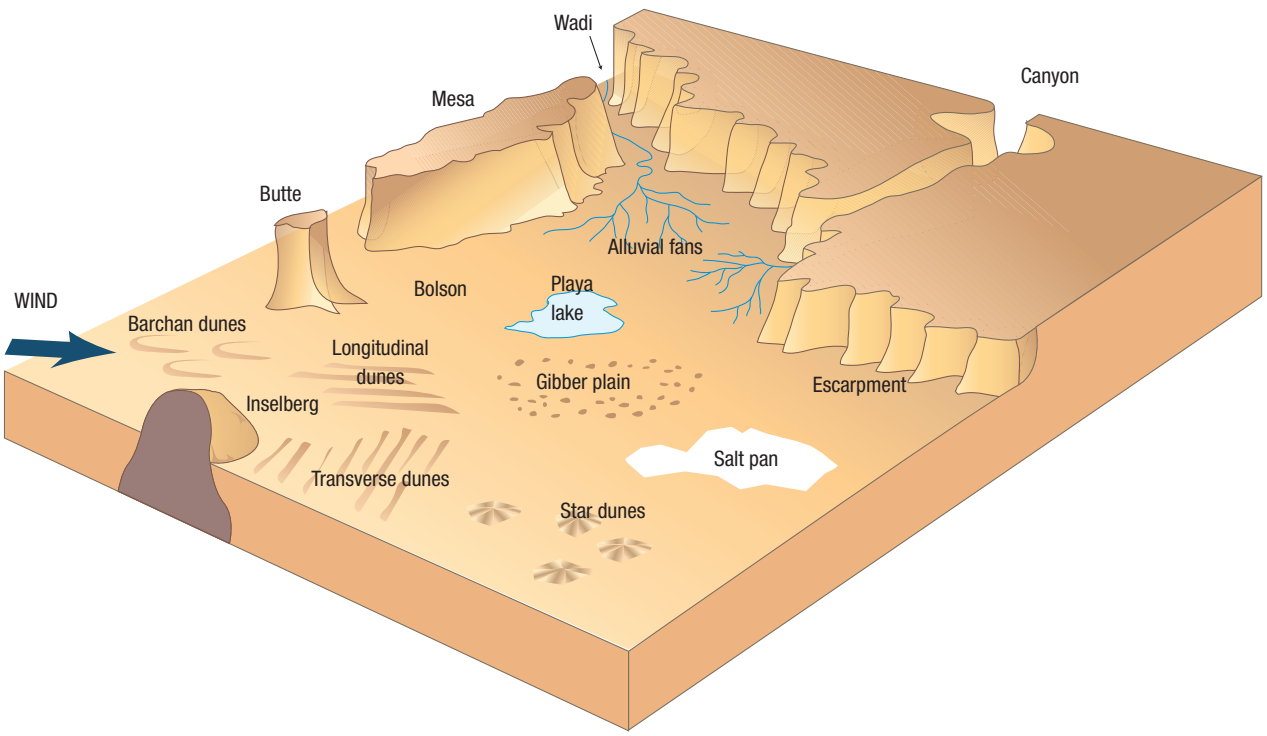

Figure 2.1.1c Landforms of arid environments

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Figure 2.1.1d Mesas and buttes in Monument Valley, United States

Where water flows into a desert depression, *playa lakes* form. When the water eventually evaporates, *salt* (or *clay*) *pans* are formed.

Inselbergs are large masses of resistant rock that rise abruptly from the surrounding plain. They are exposed when the softer surrounding rock material is eroded. Uluru (Ayers Rock) is one of the world's best-known inselbergs.

Distinctive dune types include *star dunes*, *longitudinal dunes*, *transverse dunes* and *barchan dunes*.

Coastal landform features

Coastal environments are constantly changing. Some are eroded by storm waves, while others move towards the sea when waves deposit large amounts of sand. The features of erosional coasts include *headlands* and *bays*, *rock platforms* and *cliffs*, *sea caves*, and *sea stacks* and *arches*. (See Figures 2.1.1f and 2.1.1g.) When storm waves crash against a cliff, they widen and deepen the cracks in the rock face. Eventually the cliff is undercut, collapses and retreats.

The features of *depositional coasts* include *sand dunes*, *tombolos*, *sandbars* and *sand spits*. In good weather, waves and onshore winds deposit large amounts of sand. This builds up a protective barrier between the land and the sea. Over time this barrier is strengthened by the growth of vegetation. (See Figure 2.1.1h.)

Glacial landform features

Glaciers are slow-moving rivers of compacted snow. They form when compacted snow, which has gathered over many years, gradually moves downhill under the influence of gravity.

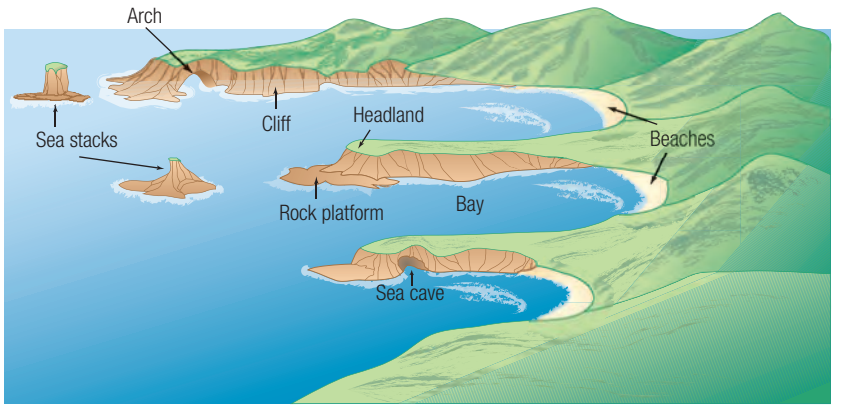


Figure 2.1.1g Erosional features of the coastal environment

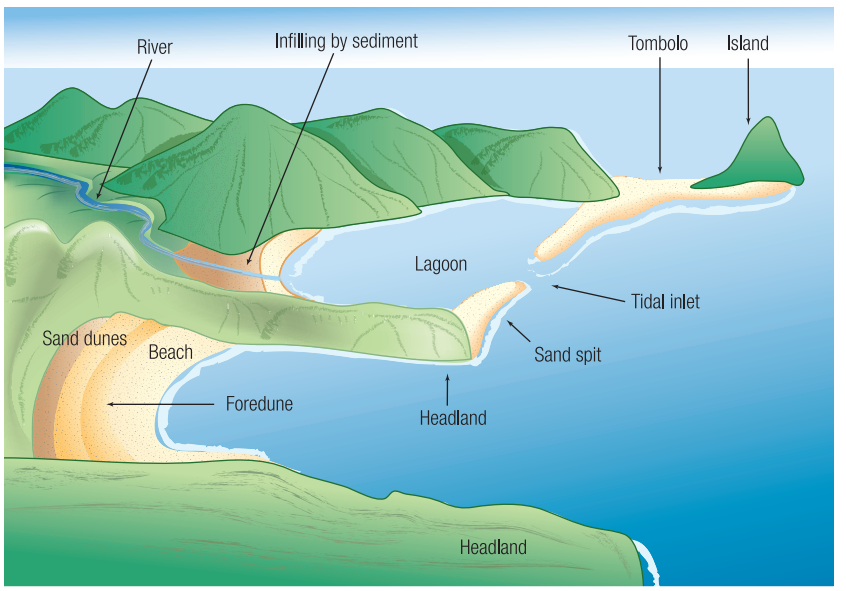


Figure 2.1.1h Depositional features of the coastal environment

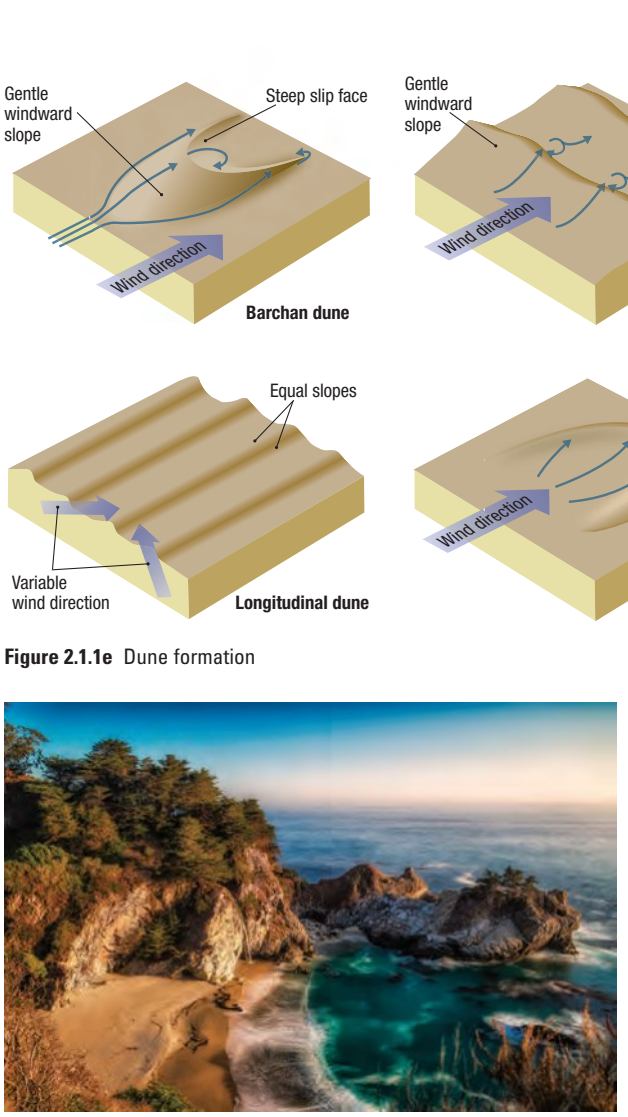
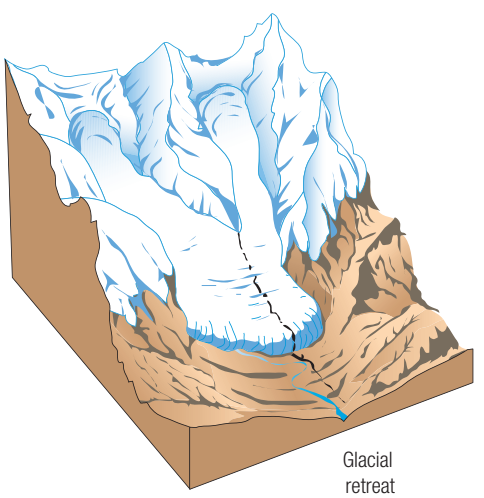


Figure 2.1.1e Dune formation

Figure 2.1.1i Mount McKinley, Alaska

Figure 2.1.1f The spectacular coastline of Big Sur on the west coast of the United States is dominated by erosional landform features.



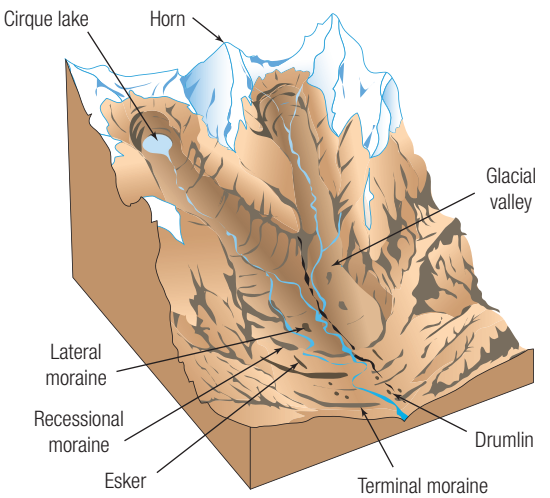


Figure 2.1.1j Glacial landform features

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Glaciers and *ice sheets* are very effective at eroding and transporting rock. The surface of the land is scratched and worn down by rock fragments that have been picked up from the ground and frozen into the base of the glacier. This process is known as *abrasion*. Figures 2.1.1i and 2.1.1j show some of the distinctive landform features associated with glaciers.

Figure 2.1.1k Former glacial valley, Furka, Switzerland

Rivers: shaping the land

Rivers shape the land by eroding, transporting and depositing material. In their mountainous *headwaters*, rivers erode downwards. This forms narrow *V-shaped valleys*. The point at which the river starts is called its source.

Away from the mountains, valleys become wider and some of the river's load of *sediment* is deposited. Closer to the sea, the river flows across a wide, flat plain, depositing fine particles of soil called *alluvium*. These alluvial soils are usually very fertile. Where the river enters the sea, an estuary (or delta) forms.

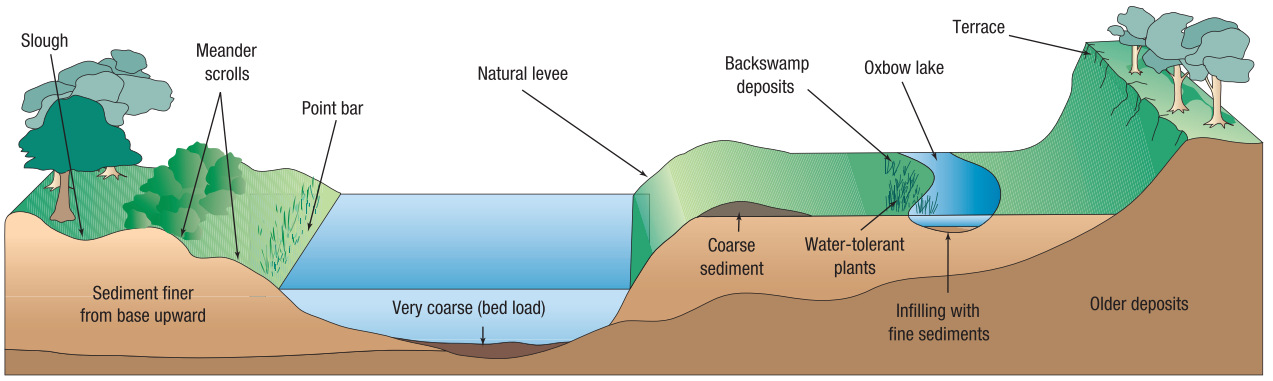

Figure 2.1.1l Landform features of the floodplain of a river

A *catchment*, or drainage basin, is the area of land that is drained by a river and its *tributaries*. Tributaries are smaller rivers and streams that flow into larger rivers. The boundary of the catchment is marked by a ridge of elevated land. This boundary is called a *watershed*. (See Figure 2.1.1m.)

Some rivers only flow after heavy rainfall. These are called *intermittent rivers*. On topographic maps they are usually shown by a broken blue line.

River *meanders* develop when the river undercuts the outside bank of a river channel and deposits silt and sand on the inside bend. During floods, loops in the river may be cut off, forming a *billabong* (or *oxbow lake*). (See Figures 2.1.1n and 2.1.1o.)

Figure 2.1.1l illustrates the landform features commonly found on the floodplain of a river.

Waterfalls develop when a hard layer of rock forms a barrier to a river's downcutting action. The power of the falling water forms a plunge pool at the base of the waterfall. (See Figure 2.1.1p.) Often, the rock below the more resistant layer will be eroded, creating a cave-like formation or rock shelter.

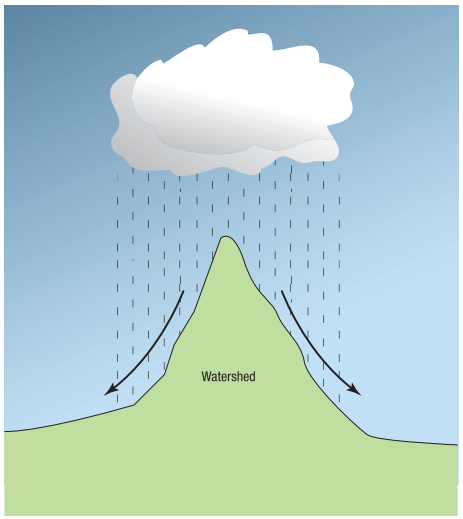

Figure 2.1.1m A watershed divides one catchment from another.

Figure 2.1.1n Meandering river, Tambopata National Reserve, Peru

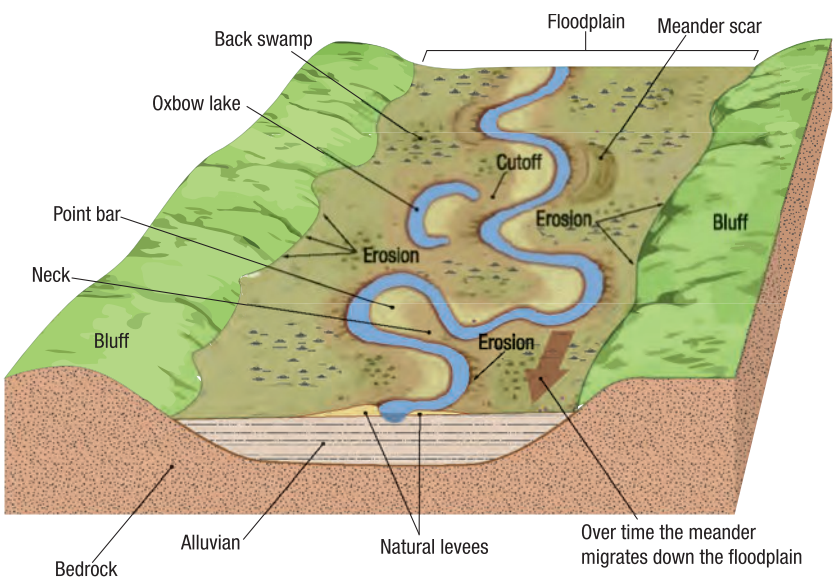

Figure 2.1.1o Formation of river meanders

Figure 2.1.1p The Iguazu Falls on the Argentine-Brazilian border

ACTIVITIES

1. Distinguish between the processes of weathering and erosion.
2. What are the agents of erosion?
3. Draw a series of sketches featuring the following landform features: escarpment, gorge, plateau, saddle and spur. Draw one sketch per feature.
4. What is the most important agent of erosion in deserts?
5. Explain the processes responsible for the formation of barchan, longitudinal, transverse and blowout dunes.
6. Distinguish between a mesa and a butte.
7. What is an inselberg?
8. List the landform features commonly associated with:
   a. erosional coasts
   b. depositional coasts.
9. What is a glacier? How is it formed?
10. What is abrasion? How do glaciers abrade the landscape?
11. Research task: investigate how cirque lakes are formed.
12. Draw an annotated sketch featuring the landform features associated with the work of rivers.

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2.1.2 AUSTRALIA'S LANDSCAPES AND LANDFORMS

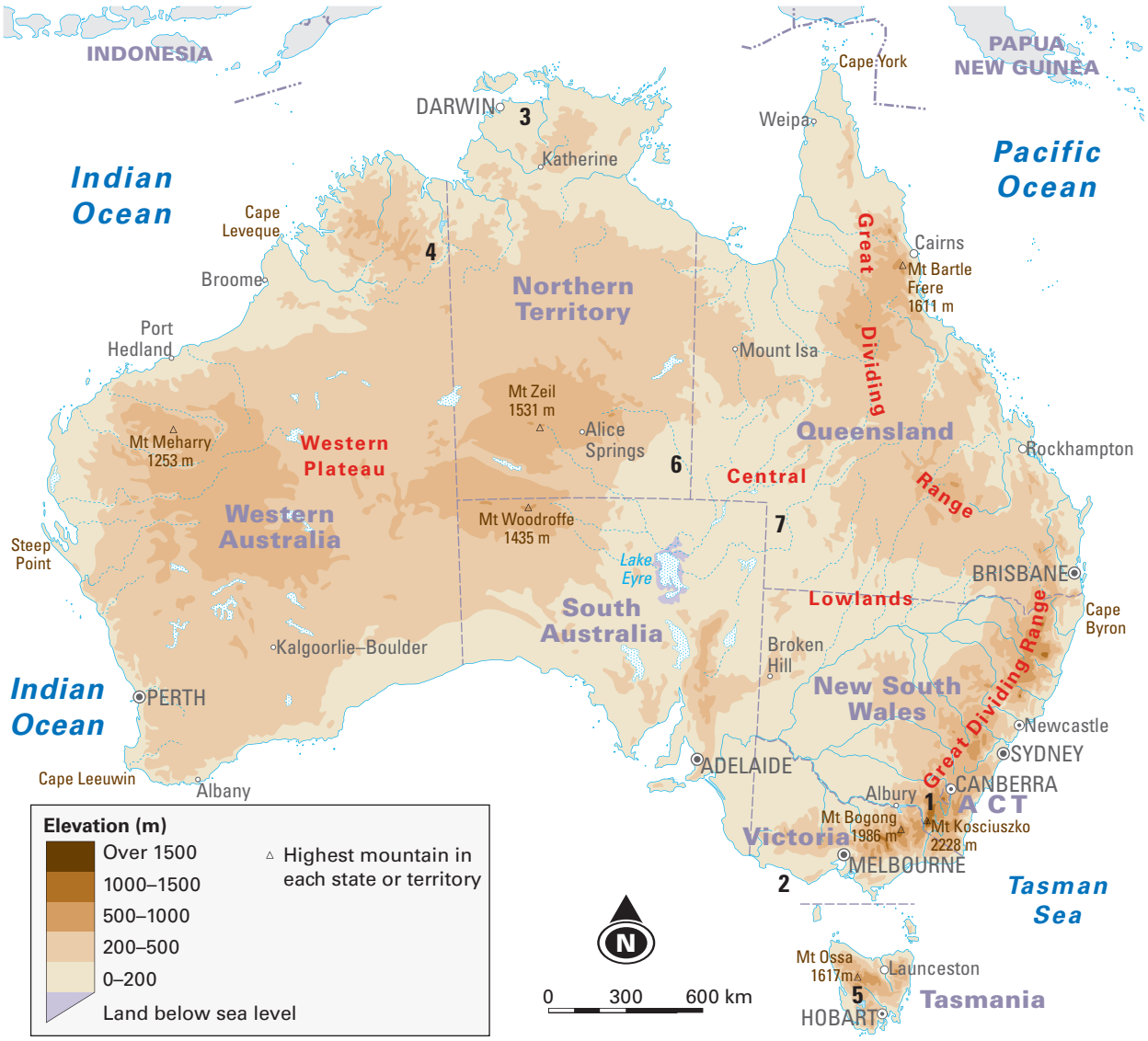

Figure 2.1.2a Australia's elevation

Figure 2.1.2b The Snowy Mountains (Australian Alps)

Figure 2.1.2c The Twelve Apostles

Figure 2.1.2d Kakadu's Jim Jim Falls

Figure 2.1.2e Bungle Bungle Range

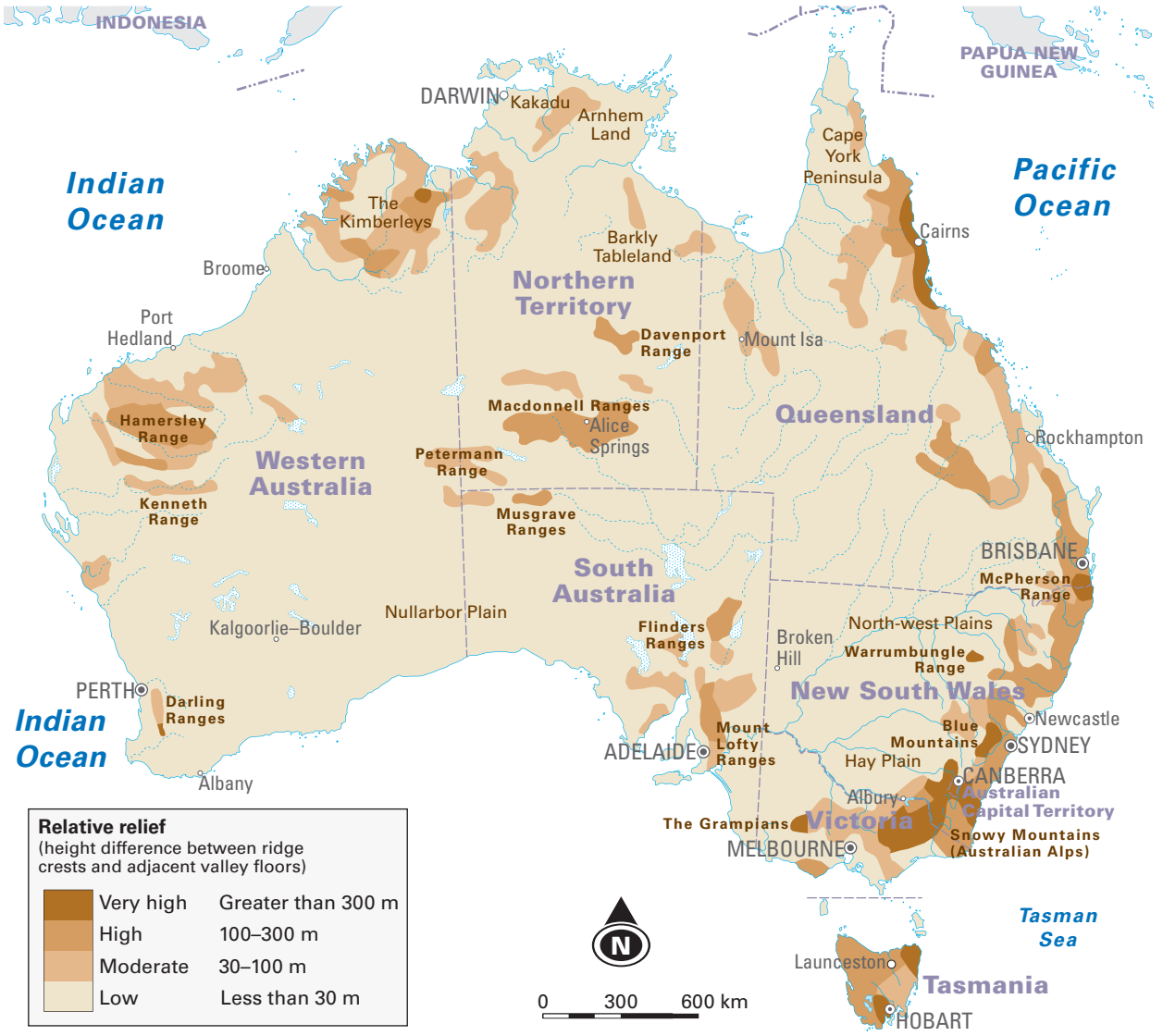

Figure 2.1.2f Australia's relative relief

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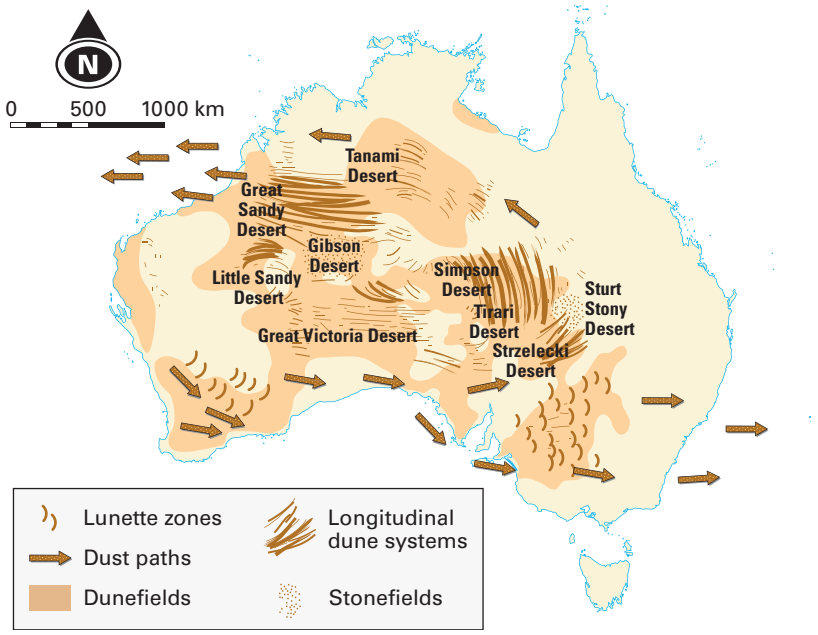

Figure 2.1.2g Australia's deserts: the alignment of dunes and the major dust paths

Figure 2.1.2h Franklin River, Tasmania

ACTIVITIES

1. Study Figure 2.1.2a and complete the following tasks:
   - a Name the three main landform divisions of Australia.
   - b Compare Figure 2.1.2a with an atlas map of the world. What evidence is there to support the observation that Australia is the 'flattest' of the continents?
2. Study Figures 2.1.2b to 2.1.2e and 2.1.2h to 2.1.2j. For each photo, identify the agent of erosion most responsible for the formation of the landscape shown.
3. Study Figure 2.1.2f. What is meant by the term 'relative relief'? With reference to Figure 2.1.2a, where is relative relief the greatest?
4. Study Figure 2.1.2g and Table 2.1.2b and answer the following questions:
   - a Where are Australia's deserts found?
   - b Which is Australia's largest desert?
   - c In which direction are the dunes aligned in the Great Sandy Desert?
   - d In which direction are the dunes aligned in the Simpson Desert?
   - e Which deserts are dominated by stonefields?
5. Select two photographs of contrasting landscapes.
   Construct photo sketches of the contrasting landscapes.
6. Study Figure 2.1.2k and complete the following tasks:
   - a What is the highest mountain in the state or territory in which you live?
   - b Calculate the difference in elevation between Mount Kosciuszko and the highest mountain in the state or territory in which you live.
   - c Calculate the difference in elevation between Victoria's highest peak and Mount Kosciuszko.
   - d By how much does the elevation of Mawson Peak on Heard Island exceed that of Mount Kosciuszko?
7. Study Table 2.1.2a. Construct a bar graph showing the relative size of Australia's plains.
8. Study Table 2.1.2b. Construct a column graph showing the relative size of Australia's deserts.

Figure 2.1.2i Sand dunes of the Simpson Desert

Figure 2.1.2j Sturt Stony Desert

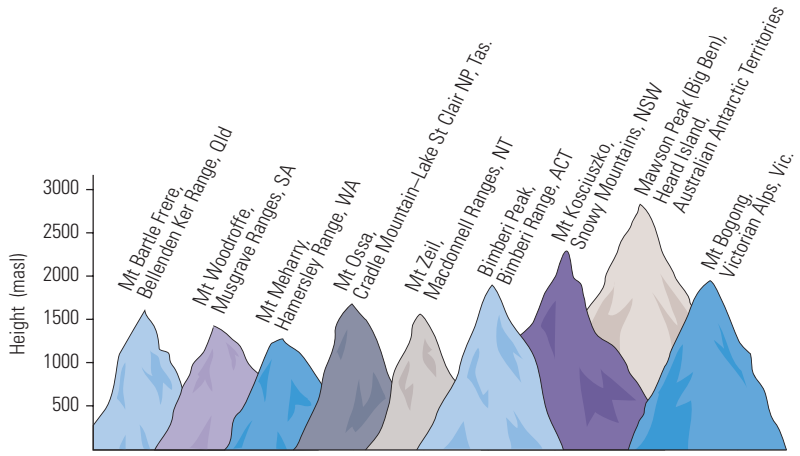

Figure 2.1.2k The highest mountain in each Australian state and territory

Table 2.1.2a Australia's plains, by size

Plain	Area (km²)
Lake Eyre Peneplain, Qld–SA–NT	1 170 000
Nullarbor Plain, SA–WA	270 000
Barkly Tableland, Qld–NT	240 000
North West Plains, NSW–Qld	145 000
Hay Plain, NSW	70 000

Table 2.1.2b Australia's deserts, by size

Name	Surface type	Area (km²)
Great Victoria Desert, SA–WA	Longitudinal dunes	348 750
Great Sandy Desert, WA	Longitudinal dunes	267 250
Tanami Desert, WA–NT	Sandplain	184 500
Simpson Desert, Qld–SA–NT	Longitudinal dunes	176 500
Gibson Desert, WA	Stony	156 000
Little Sandy Desert, WA	Longitudinal dunes	111 500
Strzelecki Desert, Qld–NSW–SA	Longitudinal dunes	80 250
Sturt Stony Desert, Qld–NSW–SA	Stony	29 750
Tirari Desert, SA	Sand dunes	15 250

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2.1.3 GEOMORPHOLOGICAL HAZARDS

Human activities, especially over the past two centuries, have had a huge effect on the environment and landscape through industrialisation and changes in land use, leading to climate change, deforestation, desertification, land degradation, and air and water pollution. These effects are strongly linked to the occurrence of geomorphological hazards, such as floods, landslides, snow avalanches, soil erosion and others. The work undertaken by geomorphologists includes not only the understanding but also the mapping and modelling of the Earth's surface processes, and many of these processes directly affect human activities and societies.

Geomorphological hazards include earthquakes and volcanic activity, and mass movements of soil and rock material. These hazards can kill tens of thousands of people, devastate whole communities, disrupt communications and cause great economic hardship.

Plate tectonics

The Earth's *crust* is broken into eight vast segments or *plates* (and several smaller plates) that travel slowly across the face of the planet, a movement powered by currents deep within the Earth's liquid *mantle*. The name given to this process is *plate tectonics*.

Earthquakes

Earthquakes occur when the pressure deep within the Earth's crust builds and is then released suddenly. While they are most commonly associated with the movement of the Earth's crustal plates, smaller, often less destructive earthquakes can occur well away from the plate margins. These are usually associated with faults (lines of weakness) in the rock strata.

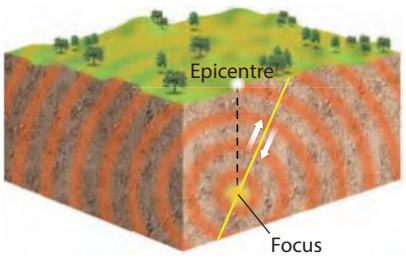

Figure 2.1.3d Earthquake epicentre and focus

Volcanic eruptions

Volcanic eruptions occur when molten material (*magma*) forces its way to the Earth's surface through cracks or faults in the Earth's crust.

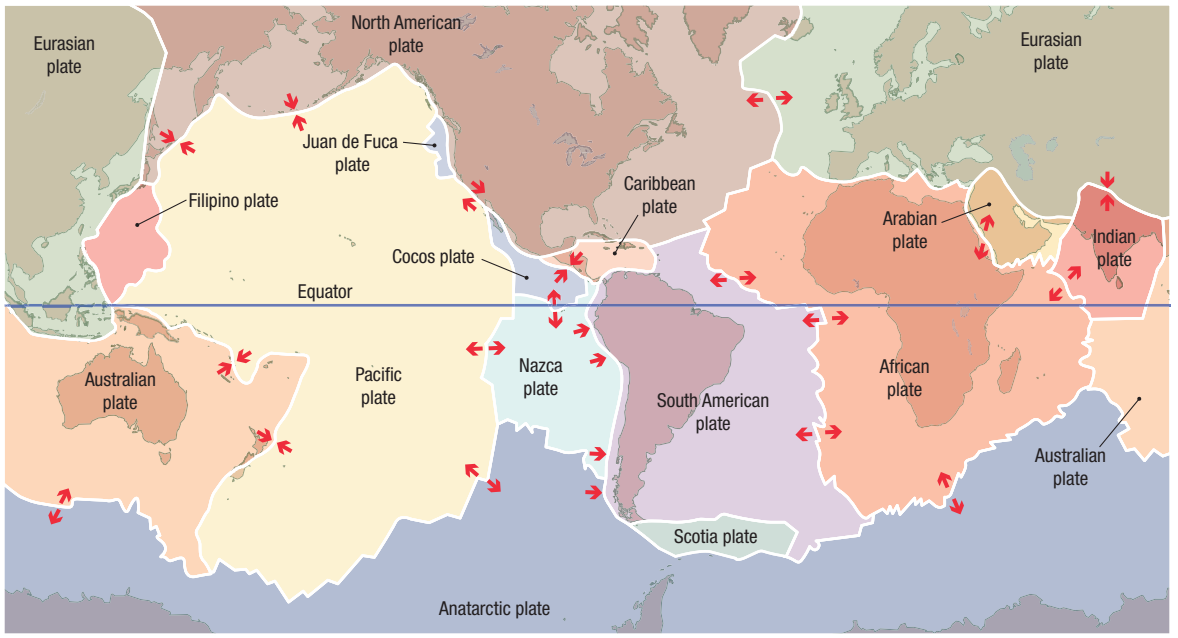

Figure 2.1.3a The Earth's crust is broken into eight vast segments, or plates, and several smaller plates.

Type of margin	Divergent	Convergent	Transform
Motion	Spreading	Subduction	Lateral sliding
Effect	Constructive (oceanic lithosphere created)	Destructive (oceanic lithosphere destroyed)	Conservative (lithosphere neither created nor destroyed)
Topography	Ridge/rift	Trench	No major effect
Volcanic activity	Yes	Yes	No

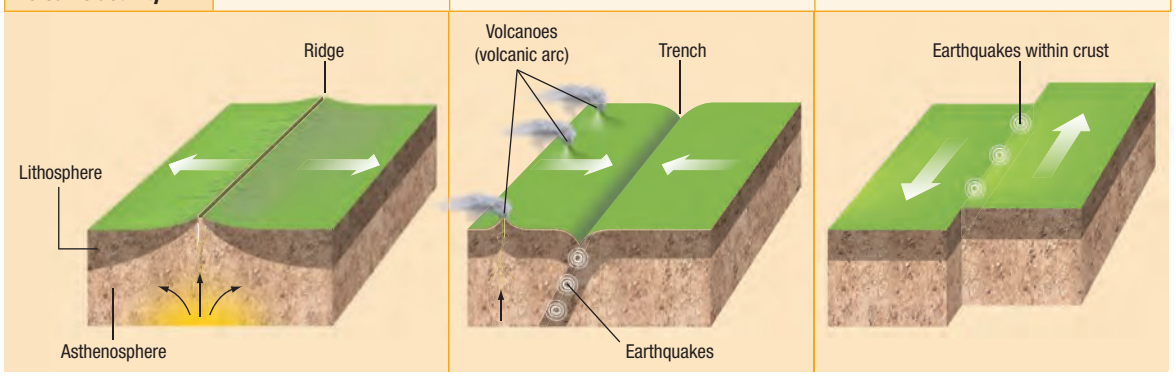

Figure 2.1.3b The three main tectonic plate boundary types

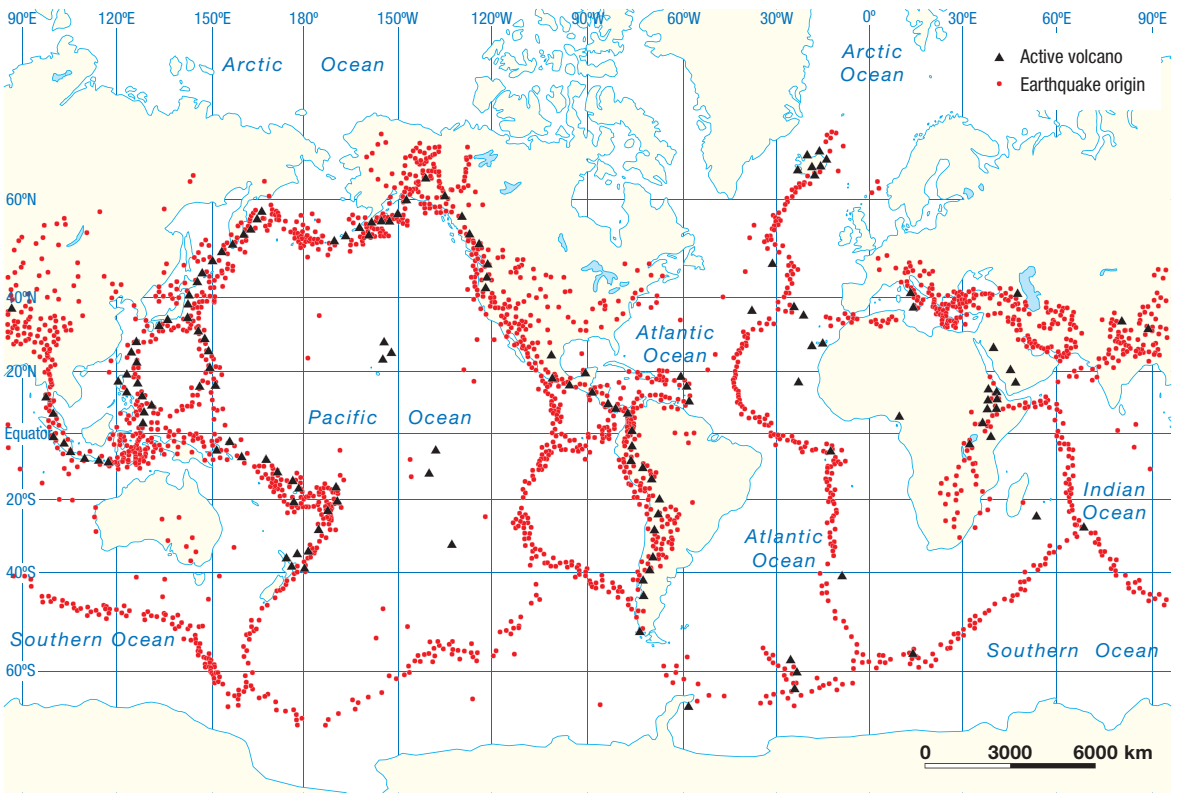

Figure 2.1.3c Recent earthquakes and volcanic eruptions

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Table 2.1.3a The Richter scale

Magnitude	Description	Impacts	Average frequency
Less than 2.0	Micro	Micro-earthquakes, not felt or felt rarely by sensitive people. Recorded by seismographs.	1 300 000
2.0–2.9 3.0–3.9	Minor	Often felt by people, but very rarely causes damage. Shaking of indoor objects can be noticeable.	130 000
4.0–4.9	Light	Noticeable shaking of indoor objects and rattling noises. Felt by most people in the affected area. Slightly felt outside. Generally causes no to minimal damage. Moderate to significant damage very unlikely. Some objects may fall off shelves or be knocked over.	13 000
5.0–5.9	Moderate	Can cause damage of varying severity to poorly constructed buildings. At most, no to slight damage to all other buildings. Felt by everyone. Casualties range from none to a few.	1319
6.0–6.9	Strong	Damage to many buildings in populated areas. Earthquake-resistant structures survive with slight to moderate damage. Poorly designed structures receive moderate to severe damage. Felt in wider areas, up to hundreds of kilometres from the epicentre. Damage can be caused far from the epicentre. Strong to violent shaking in epicentre area. Death toll ranges from none to 25 000.	134
7.0–7.9	Major	Causes damage to most buildings; some may partially or completely collapse or receive severe damage. Well-designed structures are likely to receive damage. Felt in enormous areas. Death toll ranges from none to 250 000.	15
8.0–8.9	Great	Major damage to buildings; structures likely to be destroyed. Will cause moderate to heavy damage to sturdy or earthquake-resistant buildings. Damaging in large areas, some totally destroyed. Felt in extremely large regions. Death toll ranges from 100 to approaching 1 million.	1
9.0–9.9		Severe damage to all or most buildings with massive destruction. Damage and shaking extends to distant locations. Permanent changes in ground topography. Death toll ranges from 1000 to potentially several million.	

Tsunamis

A tsunami is a series of ocean waves caused by a large earthquake or under-sea volcanic eruption. Tsunami waves are unlike those you see at the beach. They are a surge of water tens of metres high. While the impact of tsunamis is limited to coastal areas, their destructive power can be enormous and their effects extensive, as the world's coastal plains are the most densely settled areas of the Earth's surface.

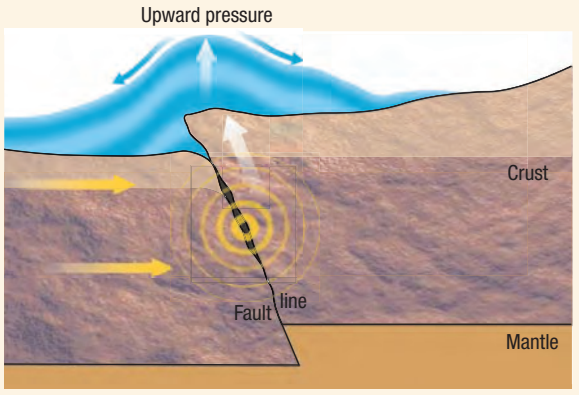

Figure 2.1.3e Tsunami wave formation

Table 2.1.3b Earthquake magnitude versus ground motion and energy

Magnitude change	Ground motion change (displacement)	Energy change
1.0	10.0 times	about 32 times
0.5	3.2 times	about 5.5 times
0.3	2.0 times	about 3 times
0.1	1.3 times	about 1.4 times

Table 2.1.3c Recent earthquakes and their effects

Year	Place	Size*	Impacts
1976	Tangshan, China	7.8	250 000 dead; 650 000 homeless
1985	Mexico City, Mexico	8.1	10 000 dead; 1000 large buildings collapse
1989	San Francisco, United States	7.1	62 dead; further 81 die when freeway collapses
1993	Latur, India	6.4	24 000 dead; 150 000 homeless
1994	Los Angeles, United States	6.7	57 dead; 20 000 homeless; over 100 fires
1995	Kobe, Japan	7.2	5500 dead; 310 000 homeless
1998	North-east Afghanistan	6.1 6.9	February: 4000 dead June: 3000 dead; 28 villages destroyed
1998	Papua New Guinea	7.0	Earthquake at sea triggers a tsunami; 3000 dead
1999	Turkey	7.8	17 127 dead; 43 953 injured; 20 000 buildings destroyed
2003	Iran	6.3	45 000 dead; 30 000 injured
2004	Great Sumatra–Andaman earthquake and tsunami	9.2	225 000 dead across 11 countries
2008	Sichuan, China	7.9	69 000 dead; 374 600 injured; 4.8 million left homeless
2010	Chile	8.8	525 dead
2011	Christchurch, New Zealand	6.3	185 dead
2011	Japan (Tohoku) earthquake and tsunami	9.0	15 854 dead; 3155 people missing; 129 225 buildings totally destroyed, with a further 947 000 buildings partially damaged
2014	Ludian, China	7.0	617 dead; 2400 injured
2015	Nepal earthquake		9000 killed; 22 000 injured. Damage to property $10 billion.

* Richter scale

Figure 2.1.3f Lushan earthquake, China, 2013

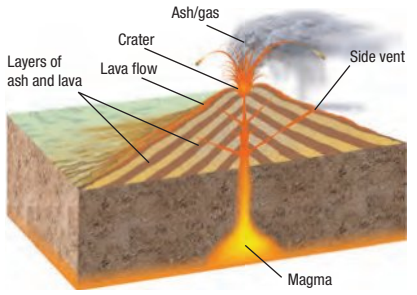

Figure 2.1.3g Features of a volcano

Figure 2.1.3h Active volcanic landscape, Bromo Tengger Semeru National Park, Indonesia

Table 2.1.3d Volcanic eruptions causing great loss of life

Year	Place	Impacts
1815	Tambora, Indonesia	92 000 people died, mostly in Indonesia because of starvation caused by the loss of crops and livestock
1883	Krakatau, the Sundra Strait, Indonesia	The resulting tsunami between Java and Sumatra killed 36 000
1902	Pelee, Martinique	Poisonous volcanic gases killed 36 000
1985	Nevado del Ruiz, Colombo	A wave of mud smothered 23 000
1991	Mt Pinatubo, the Philippines	900 people were killed
2010	Mt Merapi, Indonesia	353 people were killed and 350 000 people were evacuated

ACTIVITIES

1 Study Figures 2.1.3a and 2.1.3c. Describe the relationship between the distribution of earthquakes and volcanic eruptions.

2 Study Figure 2.1.3b. Distinguish between divergent, convergent and transform tectonic plate margins.

3 Study Figure 2.1.3d. Explain the difference between an earthquake's focus and its epicentre.

4 Study Table 2.1.3c. Select a recent earthquake event and note its magnitude. State the likely effects of an earthquake of that magnitude.

5 Study Table 2.1.3b. How much greater is the amount of energy released in an earthquake of magnitude 8 compared to one of 7? How much greater is the ground displacement?

6 Study Figure 2.1.3e. Write a paragraph explaining the origins of a tsunami.

7 Study Table 2.1.3c. Construct a column graph showing the death toll of the 10 most deadly earthquakes since 1976.

8 Study Figures 2.1.3g and 2.1.3h. Construct a photo sketch of the Bromo Tengger Semeru National Park's volcanic landscape. Annotate your sketch with the names of the prominent landform features shown.

9 Study Table 2.1.3d. Construct a column graph showing the death toll of the volcanic eruptions listed.

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2.2 Place and liveability

2.2.1 LIVEABILITY OF PLACES

The term 'liveability' refers to the characteristics of a city that contribute to the quality of life experienced by those who live in, or visit, the place. Indicators of liveability typically include: political stability, availability of goods and services including healthcare and education, low personal risk and efficient infrastructure.

Liveability surveys

There are three liveability rankings published each year.

1. The Economist Intelligence Unit (EIU) Global Liveability Index

The London-based EIU allocates a rating to 30 criteria grouped into five broad categories: stability; healthcare; culture and environment; education; and infrastructure. The ratings are then tallied to give a score of 1–100, where 1 is considered intolerable and 100 is considered ideal. The EIU's 2021 liveability report ranked cities in Australia, New Zealand, Japan and Switzerland as the most liveable cities in the world. For the most part, people living in these countries' cities have access to a wide variety of goods and services, low personal risk and quality infrastructure.

The index does not, however, take into account climate or the cost of living.

2. Mercer Quality of Living Survey

European cities dominate the Mercer Quality of Living Survey, with cities in New Zealand and Canada also ranked highly. Vienna, the capital of Austria, was Mercer's top-ranked city in 2019. Sydney was ranked number 11. The Mercer survey compares 221 cities on 39 measures, which include criteria related to personal safety, education, hygiene, healthcare, culture, environment, recreation, political-economic stability and public transportation.

3. Monocle's Most Liveable Cities Index

Monocle, a London-based lifestyle magazine, publishes an annual list of the most liveable cities. Denmark's capital, Copenhagen, was ranked the most liveable city in 2021, followed by Zurich in Switzerland. Sydney was ranked tenth and Melbourne seventeenth. The criteria used in this survey include safety/crime, international connectivity, climate/sunshine, quality of architecture, public transport, tolerance, environmental issues and access to nature, urban design, business conditions and medical care.

Table 2.2.1a Economist Intelligence Unit, Global Liveability Index, 2021

Rank	City	Country
1	Auckland	New Zealand
2	Osaka	Japan
3	Adelaide	Australia
4	Wellington	New Zealand
5	Tokyo	Japan
6	Perth	Australia
7	Zurich	Switzerland
8	Geneva	Switzerland
9	Melbourne	Australia
10	Brisbane	Australia

Table 2.2.1b Mercer Quality of Living Survey, 2019*

Rank	City	Country
1	Vienna	Austria
2	Zurich	Switzerland
3	Vancouver	Canada
4	Munich	Germany
5	Auckland	New Zealand
6	Dusseldorf	Germany
7	Frankfurt	Germany
8	Copenhagen	Denmark
9	Geneva	Switzerland
10	Basel	Switzerland

Table 2.2.1c Monocle's Liveable Cities Index, 2021

Rank	City	Country
1	Copenhagen	Denmark
2	Zurich	Switzerland
3	Helsinki	Finland
4	Stockholm	Sweden
5	Tokyo	Japan
6	Vienna	Austria
7	Lisbon	Portugal
8	Auckland	New Zealand
9	Taipei	Taiwan
10	Sydney	Australia

* Due to the COVID-19 pandemic more recent rankings were not published.

Criteria	Score 1 Very poor 2 Poor 3 Satisfactory 4 Good 5 Very good
Category 1: Environment	
• Temperature/humidity	1 2 3 4 5
• Quality of urban design and architecture	1 2 3 4 5
• Access to parks and gardens	1 2 3 4 5
• Amenity of streetscapes	1 2 3 4 5
• Maintenance of public spaces	1 2 3 4 5
Category 2: Cultural	
• Quality of community recreational facilities	1 2 3 4 5
• Availability of places of worship	1 2 3 4 5
• Diversity and quality of restaurants	1 2 3 4 5
• Availability of public libraries	1 2 3 4 5
• Range of entertainment venues	1 2 3 4 5
Category 3: Economic	
• Range of employment opportunities	1 2 3 4 5
• Access to affordable housing	1 2 3 4 5
• Access to consumer goods and services	1 2 3 4 5
Category 4: Infrastructure	
• Quality of road network	1 2 3 4 5
• Quality of public transport	1 2 3 4 5
• Quality of telecommunications infrastructure	1 2 3 4 5
• Availability of good quality housing	1 2 3 4 5
• Provision of utilities – water, electricity, sewerage	1 2 3 4 5
• Availability of cycle ways	1 2 3 4 5
Category 5: Education	
• Availability of private schools	1 2 3 4 5
• Quality of public schools	1 2 3 4 5
• Access to post-school educational institutions	1 2 3 4 5
Category 6: Health care	
• Quality of private healthcare	1 2 3 4 5
• Quality of public healthcare	1 2 3 4 5
• Availability of aged-care facilities	1 2 3 4 5
Category 7: Law and order	
• Amount of petty crime	1 2 3 4 5
• Amount of violent crime	1 2 3 4 5
• Graffiti and vandalism	1 2 3 4 5
• Sense of personal safety	1 2 3 4 5

Figure 2.2.1a Liveability survey sheet

Planning more liveable cities

Liveability, connectivity and affordability are the top three qualities people now demand in urban living. Better connections to all elements of a city – public transport, open spaces, parks, work, entertainment, shops, cafes and restaurants – are seen as the key elements of a better living environment.

People crave connectivity. People want to live in neighbourhoods close to where they work and entertain themselves. They want to live in places with excellent infrastructure, quality public spaces and efficient transport links.

The growing demand for such urban places has initiated a boom in the construction of medium- and high-density housing on sites close to public transport nodes, especially railway stations. Geographers refer to this process as urban renewal and urban consolidation.

Urban renewal (the redevelopment of an urban area) is most frequently considered a response to the process of urban decay – the process by which a previously functioning part of a city falls into disuse and disrepair. The transformation of such areas into high-density residential precincts is an example of urban consolidation. Urban consolidation (or densification as it is often called) involves increasing population densities in an urban area in order to make more efficient use of existing infrastructure, and to limit

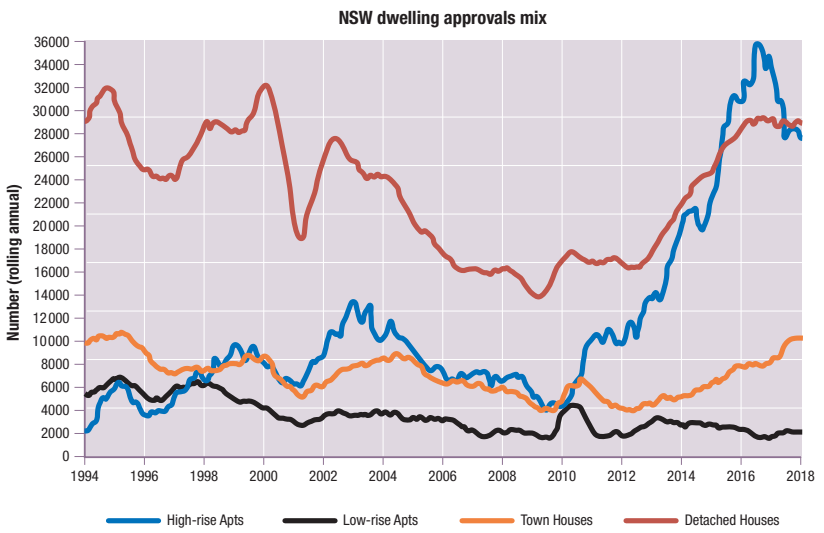

Figure 2.2.1b NSW dwelling approvals by type, 1994–2018

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the spread of urban land uses into surrounding rural areas (urban sprawl).

The need for urban consolidation in Sydney is becoming increasingly apparent. The New South Wales (NSW) State Government anticipates that the population of the city will increase to 8 million by the middle of this century (up from the current population of 5 million). The housing target for the Sydney region is an additional 664 000 dwellings. It is not feasible to accommodate this growth on the periphery of the metropolitan region. The cost of providing the necessary infrastructure would be prohibitive. Infilling is the only feasible option, meaning that density living, especially in areas close to public transport nodes, is inevitable.

Darling Square is an example of urban renewal and consolidation. It is Sydney's newest residential and commercial inner-city neighbourhood in Darling Harbour. Darling Square is home to 4200 residents and the workplace of a further 2500 people. There are over 1500 apartments and accommodation for 1000 students in buildings of varying heights. At ground level more than 60 shops, bars and restaurants line new streets and laneways. Commercial office space have also been included in the expectation that the area will become a new centre for firms engaged in technical innovation. Twenty-five per cent of the area is open space.

Liveability in Sydney

In November 2019, *Domain*, the real estate arm of the Nine Entertainment Group (publishers of the *Sydney Morning Herald*), commissioned a survey of liveability in Sydney (see Figure 2.2.1c). The study used 19 indicators to identify the most (and least) liveable suburbs in the city. The indicators included: access to employment; proximity to train, bus, light rail or ferry services; access to cultural facilities, such as libraries, museums and art galleries; amount of traffic congestion; and proximity to schools, shopping, cafes and restaurants. Other factors used were the amount of public open space, the walkability of suburbs, tree cover, topographic variations, crime levels, mobile and broadband coverage and harbour and ocean views.

The most 'liveable' suburbs were those lining the harbour and the coast, with those on the lower North Shore (including Mosman and Lavender Bay). Perhaps surprisingly, some of the most liveable suburbs are also the most densely populated parts of the city. An increasing number of people are embracing high-density, inner-city housing and many apartment-dominated suburbs rated well. The high-rise, inner-city neighbourhoods of Sydney, Elizabeth Bay, Potts Point, Pyrmont and Darlinghurst were all ranked in the top 50 for liveability.

Elsewhere in the city, areas once dominated by industry (known as *brownfield*) have been transformed into high-quality, high-density residential areas. The suburb of Rhodes, for example, occupies a site once dominated by a Union Carbide factory. The factory's toxic legacy had to be remediated before construction could commence. The suburb now ranks 119 (out of a total of 569).

The transformation of other accessible brownfield sites into thriving medium- and high-density residential areas will continue to play an important role in accommodating the city's rapidly growing population. A string of suburbs, stretching from Central Station to Sydney's main airport, are currently being transformed into vibrant new urban precincts.

Suburbs at the bottom of the liveability ranking are those newly developed neighbourhoods on the edge of the metropolitan area. The liveability rankings of these suburbs will increase as transport services and other urban amenities improve.

There is also evidence of a 'multi-centre' pattern of liveability developing in Sydney. Suburban precincts, located adjacent to commercial and employment hubs such as Parramatta, Penrith, Macquarie Park, Hornsby and Liverpool, now score well in terms of liveability. While such precincts have the advantages associated with access to employment, transport and services nearby, they also benefit from more open space and less congestion than suburbs closer to the city centre.

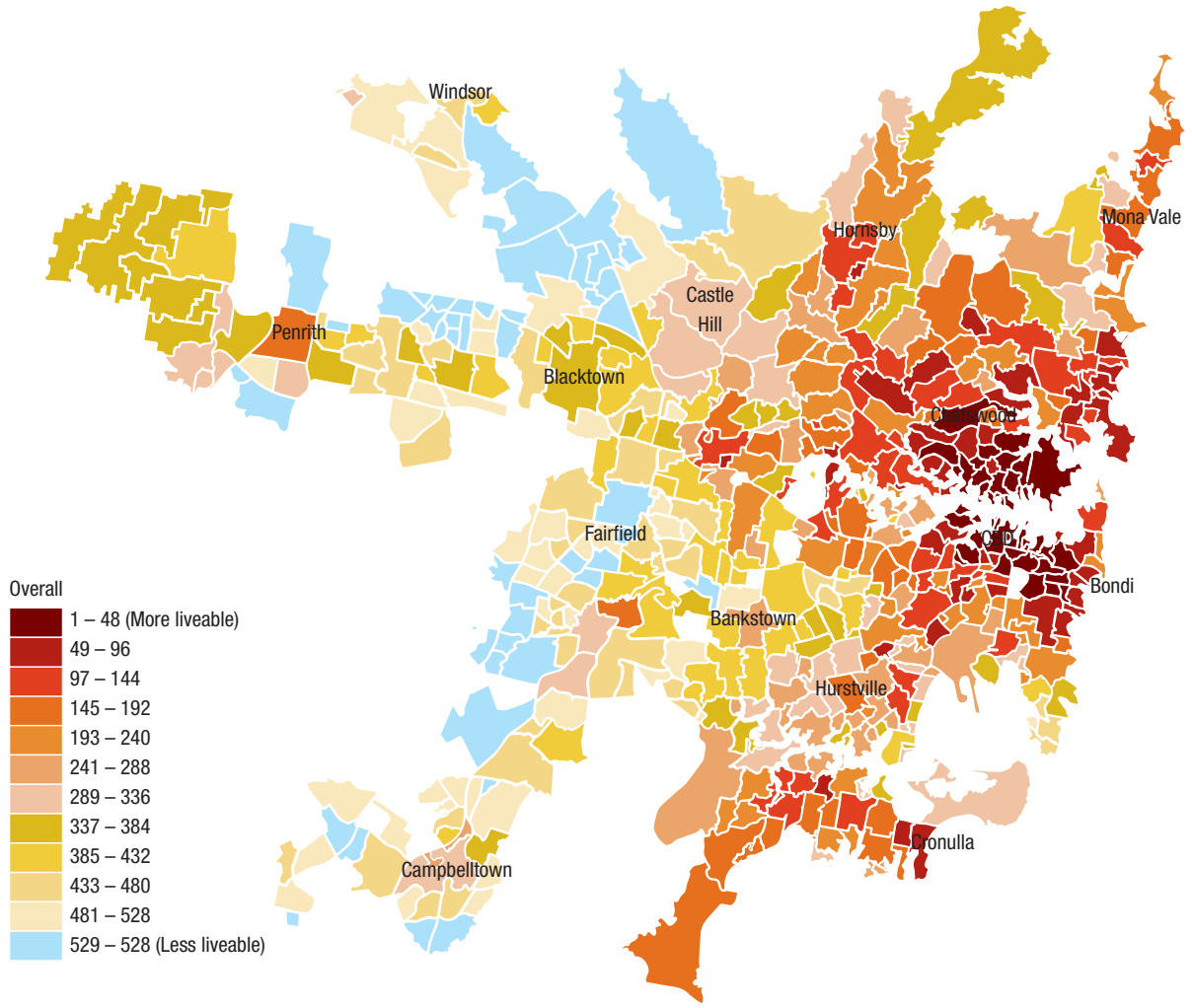

Figure 2.2.1c Suburban Sydney, liveability index, 2019

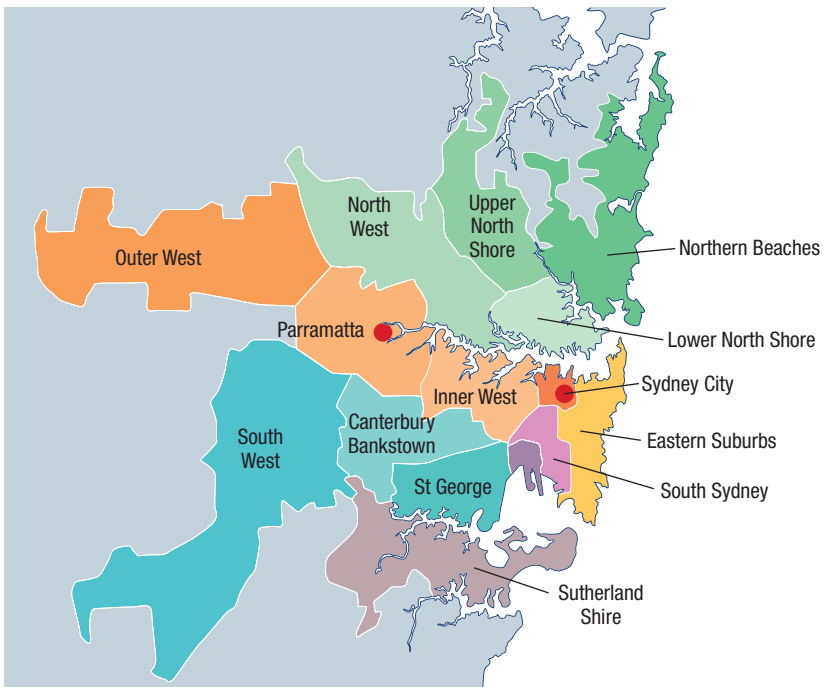

Figure 2.2.1d Sydney's geographic regions

ACTIVITIES

1. Study Tables 2.2.1a–c. Identify the cities common to all three liveability ranking surveys.
2. Study Figures 2.2.1c and 2.2.1d. Describe and account for the pattern of liveability in Sydney.
3. Individually, rank your local neighbourhood, ranking the criteria outlined in Figure 2.2.1a on the scale 1 to 5. Tally the score.
4. Working in groups, compare your ranking with others. Agree on a group-based ranking of the listed criteria. Compare your group's ranking with that of other groups. How similar are they?
5. Repeat the ranking in nearby neighbourhoods. Rank the neighbourhoods assessed.
6. Study Figure 2.2.1b. Using data from the graph, describe the trends in dwelling approvals by type since 2010.

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Barangaroo: enhancing liveability

The cities in which many of us live are dynamic places. They change over time. Advances in technology, the nature of economic activity, and the changing demographic and social characteristics of a population are the drivers of change. If managed carefully these changes can enhance the liveability of cities.

Over time, parts of cities experience periods of growth and decline. The latter involves deterioration in the quality of the constructed (or built) environment. Urban infrastructure falls into a state of disrepair and buildings are left empty for long periods of time. This process is known as *urban decay*. Such areas are sometimes the focus of *urban renewal* (or redevelopment) initiatives. These aim to breathe new life into an area, once again making it relevant to the economic, political and social needs of the city and its residents.

Also relevant here is the process of urban consolidation. Urban consolidation limits the spread of urban sprawl into rural areas, whilst also revitalising existing urban areas by more efficiently utilising the space. It involves construction of medium- to high-density housing in already built-up areas, often on former industrial sites. Urban consolidation also widens the range of housing types available to urban residents.

Barangaroo

Barangaroo, just to the west of Sydney's CBD, is an example of an urban precinct undergoing change. The port facilities that once lined the foreshore of Millers Point gradually fell into disuse and disrepair as the technologies of shipping and cargo handling changed. In 2003, the NSW Government announced that the site would be transformed into a spectacular new waterfront precinct.

Today, Barangaroo is Australia's largest urban renewal project. When complete, more than $6 billion will have been spent on the transformation of the site. More than 23 000 people will work in the precinct and thousands will call it home. Millions of Sydneysiders and tourists will visit the area to be entertained and it will become a focal point for many of Sydney's great celebrations. The project is expected to be completed by 2024.

Figure 2.2.2a The loading and unloading of ships in the 1920s highlights the labour-intensive nature of cargo handling before the introduction of containerisation in the 1950s.

Figure 2.2.2b Aerial view of Millers Point finger wharfs, 1950

Figure 2.2.2d The finger wharfs that once dominated the site now occupied by Barangaroo can be seen in this 1951 aerial photograph of central Sydney.

Figure 2.2.2c In 1937 the area that is now Barangaroo was dominated by a series of finger wharfs. These readily accomodated the size of ships built at the time and the methods used to handle cargo.

Figure 2.2.2e The partially reclaimed waterfront of Millers Point (Barangaroo) in 1968. The redevelopment of the waterfront is now well advanced.

Figure 2.2.2f Topographic map of Darling Harbour and surrounds, 1972

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Figure 2.2.2g Barangaroo and Darling Harbour, 2012

Figure 2.2.2h Computer-generated vertical image of the completed Barangaroo precinct

Change over time

The area now occupied by Barangaroo has been transformed a number of times. By the early 1900s the area was dominated by a series of finger wharfs that best accommodated the ships and cargo handling methods of the time. However, the technology of cargo handling was about to change. Containerisation was introduced in the 1950s. Before the introduction of containers, goods were mostly carried as general cargo. Goods were delivered to the dock by horse-drawn dray, rail and later by motorised lorry in advance of the arrival of the ship and stored in warehouses. When the vessel arrived, the cargo was taken from the warehouse to the wharf and then loaded on board using either the ship's cranes or those installed dockside. The unloading of vessels was the reverse of the loading operation. This process can be seen in Figure 2.2.2a. The nature of the constructed environment that developed to accommodate this method of cargo handling can be seen in Figures 2.2.2b and 2.2.2c.

By the 1960s, the increasing size of ships, together with containerisation, brought about the most dramatic transformation in the site's maritime history. The reclamation of the foreshore zone and the construction of a large concrete apron eventually replaced the previous built environment. For a time the apron was used as a container terminal. However, the site's limitations soon became apparent. The lack of a heavy rail link meant that containers had to be trucked though the congested streets of the Sydney CBD. As container ships became bigger this problem only worsened. The ultimate demise of commercial shipping in Darling Harbour, and Sydney Harbour as a working port, was the construction of Port Botany in 1979. In 2003, it was announced that the container terminal at Barangaroo would close.

Environmental sustainability

Barangaroo South will be Australia's first carbon-neutral urban precinct. A range of technologies will be used to minimise energy consumption. These include the addition of an automated solar-shading system on the outside of the commercial office towers and an energy-efficient centralised cooling system. The development will also be water positive. Rainwater capture, water-saving fixtures and appliances, and on-site treatment of waste water will allow water to be exported from Barangaroo South to nearby neighbourhoods and the rest of Barangaroo where it will be used to water parklands. The energy consumed in Barangaroo South will be offset by on-site and off-site solar power generation and the purchase of carbon offsets.

Figure 2.2.2i Computer-generated oblique image of the completed Barangaroo precinct

Figure 2.2.2j Barangaroo South waterfront

Figure 2.2.2k South's public spaces

Figure 2.2.2l Barangaroo South's waterfront restaurants and cafes

Figure 2.2.2m Barangaroo South's laneways

Figure 2.2.2n Barangaroo South's public realm

Figure 2.2.2o Barangaroo South's Hickson Road streetscape

ACTIVITIES

1. Read the introductory text and then answer the following questions:
   a. What are the principal drivers of change in large cities?
   b. Define the concepts of urban decay, urban renewal, urban sprawl and urban consolidation.
2. Study Figure 2.2.2a. Describe the nature of cargo handling shown in the photograph.
3. Study Figures 2.2.2b to 2.2.2d. Describe the nature of the constructed environment shown in the photographs.
4. Study Figures 2.2.2d and 2.2.2e. Describe how the shoreline of what is now Barangaroo changed in the period 1951 to 1968.
5. Study Figures 2.2.2e and 2.2.2f. Describe how the shoreline of what is now Barangaroo changed between 1968 and 1972.
6. Study Figure 2.2.2g. In which direction was the camera facing when this photograph was taken? Describe the nature of the constructed environment before the redevelopment of Barangaroo.
7. Study Figures 2.2.2h and 2.2.2i. Identify the key elements of the Barangaroo redevelopment. To what extent has there been an attempt to re-establish elements of the area's original biophysical environment?
8. Read the text above on environmental sustainability. Outline the features of the development that contribute to the claim that it will be Australia's first carbon-neutral urban precinct.
9. Study Figures 2.2.2j to 2.2.2o. Using the liveability survey sheet in Unit 2.2.1, assess the liveability of the completed Barangaroo development. Compare your findings with others in the class. To what degree is there agreement? Are there any differences in the assessments made?

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2.3 Water and the world

2.3.1 AUSTRALIA'S CLIMATE

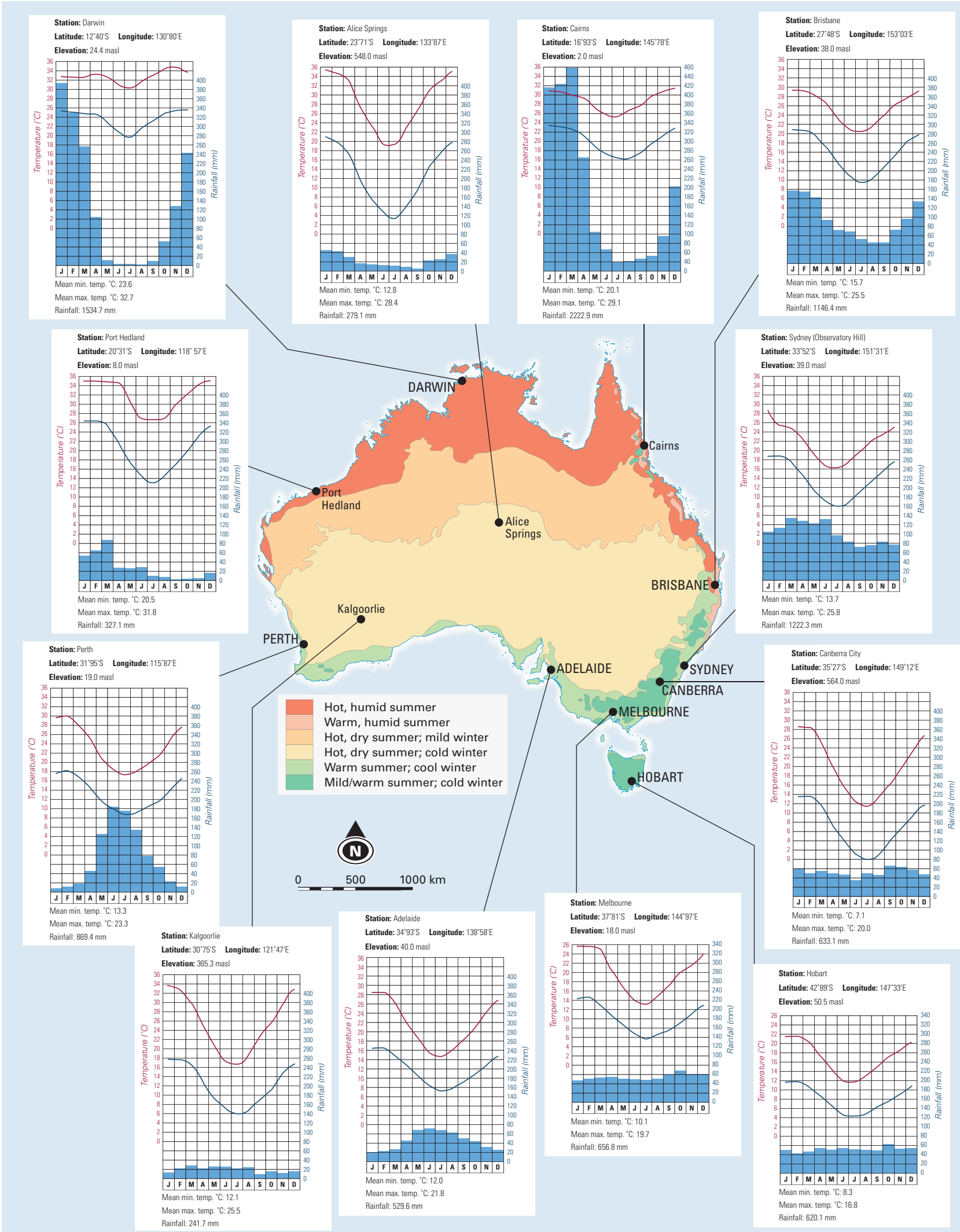

Figure 2.3.1a Main climatic zones of Australia (based on temperature and humidity)

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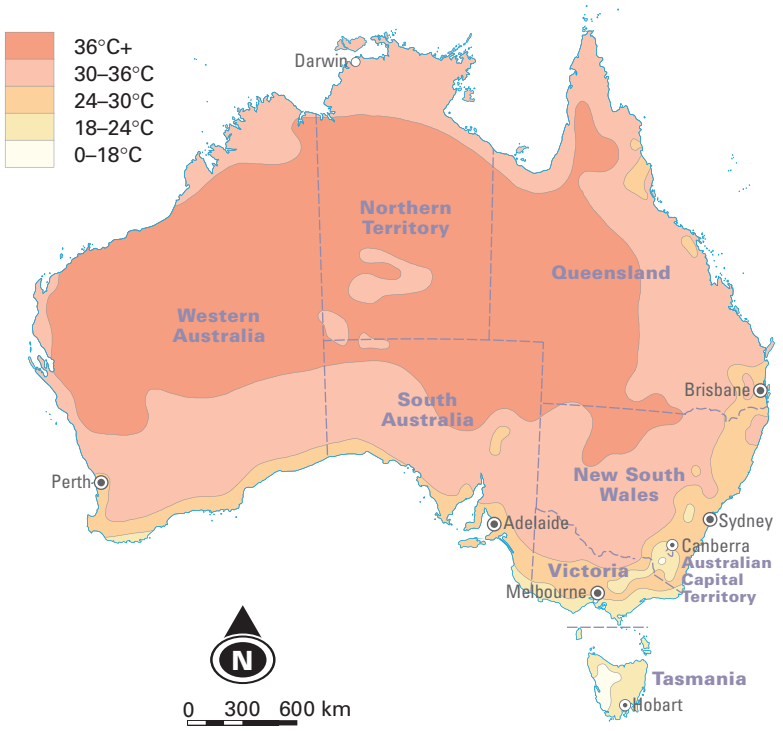

Figure 2.3.1b January maximum temperatures in Australia

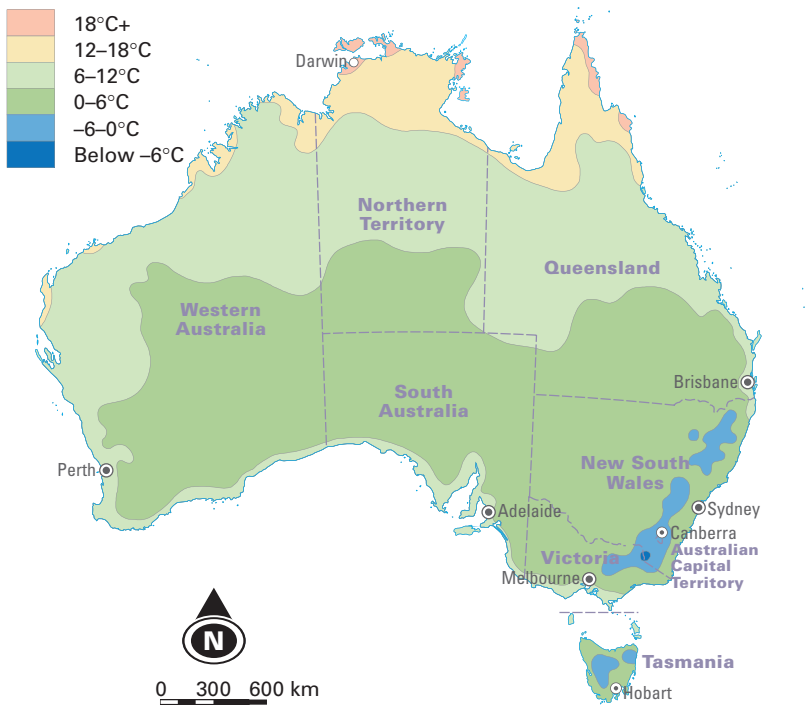

Figure 2.3.1c July minimum temperatures in Australia

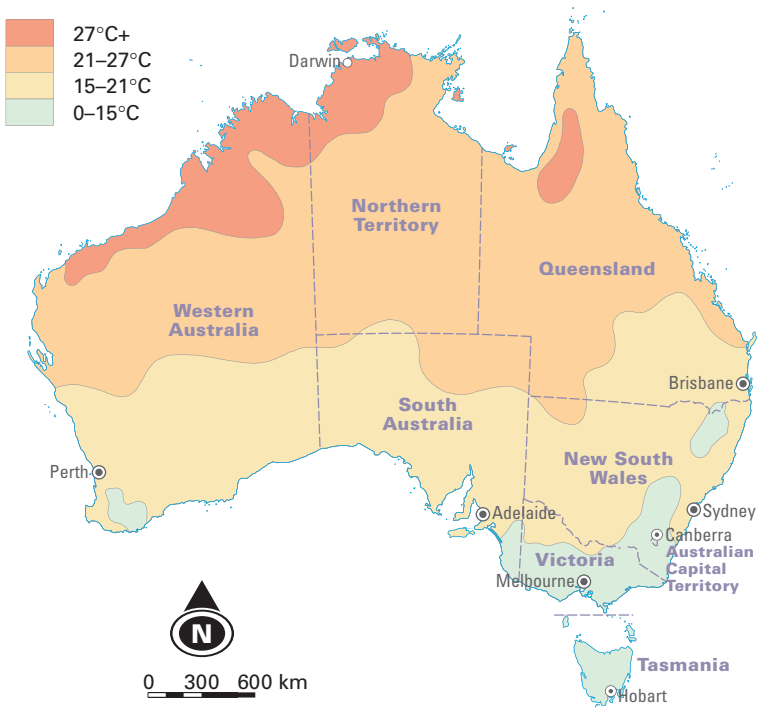

Figure 2.3.1d Mean temperatures in Australia

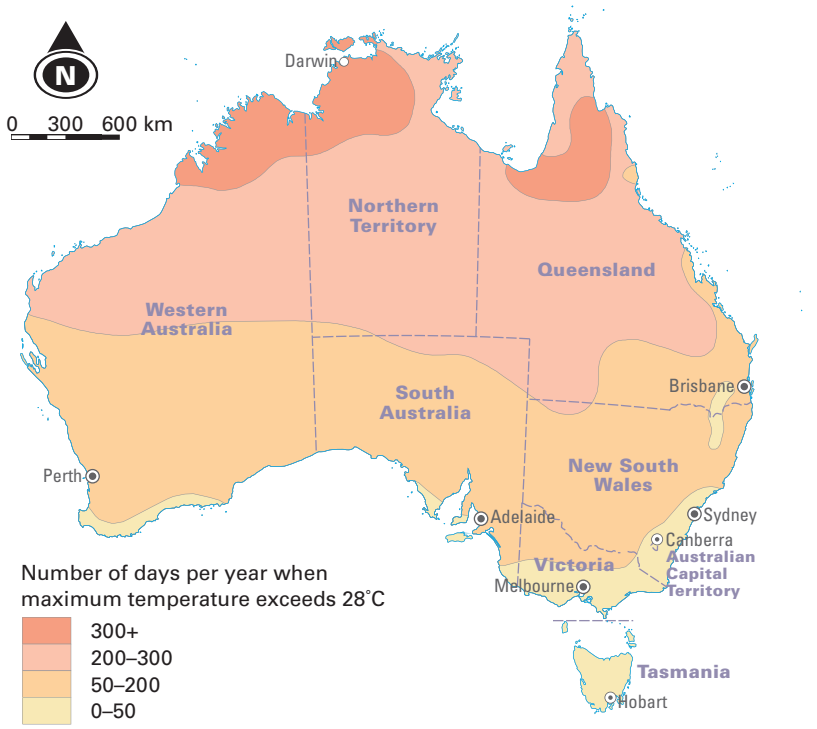

Figure 2.3.1e Hot days in Australia

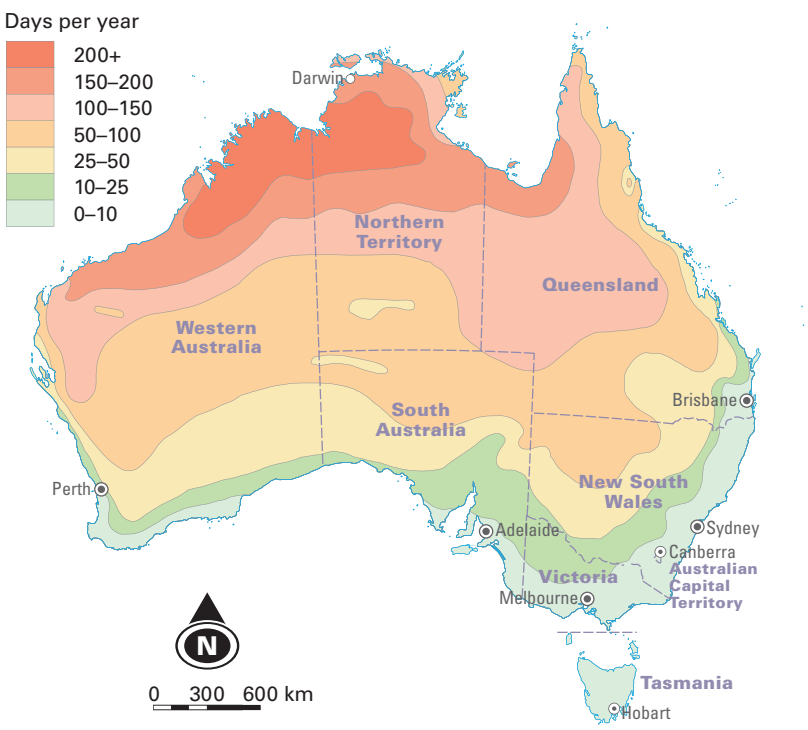

Figure 2.3.1f Heat discomfort in Australia

ACTIVITIES

1 Study Figure 2.3.1a and complete the following tasks:
   - a On an outline map of Australia, draw the boundaries of each climatic zone. Annotate your map with a brief description of the climate experienced in each zone.
   - b With the aid of Figure 2.3.1a, describe the distribution of the following climatic zones:
     - i hot, humid summers
     - ii warm, humid summers
     - iii hot, dry summers and mild winters
     - iv hot, dry summers and cold winters
     - v warm summers and cool winters
     - vi mild/warm summers and cold winters.

2 Study Figures 2.3.1a, 2.3.1d and 2.3.1i (page 40–42). Describe the different climates you would experience on a road journey from Darwin to Adelaide.

3 Study the climate graphs in Figure 2.3.1a and complete the following tasks:
   - a Which location has the highest daily maximum temperature?
   - b Which location has the lowest daily minimum temperature?
   - c Which location has the largest range of mean daily maximum temperatures?
   - d Which location has the smallest range of mean daily maximum temperatures?
   - e Which location has the highest mean annual rainfall?
   - f Which location has the lowest mean annual rainfall?
   - g Estimate the average July temperature experienced by Darwin, Alice Springs, Adelaide and Hobart. Comment on the pattern evident.
   - h Describe the seasonal distribution of rainfall in Cairns and Darwin.
   - i Describe the seasonal distribution of rainfall in Perth and Adelaide.

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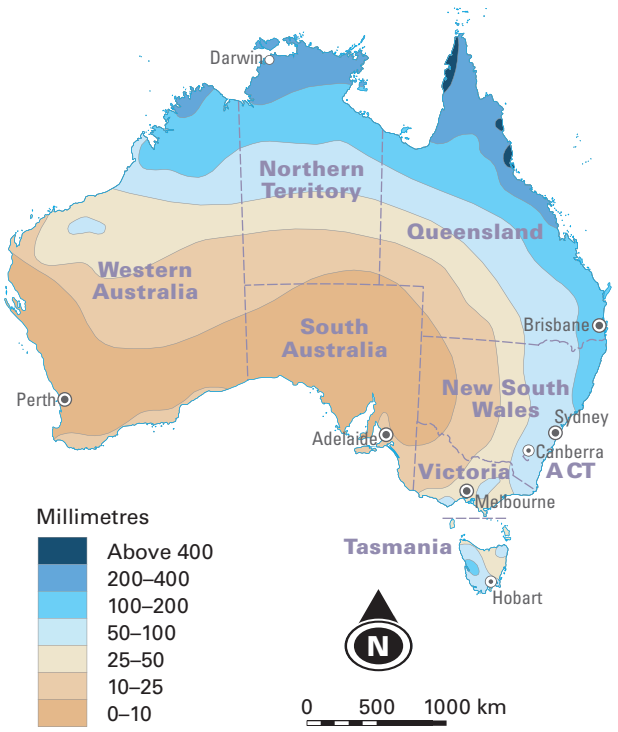

Figure 2.3.1g January rainfall in Australia

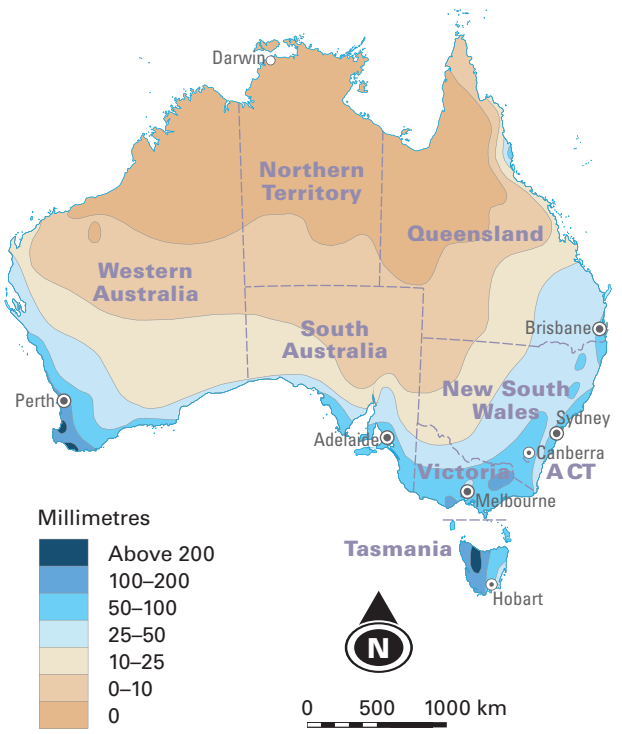

Figure 2.3.1h July rainfall in Australia

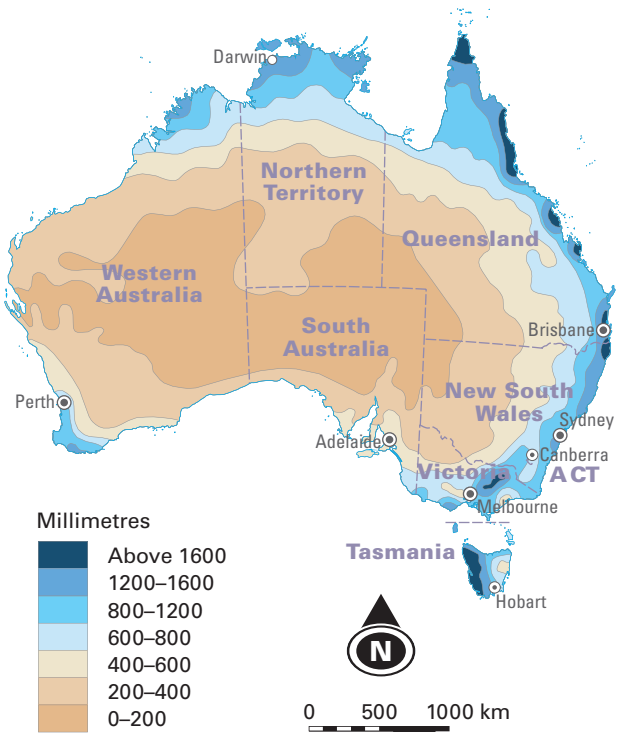

Figure 2.3.1i Median annual rainfall in Australia

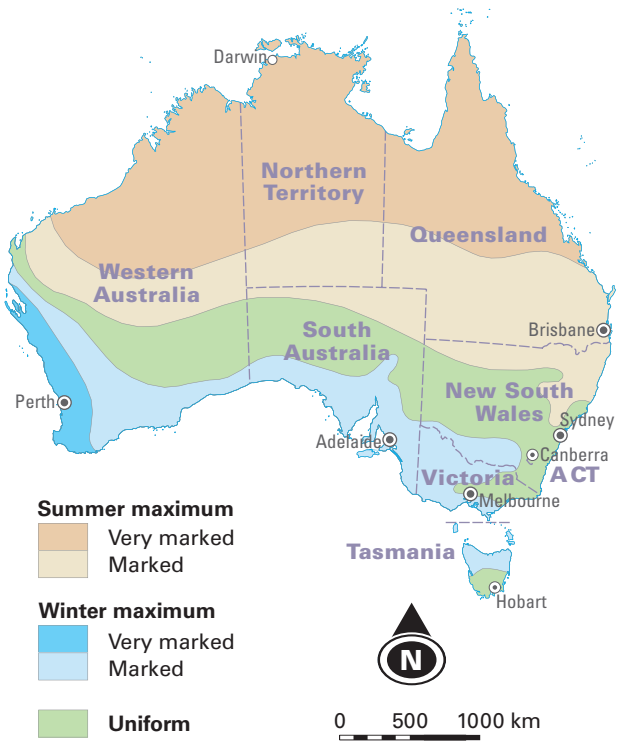

Figure 2.3.1j Seasonal rainfall in Australia

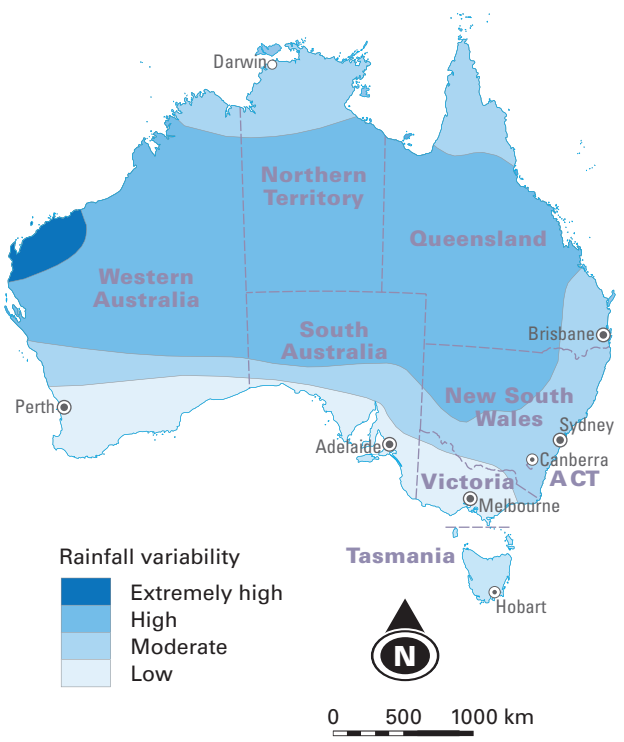

Figure 2.3.1k Rainfall variability in Australia

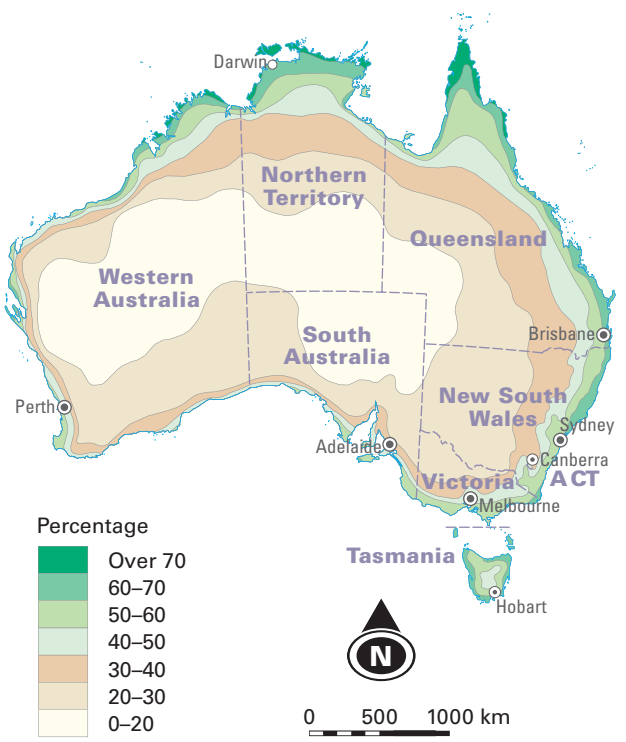

Figure 2.3.1l Relative humidity in Australia

ACTIVITIES

4 Study Figure 2.3.1a (page 41) and list the locations that:
- a receive most of their rainfall in summer
- b receive most of their rainfall in winter
- c have rainfall evenly distributed throughout the year.

5 Study Figure 2.3.1b (page 41) and answer the following questions:
- a Which part of Australia experiences the highest January maximum temperature?
- b Which parts of Australia experience the lowest January maximum temperature?
- c What is Darwin's mean January maximum temperature?

6 Study Figure 2.3.1c (page 41) and answer the following questions:
- a Which parts of Australia experience July minimum temperatures in excess of 12°C?
- b Which part of Australia experiences the lowest July minimum temperatures?

7 Study Figure 2.3.1d (page 41) and describe the pattern of mean temperatures.

8 Study Figure 2.3.1e (page 41) and answer the following questions:
- a Which part of Australia has fewer than 50 days when the maximum temperature exceeds 28°C?
- b How many days does Darwin have when the maximum temperature exceeds 28°C?

9 Study Figure 2.3.1f (page 41) and answer the following questions:
- a Which part of Australia experiences the greatest heat discomfort?
- b What is the general pattern evident on the map?

10 Study Figure 2.3.1g and complete the following tasks:
- a Describe the general pattern of January rainfall.
- b What is the January rainfall experienced by the following capital cities?
  - i Adelaide
  - ii Sydney
  - iii Darwin

11 Study Figures 2.3.1b, 2.3.1f (page 41) and 2.3.1g. What factors contribute to the high levels of heat discomfort in north-west Australia?

12 Study Figures 2.3.1i and 2.3.1j. Describe the seasonal distribution of rainfall in northern Australia.

13 Study Figure 2.3.1h. Describe the general pattern of July rainfall.

14 Study Figure 2.3.1i. Describe the pattern of median annual rainfall.

15 Study Figure 2.3.1j and answer the following questions:
- a Which Australian capital cities have a uniform seasonal rainfall pattern?
- b Which Australian capital cities receive most of their rainfall in summer?
- c Which Australian capital cities receive most of their rainfall in winter?

16 Study Figure 2.3.1k and answer the following questions:
- a Which parts of Australia have the most reliable rainfall?
- b Which parts of Australia have the least reliable rainfall?

17 Study Figure 2.3.1l. What locational factor appears to be the most important influence on relative humidity?

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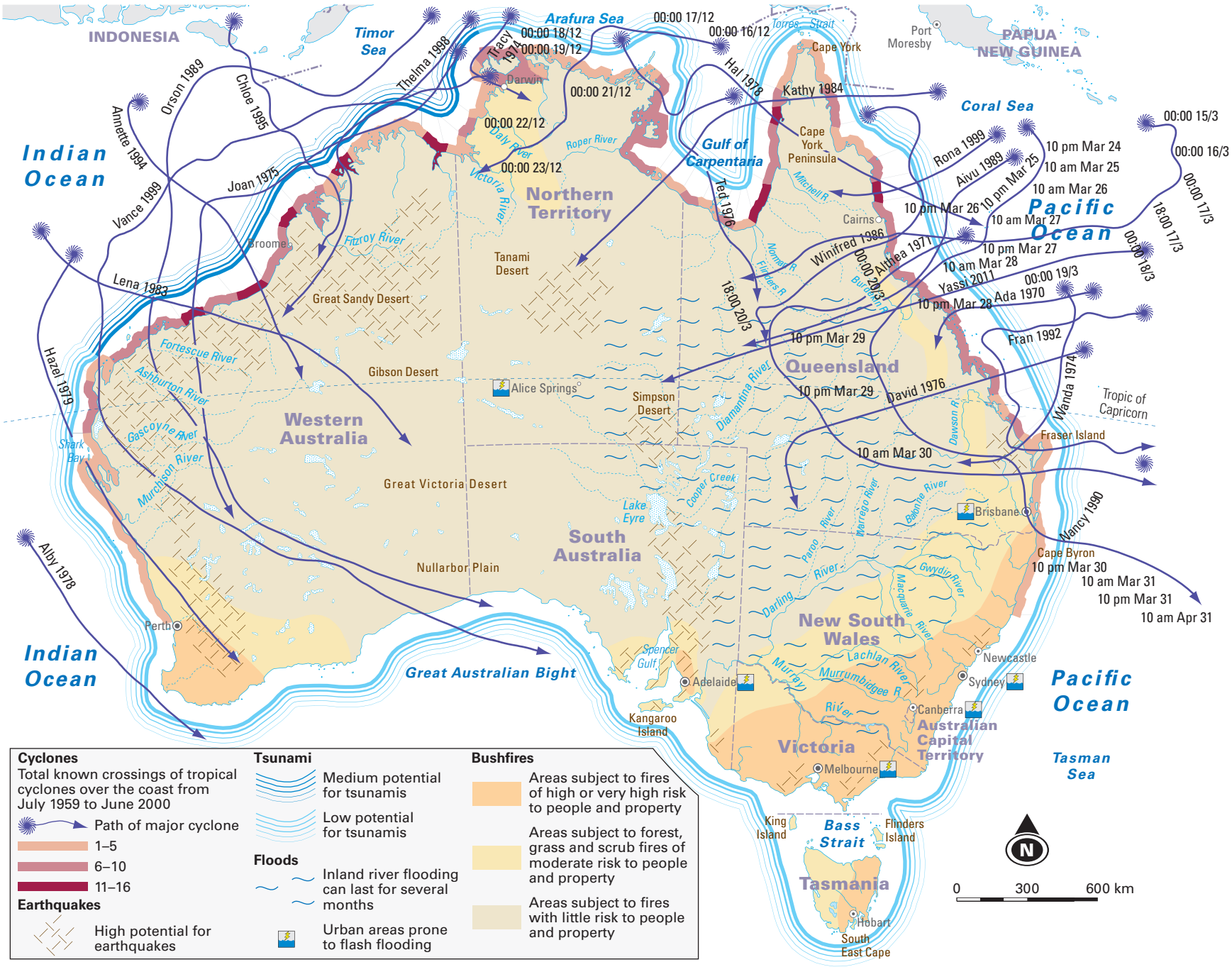
2.3.2 AUSTRALIA'S NATURAL HAZARDS



Cyclones
Total known crossings of tropical cyclones over the coast from July 1959 to June 2000
- Path of major cyclone
- 1–5
- 6–10
- 11–16

Earthquakes
- High potential for earthquakes

Tsunami
- Medium potential for tsunamis
- Low potential for tsunamis

Floods
- Inland river flooding can last for several months
- Urban areas prone to flash flooding

Bushfires
- Areas subject to fires of high or very high risk to people and property
- Areas subject to forest, grass and scrub fires of moderate risk to people and property
- Areas subject to fires with little risk to people and property

Figure 2.3.2a Natural hazards in Australia

ACTIVITIES

Study Figure 2.3.2a and complete the following tasks:

1 a Name the seas over which the majority of Australia's cyclones develop.
b Describe the paths generally taken by the cyclones that develop over these three water bodies.

2 Outline the areas of Australia that have a high potential for earthquakes.

3 Identify the parts of Australia's coastline that have a medium potential for tsunamis.

4 With the aid of Figure 2.1.2a (page 32), identify the landform division that is subject to inland flooding.

5 Identify the urban areas subject to flash flooding.

6 Identify those areas of Australia where bushfires pose a high or very high risk to people and property.

7 From which types of hazards is your community at risk?

8 Select one of the natural hazards shown on the map. Investigate the actions you could take to protect life and property.

Figure 2.3.2b Storm damage at Sydney's Collaroy Beach

Figure 2.3.2c The 2019–20 Australian bushfires directly killed 34 Australians, destroyed 3500 homes and cost $103 billion.

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2.3.3 ATMOSPHERIC AND HYDROLOGICAL HAZARDS

Figure 2.3.3a A summer storm rolls across Sydney

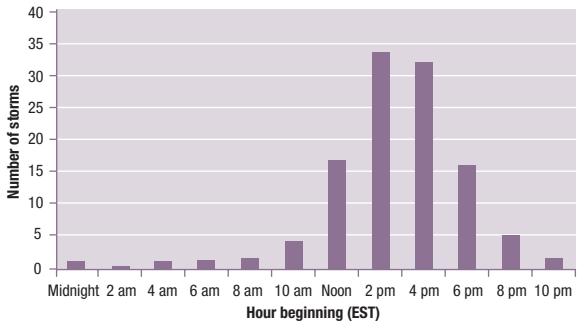

Figure 2.3.3c Average distribution of severe thunderstorms in NSW and the ACT by time of day

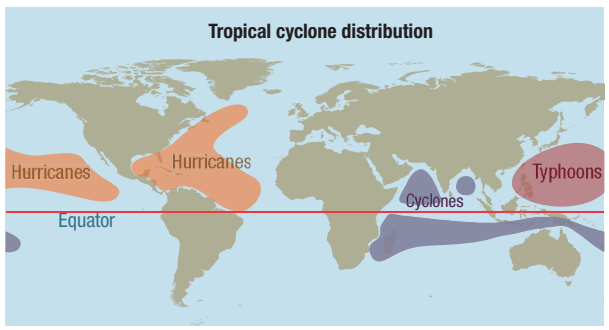

Figure 2.3.3e Getting the name correct! Tropical cyclones, hurricanes and typhoons

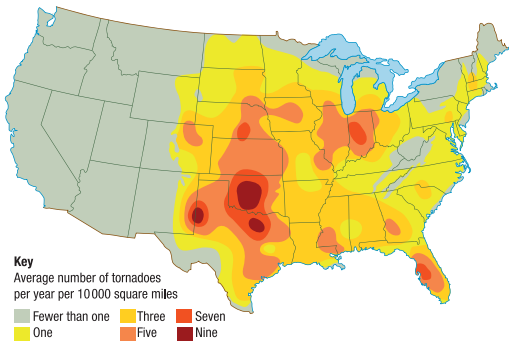

Figure 2.3.3g Average number of tornadoes per year, United States

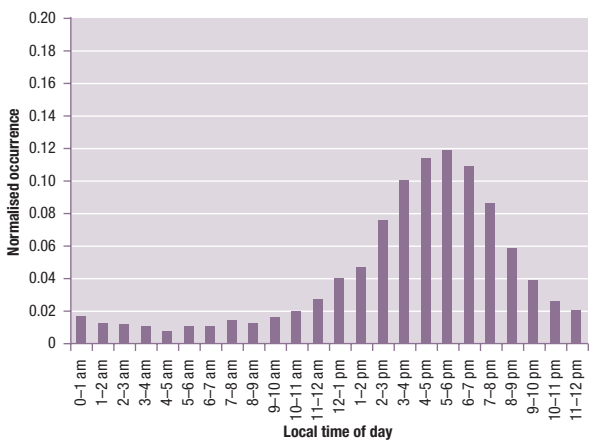

Figure 2.3.3i Average number of tornadoes per hour of day, United States

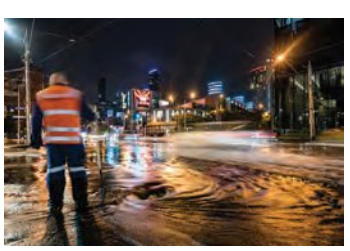

Figure 2.3.3j Flash flooding in suburban Melbourne

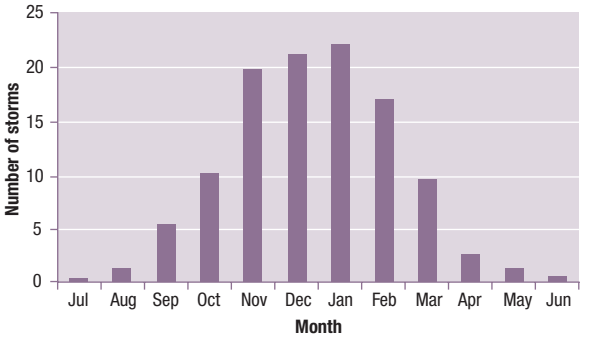

Figure 2.3.3b Average monthly distribution of severe thunderstorms in NSW and the ACT

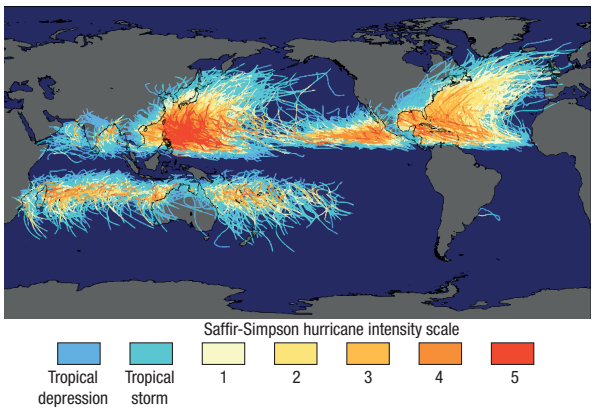

Figure 2.3.3d Distribution and intensity of tropical cyclones, hurricanes and typhoons

Figure 2.3.3f Three tornadoes at the same time near Dodge City, Kansas, 24 May 2016

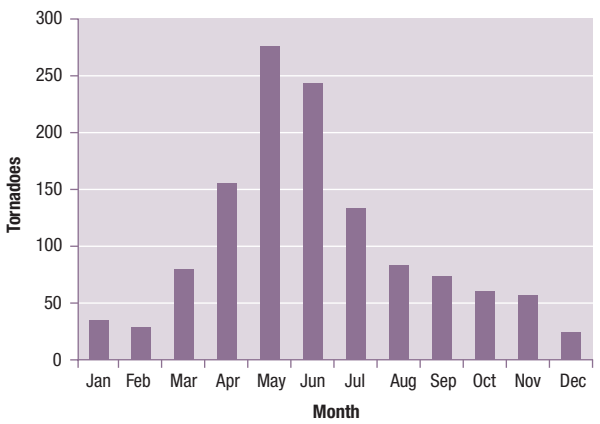

Figure 2.3.3h Average number of tornadoes per month, United States, 1991–2010

Figure 2.3.3k Couple awaiting rescue during flooding in southern Queensland

Weather-related hazards and disasters include severe storm systems, tornadoes, flooding, heatwaves and drought. They are all classified as natural hazards and disasters. Natural hazards are extreme and unusual natural events. When natural hazards impact on people, they are referred to as natural disasters.

Severe storms

Severe storms are the most common of all the atmospheric hazards.
They are a local disturbance in the atmosphere and are accompanied by thunder, lightning, rain, hail and, in some cases, snow. They can occur anywhere and are responsible for more damage than any other natural hazard. (See Figures 2.3.3a, 2.3.3b and 2.3.3c.)

Tropical cyclones

Tropical cyclones (also known as hurricanes and typhoons in other parts of the world) are intense low-pressure systems (or severe storms) that form over warm tropical waters. Tropical cyclones are typically accompanied by damaging, gale-force winds and torrential rainfall. (See Figures 2.3.3d and 2.3.3e.)

Tornadoes

A tornado is a violently rotating column of air extending from the base of a thunderstorm to the ground. The most violent tornadoes carve a path of destruction across the landscape. (See Figures 2.3.3f, 2.3.3g, 2.3.3h and 2.3.3i.)

Flooding

Floods occur when a waterway overflows its natural banks onto normally dry land. Floods can result from prolonged periods of rain, rapid winter snowmelt or sudden, heavy downpours. (See Figure 2.3.3j.)
There are three types of floods:

- *Slow-onset floods* build up over time and may last for weeks, even months. They are often the result of a long period of above-average rainfall.
- *Rapid-onset floods* occur more quickly, and are more common in mountain areas of larger river systems and in rivers draining to the coast. These floods often only last a day or two.
- *Flash floods* occur when intense storms bring large amounts of rainfall within a brief period of time. Flash floods can be extremely dangerous. Sometimes they are caused by heavy rainfall many kilometres away. The resulting floodwaters surge down waterways, sweeping away all in their path: they can move boulders, tear out trees and destroy buildings and bridges.

Other types of atmospheric and hydrological hazards include heatwaves and drought.

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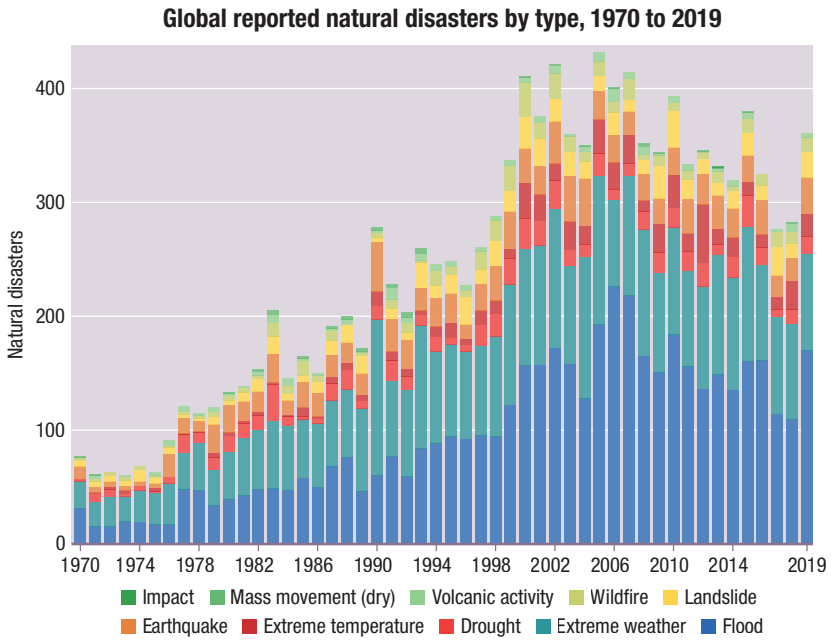

Figure 2.3.3l Recorded natural disasters worldwide, by type, 1970–2019

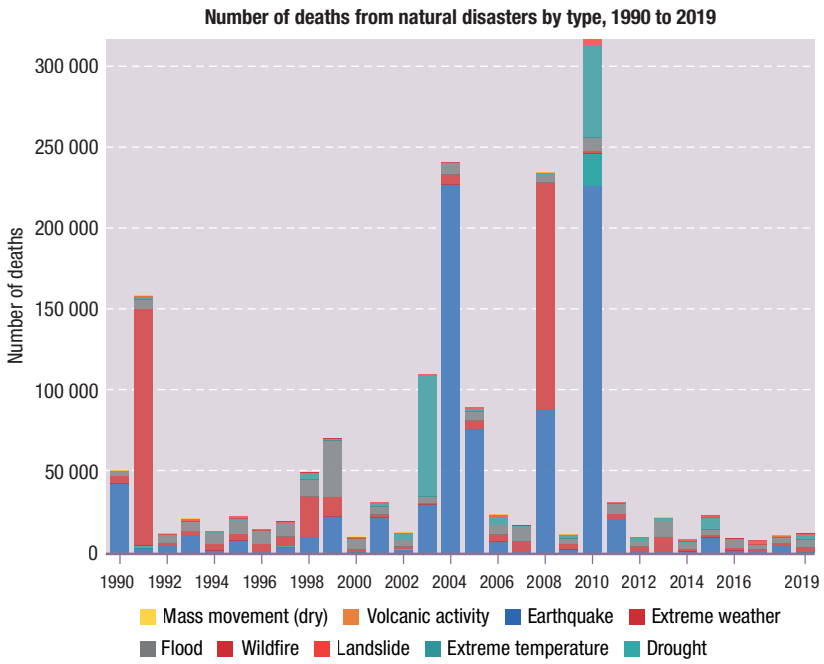

Figure 2.3.3m Recorded deaths from natural disasters worldwide, by type, 1990–2019

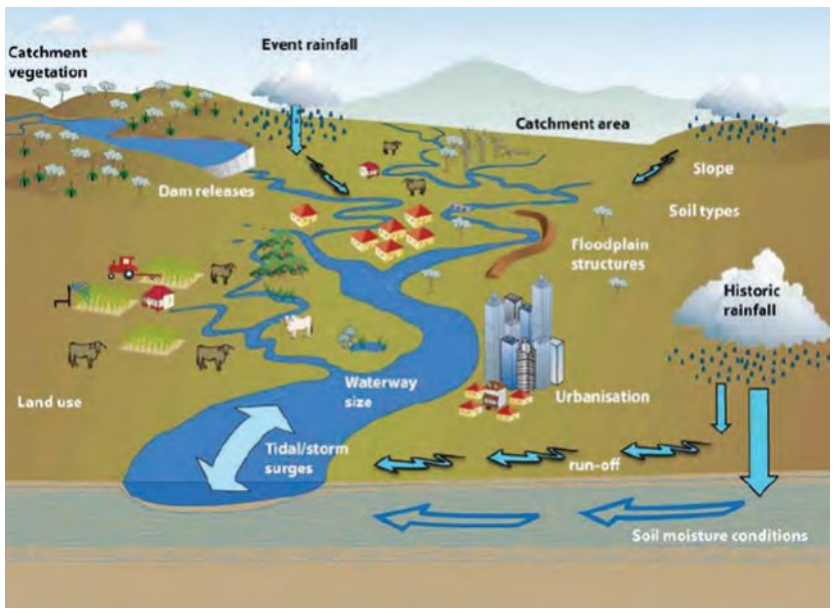

Figure 2.3.3n Rainfall is the most important factor in the onset of flooding, but there are many other contributing factors. When rain falls in a catchment, the amount of rainwater that reaches its rivers and streams depends on the characteristics of the catchment, particularly its size, shape and the land uses present. Some rainfall is 'captured' by soil and vegetation, and the remainder enters waterways as flow. River characteristics such as size and shape, the vegetation in and around the river, and the presence of structures in and adjacent to the waterway, all affect the level of water in the waterway.

Figure 2.3.3o October 5, 2020. Emergency workers clear debris following heavy rains and floods in Breil-sur-Roya, a French village close to the Italian border. Houses were buried in mud and turned-over cars were stuck in the riverbed.

ACTIVITIES

1 Read the introductory text and answer the following questions:
- a List the types of weather-related hazards and disasters.
- b Name the atmospheric hazard responsible for more damage than any other natural hazard.
- c State the names given to tropical storm systems in various parts of the world.
- d Distinguish between slow-onset, rapid-onset and flash flooding.

2 Study Figures 2.3.3b and 2.3.3c and answer the following questions:
- a In which month of the year does the number of severe storms peak in NSW and the ACT?
- b In which season do most storms occur?
- c At what time of day are severe storms likely to occur?

3 Study Figures 2.3.3d and 2.3.3e and answer the following questions:
- a In which region of the world do hurricanes occur?
- b In which region of the world do typhoons occur?
- c Locate the region that experiences the most intense (Category 5) hurricanes/typhoons.

4 Study Figures 2.3.3g to 2.3.3i and answer the following questions:
- a With the aid of an atlas identify where the average number of tornadoes a year exceeds nine.
- b In which months of the year does tornado activity peak?
- c At what time of day are tornadoes most likely to occur?

5 Study Figures 2.3.3l and 2.3.3m and answer the following questions:
- a Which year was the worst for recorded natural disasters by type? In a typical year what is the most common form of recorded natural disaster?
- b Which was the worst year for flooding?
- c Identify the three deadliest years for natural disaster deaths since 1990.
- d How many people died as a result of earthquakes in 2010?
- e What was the principal cause of natural hazard deaths in 2008?
- f What was the principal cause of natural hazard deaths in 2003?

6 Study Figure 2.3.3p. Write a paragraph or two outlining the factors that contribute to flooding in the catchment illustrated.

Figure 2.3.3p In 2021, Lake Mead, in Nevada and Arizona, fell to its lowest level since the Hoover Dam's construction, in the early 1930s, as a result of prolonged drought in the west of the United States.

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2.4 Interconnections

2.4.1 CONNECTING WITH PEOPLE AND PLACES

The use of technologies such as the internet and smartphones means that we are now connected with other people and places in ways unimaginable to previous generations. As a result, we live in an increasingly interdependent world. Our online networks allow us to send and receive messages to and from people spread across the planet.

As we become more connected, information circulates more efficiently, we interact more easily, and we manage more and different kinds of social connections. Information that now spreads from person to person will soon spread even further and faster as the nature and scale of our interactions increase.

The internet

The internet makes it possible for individuals to transfer large amounts of information around the world 24 hours a day, at high speed and at a low cost. The number of internet users worldwide increased from 242 million in 2000 to more than 4.8 billion in 2020.

The internet, and the technologies it supports, has played an important role in the process of globalisation. It has helped reshape the world's pattern of production and consumption of goods and services, and accelerated the process of cultural integration. This technology has, for example, enabled many small businesses to market their products to a global audience 24 hours a day and led to the rapid growth of online retailing.

2020 Internet Minute (60 seconds)

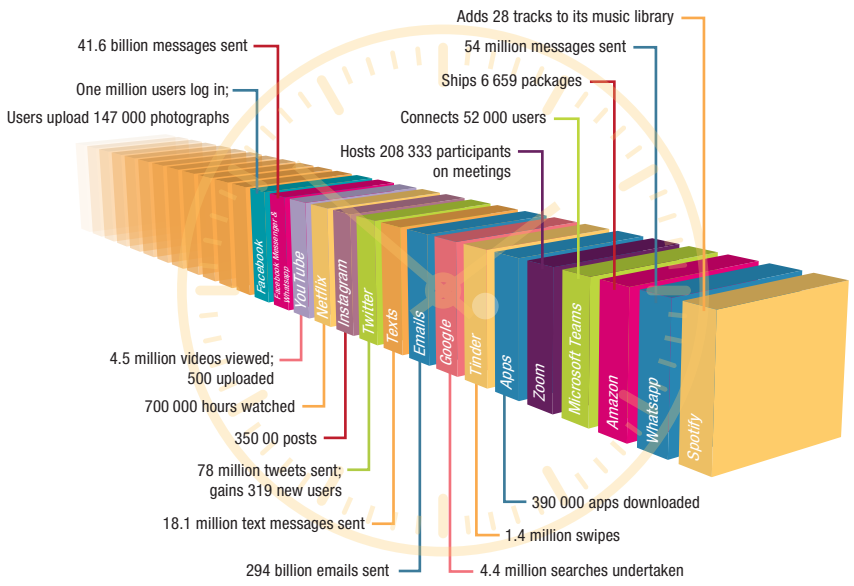

Figure 2.4.1a What happens in an internet minute?

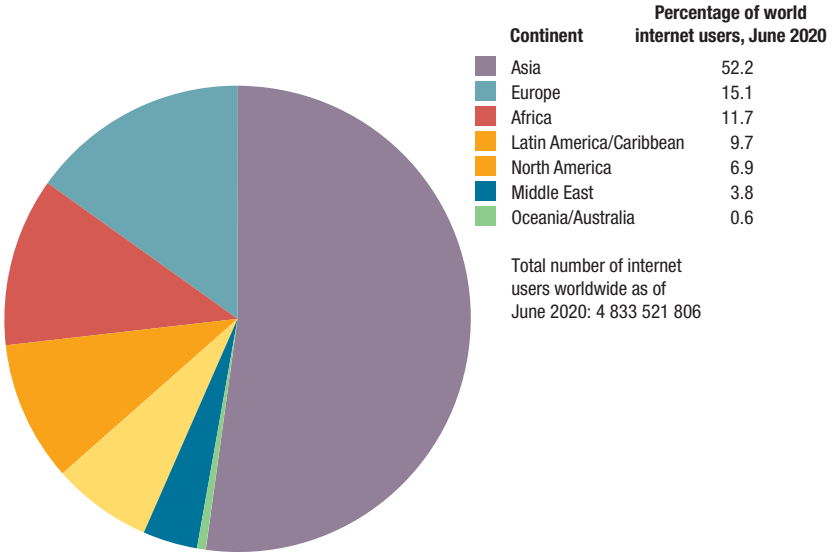

Figure 2.4.1c Percentage distribution of internet users by region, June 2020

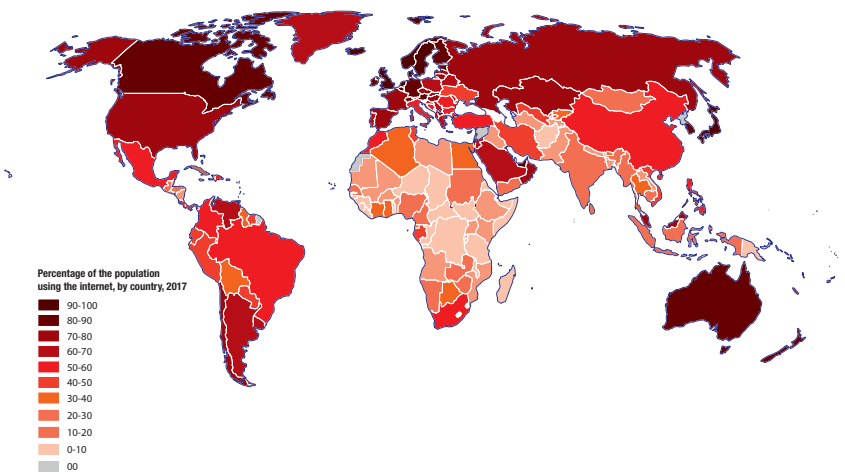

Figure 2.4.1e Percentage of the population using the internet, by country, 2017

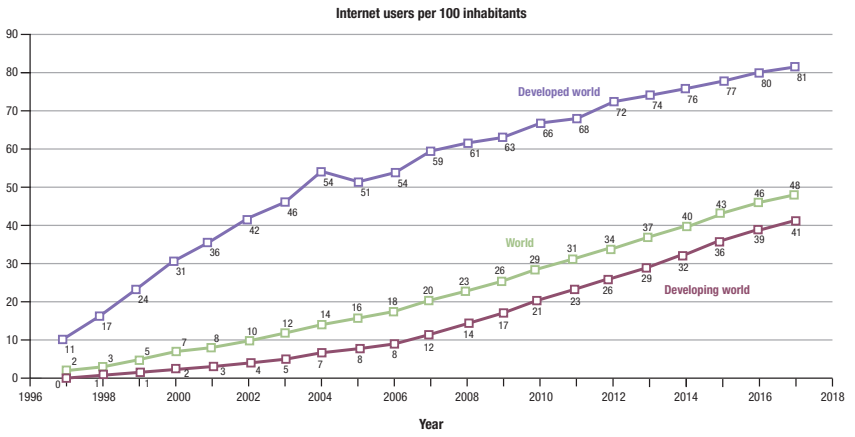

Figure 2.4.1b Internet users, percentage of population, 1997–2017

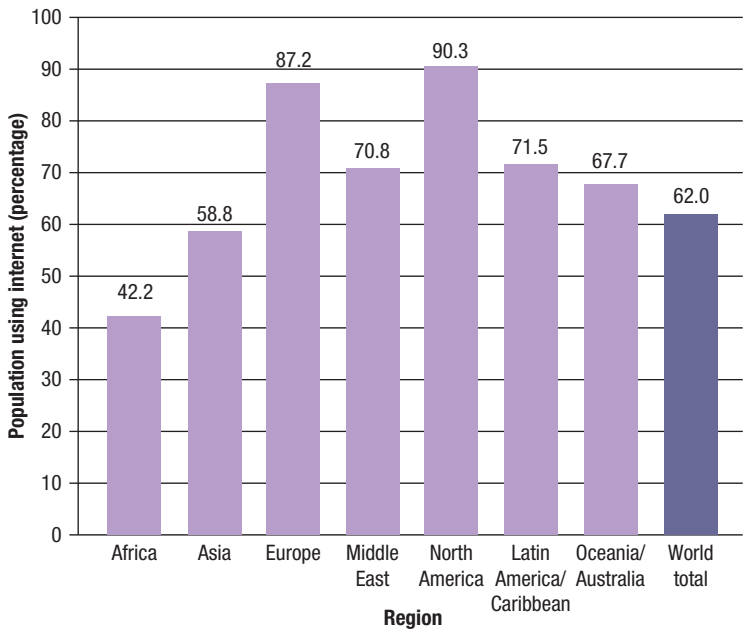

Figure 2.4.1d Percentage of the population using the internet, by region, June 2020 (penetration rate)

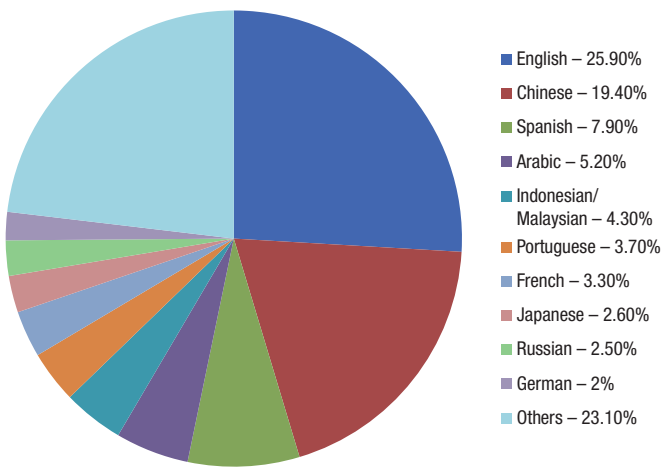

Figure 2.4.1f Percentage of internet users by language, March 2020

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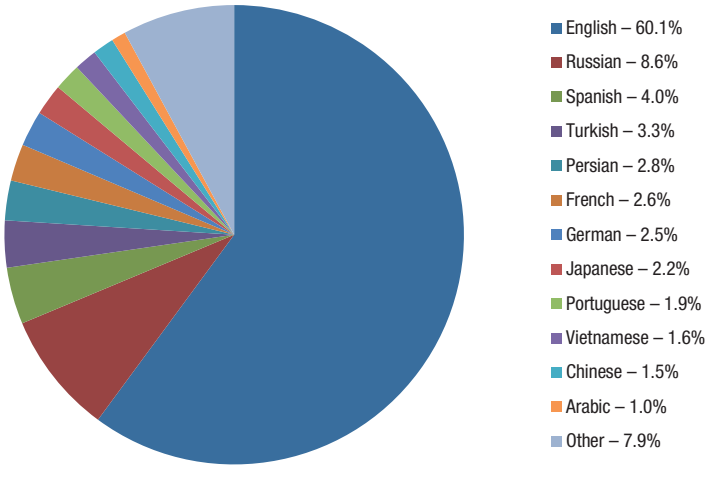

Figure 2.4.1g Websites by language used, 2020

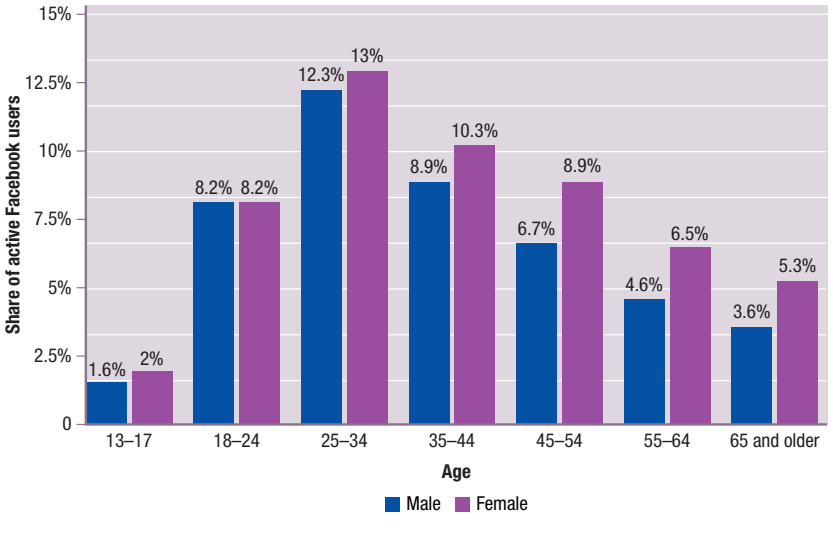

Figure 2.4.1i Age and gender distribution of Australian Facebook users, 2020

Figure 2.4.1j This is a map of world airline routes (pre-pandemic). The map shows 59 036 airline routes between 3209 airports by 531 airlines.

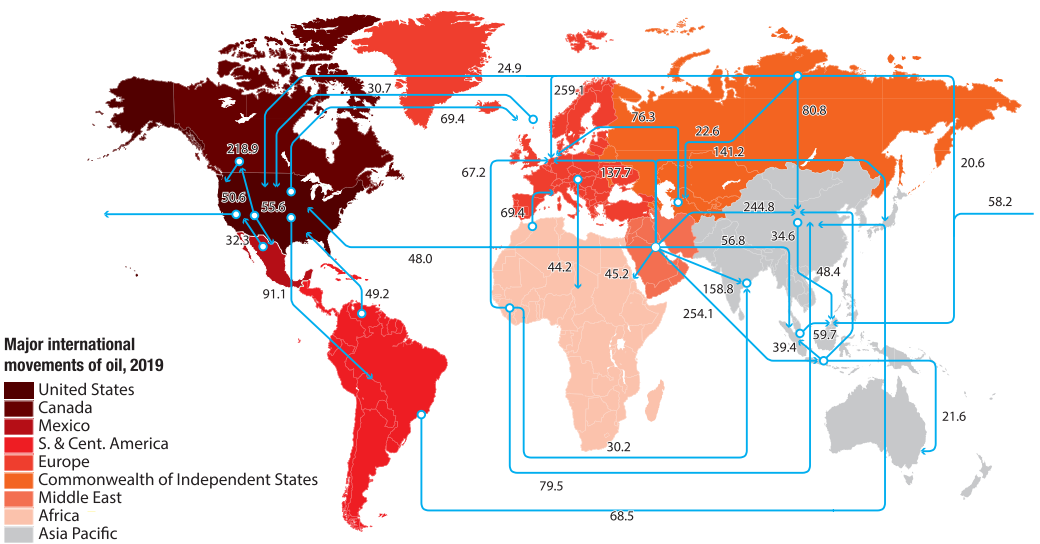

Figure 2.4.1k Major international movements of oil, 2019

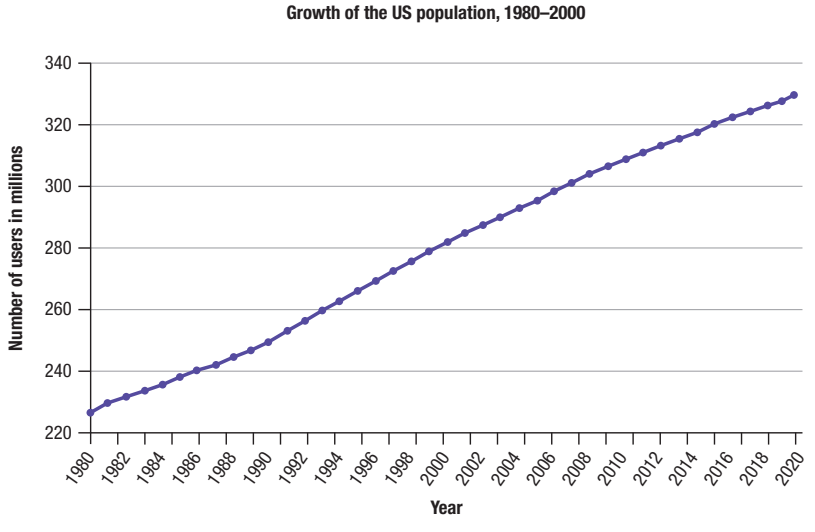

Figure 2.4.1h Number and distribution of monthly active Facebook users worldwide, third quarter, 2008 to second quarter of 2020 (in millions)

Social media

Social media has transformed the way people interact. They now use a range of platforms to exchange messages, post status updates and photos, share videos and receive notifications when others update their profiles or post a message. They can also use them to find out information about a range of goods and services.

The most popular of the social websites are Facebook (2.45 billion users), Instagram (1 billion active users), Twitter (330 monthly users), Snapchat (360 million monthly users) and Reddit (430 monthly users).

Zoom, as we all found out during the COVID-19 pandemic, and services such as Facetime are other means by which people can interact.

Facebook is the world's most popular social networking site. Mark Zuckerberg, and fellow Harvard College students and roommates, launched the site in February 2004. The company had a share market value of US$520 billion in late-2020. Instagram, the photo-and video-sharing platform (which is owned by Facebook), is valued at more than $120 billion. Massive amounts of wealth have been created by internet-based technologies.

Air transport

Developments in aviation technology, especially the introduction of the Boeing 747 and the Airbus A380, have helped to lower travel costs and increase the volume of international tourism and business activity. In addition to these cost savings, better coordination between different types of transportation (air, road, rail and shipping) has helped to reduce the time lost in the movement of people and goods. The result has been a rapid increase in world trade and international tourism.

This, in turn, has had an effect on cultural identity. People are increasingly exposed to new ideas, customs and traditions, and they often integrate aspects of these into their own way of life.

World oil trade

The global oil industry includes the exploration, extraction, refining, transporting and marketing of oil-based products, especially petroleum. The principal products of the industry are fuel oil and petrol. Oil is also the raw material for many chemical products, including pharmaceuticals, solvents, fertilisers, pesticides and plastics.

The global pattern of production and consumption features significant differences between areas of production and consumption. To address this, a vast global distribution system has been developed using tankers and pipelines.

Table 2.4.1a Percentage of population using Facebook, by region, January 2020

World region	Percentage of population
North America	68.5
Latin America/Caribbean	63.4
Oceania/Australia	54.0
Europe	47.4
Middle East	35.7
Asia	19.4
Africa	15.9

Total number of users 1.69 billion

Source: https://www.statista.com/statistics/241552/share-of-global-population-using-facebook-by-region/

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Figure 2.4.1l Container terminal, Hong Kong. The rapid expansion of world trade demonstrates how connected and integrated the world's economy has become.

Table 2.4.1b Australia's major trading partners, 2019

Total trade (Top 10 trading partners)		Exports (Top 10 export destinations)		Imports (Top 10 import sources)	
Country	(A$ million)	Country	(A$ million)	Country	(A$ million)
China	252 016	China	169 129	China	82 887
Japan	87 044	Japan	60 633	United States	55 661
United States	81 101	Rep. of Korea	28 246	Japan	26 411
Rep. of Korea	41 343	United States	25 440	Germany	18 194
United Kingdom	38 500	India	21 873	Thailand	17 400
Singapore	33 328	United Kingdom	21 208	United Kingdom	17 292
New Zealand	31 161	Singapore	16 866	Singapore	16 462
India	29 330	New Zealand	16 566	New Zealand	14 596
Malaysia	23 962	Taiwan	14 249	Rep. of Korea	13 097
Thailand	23 093	Malaysia	11 702	Malaysia	12 261

Australia's major trading partners

International trade involves the transfer of goods and services from one country to another in exchange for money, goods or services. Australia's two-way trade in goods and services was worth nearly $892 billion in 2019 – a vital component of Australia's economic prosperity. Australia's 10 largest trading partners, export markets & import sources are listed in Table 2.4.1a.

ACTIVITIES

1 Study Figure 2.4.1a (page 46). What does this illustration, and the data it contains, tell us about the nature of the connections that are transforming the ways in which we live our lives?

2 Study Figure 2.4.1b (page 46) and then answer the following questions:
- a When did the internet reach 50 per cent of the inhabitants in the developed world?
- b What rate was achieved in the developing world in that year?
- c What was the gap in internet users per 100 inhabitants between the developed and developing world in 2017?

3 Study Figure 2.4.1c (page 46) and then answer the following questions:
- a Which region has the largest number of internet users?
- b How many internet users were there in Europe in 2020?

4 Study Figure 2.4.1d (page 46). Which region had the highest internet penetration rate in 2020? Which had the lowest?

5 Study Figure 2.4.1e (page 46) and then answer the following questions:
- a Which countries/regions had an internet use rate greater than 80 per cent in 2017?
- b In which regions were the rates of internet usage lowest?

6 Study Figure 2.4.1f (page 46) and then answer the following questions:
- a What percentage of internet users speak: i English? ii Chinese?
- b Which are the two content languages most commonly found on the internet?

7 Study Figure 2.4.1g (page 47). State the percentage of the world's websites that are English based.

8 What is the most distinctive difference between the language of internet users shown in Figure 2.4.1f (page 46) and the website languages shown in Figure 2.4.1g (page 47)?

9 Study Figure 2.4.1h and 2.4.1i (page 47) and complete the following tasks:
- a Calculate the percentage by which the number of Facebook users increased between the 4th quarter 2011 and the 2nd quarter of 2020.
- b Which region had the highest percentage of its population using Facebook in 2020?
- c Which region had the lowest percentage of its population using Facebook in 2020?

10 Study Figure 2.4.1j (page 47). With the aid of an atlas, identify the world's main concentrations of airline activity.

11 Study Figure 2.4.1k (page 47). With the aid of an atlas, identify the four most important markets for oil sourced from the Middle East.

12 Study Table 2.4.1b and then complete the following tasks:
- a Identify Australia's three largest trading partners in 2019.
- b Identify Australia's most important export destination.
- c Identify Australia's largest source of imports.
- d Construct two column graphs, one showing the distribution of exports, the other showing the source of imports.

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2.4.2 GLOBAL TOURISM

According to the Australian Bureau of Statistics (ABS), tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited. International tourist movements surpassed 1 billion people for first time in 2012. In 2019 the number of movements exceeded 1.4 billion. The economic activity generated by tourism exceeded US$8.9 trillion in 2019 (10.3 per cent or the world's GDP). Chinese people are now the world's biggest tourism spenders. In 2019, 134 million Chinese tourists spent $277 billion.

Because tourism is a 'discretionary' expenditure, the industry is subject to shifts in consumer confidence. In time of economic uncertainty, people will postpone or even cut back on such spending.

The global pandemic of 2019–20 had a devastating impact on global tourism. International tourist arrivals declined 65 per cent in the first six months of the year. This resulted in a loss of US$460 billion in export earnings. It will take the industry years to recover.

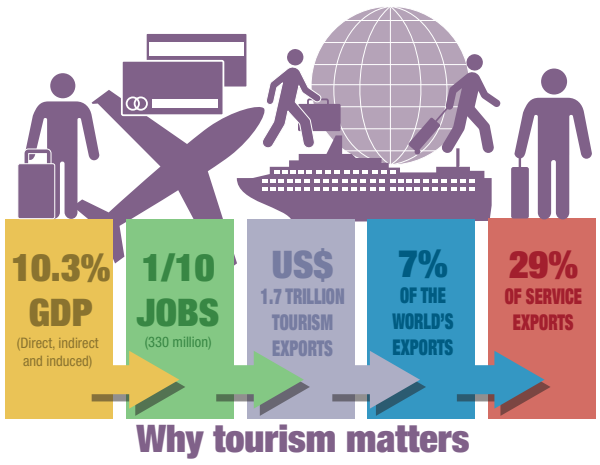

Figure 2.4.2a Why tourism matters, 2020

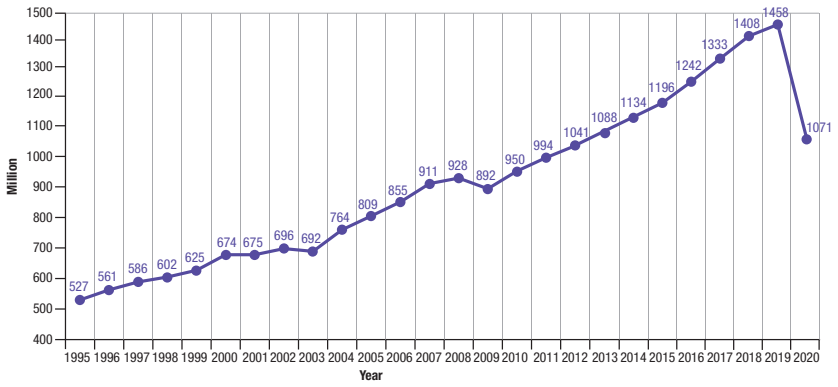

Figure 2.4.2b Growth in world inbound tourism, 1995–2019

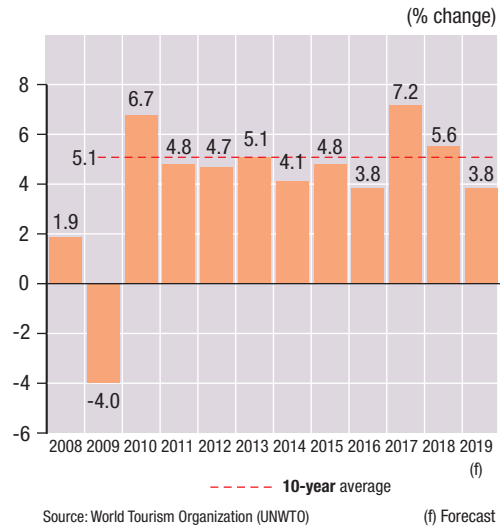

Figure 2.4.2c International tourist arrivals, annual change, 2008–2019

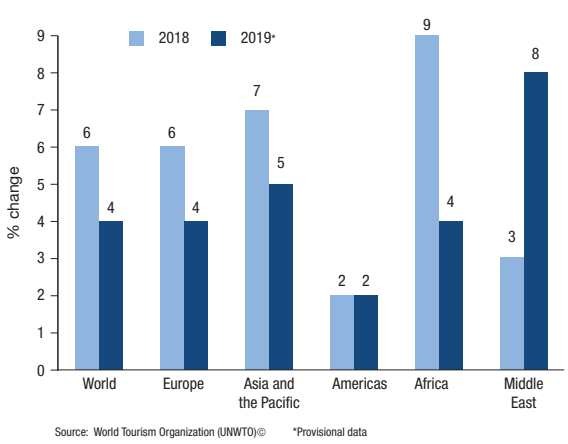

Figure 2.4.2d International tourist arrivals, by region. Percentage change 2018 and 2019

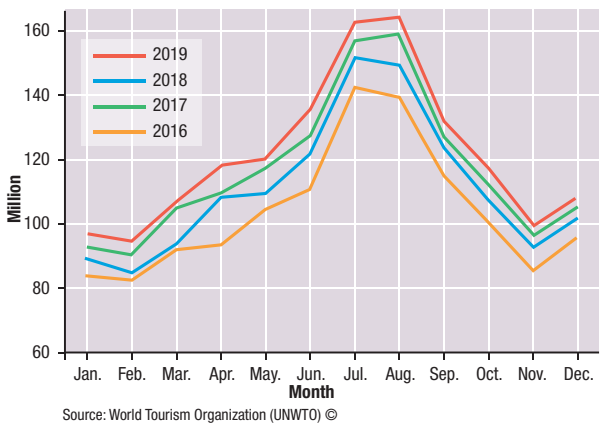

Figure 2.4.2e International tourism arrivals by month, 2016–2019

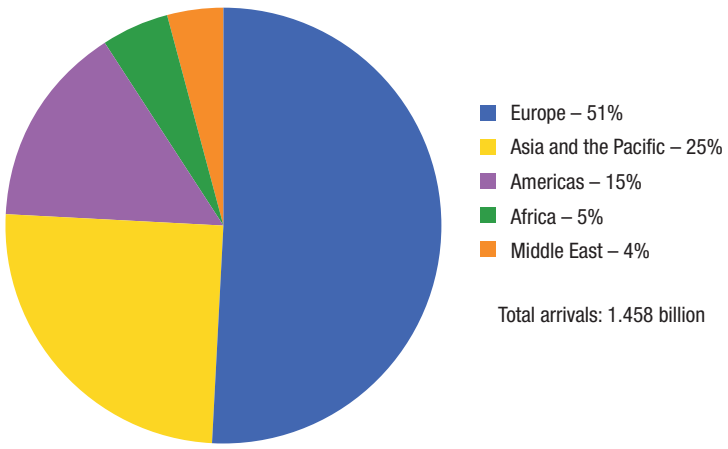

Figure 2.4.2f International tourist arrivals, by region, 2019

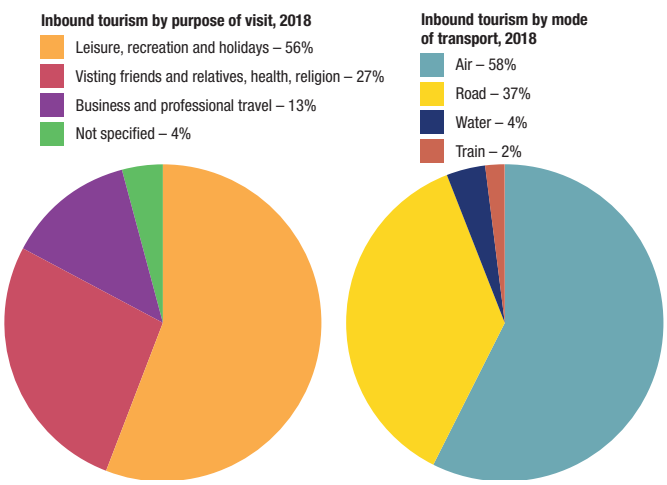

Figure 2.4.2g Purpose and mode of travel, 2018

Figure 2.4.2h New York City is one of the world's most popular tourist destinations.

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Australian tourism

Tourism is an important Australian industry. Before the COVID-19 pandemic, it accounted for 3.1 per cent of Australia's gross domestic product (GDP) and is worth around $60.8 billion a year to the national economy. Domestic tourism accounts for approximately 70 per cent of all tourism-related GDP. International tourism accounts for the rest. The industry employed 666 000 (5.2 per cent of the workforce) in 2019, of which 45 per cent were employed casually or part-time.

In 2019, more than 9.4 million international visitors came to Australia. The 'selling' of the tourist experience contributed A$37.4 billion to the Australian economy. Tourism is Australia's third most-valuable export after iron ore (A$61 billion) and coal (A$60 billion).

Popular Australian destinations include the coastal cities of Sydney and Melbourne, and the Gold Coast and the Great Barrier Reef in Queensland. Uluru and the Australian Outback are also popular destinations.

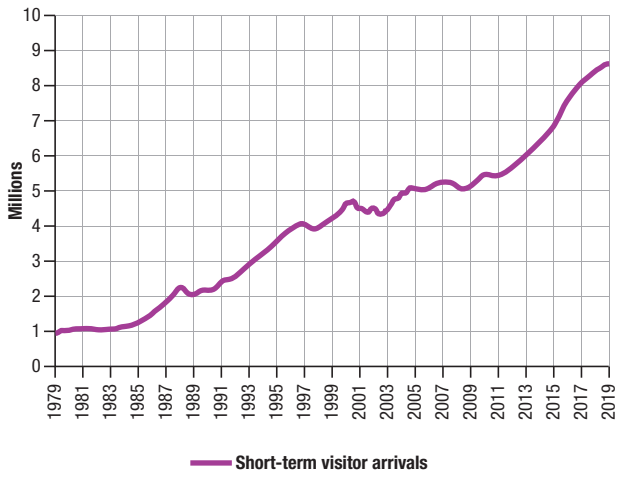

Figure 2.4.2i Short-term visitor arrivals, Australia, 1979–2019 (year ending December)

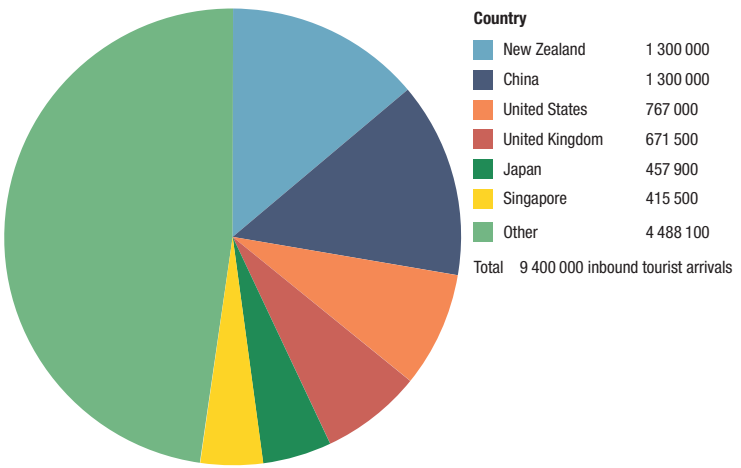

Figure 2.4.2j Where are they coming from? Country of origin, short-term visitors to Australia, 2019

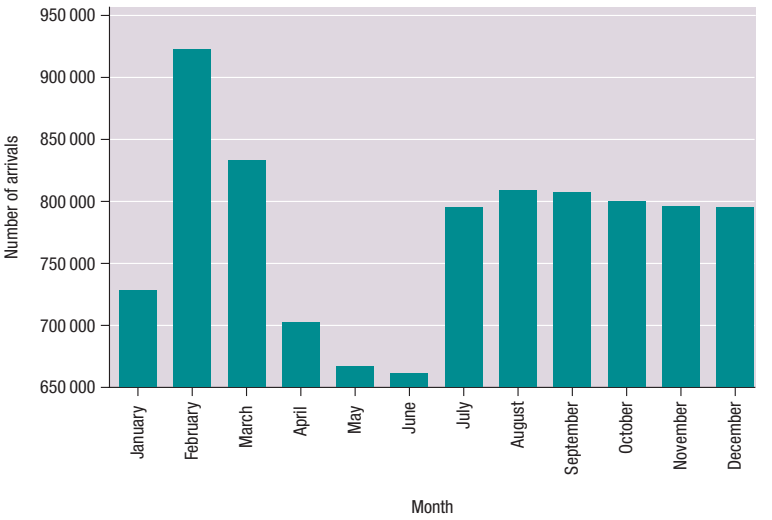

Figure 2.4.2k International arrivals by month, 2019

Figure 2.4.2l International arrivals by state/territory, 2019

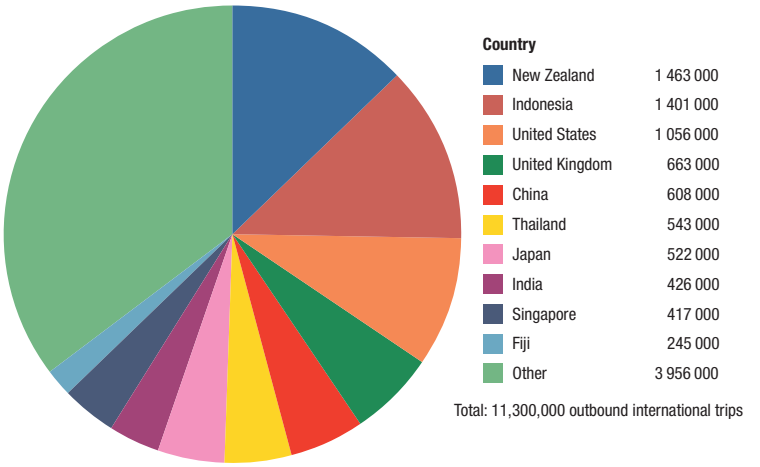

Figure 2.4.2m Where are Australians going to? Destination of short-term departures, 2019

ACTIVITIES

1 Study Figure 2.4.2a (page 49). Write a paragraph outlining the global significance of the tourism industry.

2 Study Figure 2.4.2b (page 49) and then answer the following questions:
- a What was the absolute growth in international tourist movements between 1995 and 2019?
- b What was the percentage increase in international tourist arrivals between 1995 and 2019?

3 Study Figure 2.4.2c (page 49). Describe the trend in international tourist arrivals since 2008 using data from the graph.

4 Study Figure 2.4.2d (page 49) and then answer the following questions:
- a Identify the region that experienced an increase in the rate of growth in international tourist arrivals in 2019 compared with that achieved in 2018.
- b Identify the region whose growth rate in 2019 was less than half that achieved in 2018.

5 Study Figure 2.4.2e (page 49). State the months of the year in which international tourist arrivals peak. Can you think of a reason why this may be the case?

6 Study Figure 2.4.2f (page 49) and then answer the following questions:
- a What proportion of international in-bound tourists did Europe account for in 2019?
- b How many international in-bound tourists did the Americas account for in 2019?

7 Study Figure 2.4.2g (page 49) and then answer the following questions:
- a What is the principal reason for travel?
- b What percentage of travel is for the purpose of business?
- c What is the principal mode of travel?
- d What percentage of travel is by road?

8 Study Figure 2.4.2i. Using data from the graph, describe the trend in short-term visitor arrivals to Australia.

9 Study Figures 2.4.2j and then answer the following questions:
- a What were the largest sources of in-bound short-term visitor arrivals in 2019?
- b What percentage of short-term arrivals came from China?
- c How many tourists came from the United States?
- d Which country accounts for 7% of short-term visitors?

10 Study 2.4.2k. Using data from the graph, write a paragraph outlining the distribution of international arrivals to Australia in 2019.

11 Study Figure 2.4.2l and then complete the following tasks:
- a Name the three Australian states/territories that receive the bulk of international arrivals.
- b As a class, brainstorm the factors that might explain the dominance of the three eastern states.

12 Study Figure 2.4.2m and then answer the following questions:
- a What are the three most popular destinations for Australians travelling overseas?
- b What percentage of departing Australians went to the United States?
- c How many departing Australians travelled to New Zealand?

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2.4.3 GLOBAL CRUISE INDUSTRY

Until the outbreak of COVID-19, the cruise industry was one of the fastest-growing sectors of the global tourism industry. In 2019 the industry's fleet of 278 cruise ships carried 30 million passengers.

The cruise industry has had an average annual passenger growth rate of 7 per cent since 1990. This growth has, at least in part, been driven by the ageing of the baby boomer generation. As people age, cruising becomes one of the few holidays available to those with mobility ailments. Rising disposable incomes have also increased demand for cruise-based holidays. A total of 19 new ships were scheduled to enter service in 2020.

There is, however, considerable potential for further growth in the industry. If all the world's cruise ships were filled to capacity all year long, the number of people involved would still only equal less than half the number of tourists that visit Las Vegas (more than 40 million a year).

Economic impact: In 2019, the global cruise industry generated $150 billion in economic activity, of which, $50.24 billion was paid in wages and salaries for the 1 177 000 people employed in the industry.

Pandemic impacts: The outbreak of COVID-19 was devastating for the industry. The world's fleet of cruise ships lay idle well into 2020. Companies, in their struggle for survival, scrapped (see Figure 2.4.3d) older vessels. Orders for new ships were either delayed or cancelled.

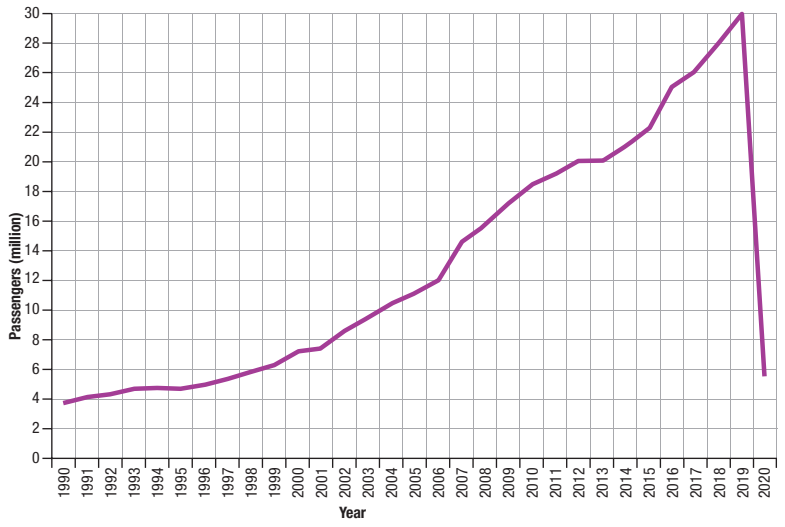
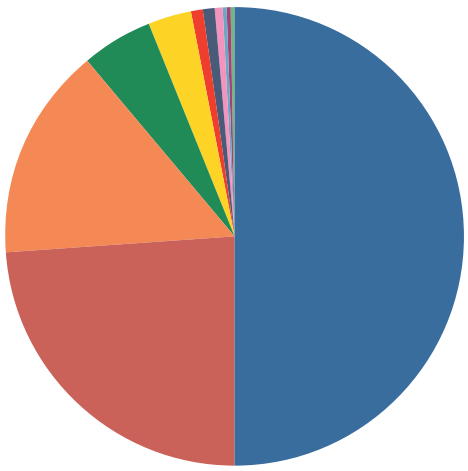


Figure 2.4.3a Growth of the global cruise industry, passengers carried, 1990–2019

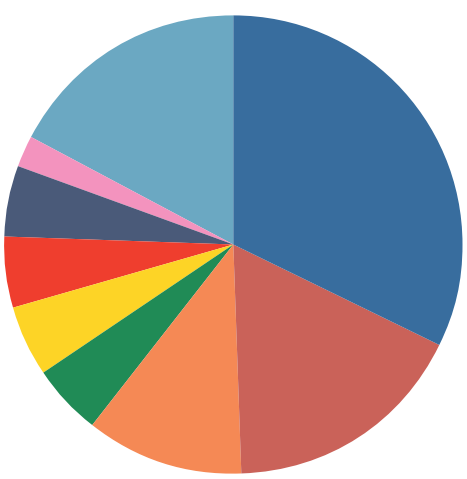
The Australian cruise industry

Before the onset of COVID-19, the Australian cruise industry was booming. By 2019, 1 in every 17 Australians (almost 6 per cent of the population) embarked on a cruise each year. Comparatively, only 4 per cent of the US population took a cruise and 3 per cent of the UK population. An increasing number of cruise ships are being based in Australia over the summer months. Some are based here all year.



Country	
North America	14 240 000
Western Europe	6 731 000
Asia	4 240 000
Australia/NZ/Pacific	1 460 000
South America	883 000
Scandinavia/Iceland	225 000
Eastern Europe	213 000
Africa	154 000
Middle East/Arabia	111 000
Caribbean	56 000
Central America	47 000
Total	28.4 million

Figure 2.4.3b Cruise passengers by region of origin, 2018



Country	
Caribbean	32%
Mediterranean	17%
Europe	11%
China	5%
Australia/NZ/Pacific	5%
Alaska	5%
Asia	5%
South America	2%
All other	17%

Total ships deployed: 278

Figure 2.4.3c Ship deployment by region, 2019

ACTIVITIES

1 Study Figure 2.4.3a and then answer the following questions:
- a By how much did the number of passengers carried by the world's cruise industry increase between 1990 and 2019?
- b In what year did the number of passengers carried exceed 12 million?
- c Which period experienced the greatest rate of increase in passenger numbers?

2 Study Figure 2.4.3b and then answer the following questions:
- a What is the largest single source of cruise ship passengers?
- b How many cruise ship passengers originated from North America?
- c What percentage of cruise ship passengers originated from the Australia/NZ/Pacific region?

3 Study Figure 2.4.3c and then complete the following tasks:
- a Write a sentence outlining the deployment of cruise ships by region in 2019.
- b State the number of cruise ships deployed in the Caribbean.
- c State the number of cruise ships based in Australia/NZ/Pacific.

4 Study Figure 2.4.3d. Investigate the impact of the COVID-19 pandemic on the global cruise industry. Present your findings as a written report.

5 Study Figures 2.4.3e. Using data from the graph write a paragraph outlining the growth of the Australian cruise industry since 2002.

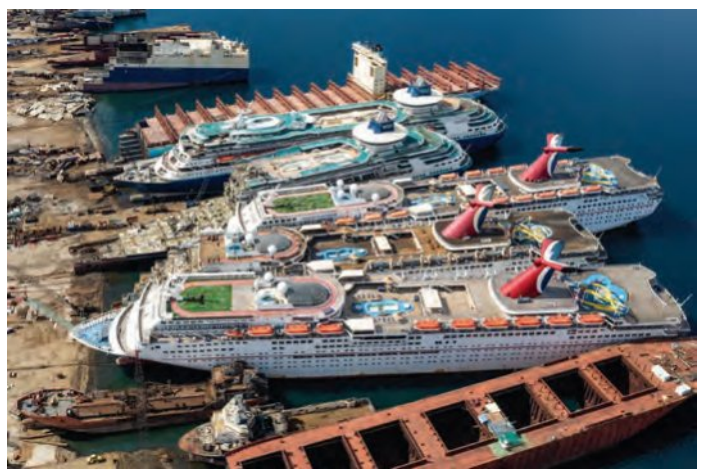


Figure 2.4.3d Cruise ships being broken up for scrap in Turkey in 2020

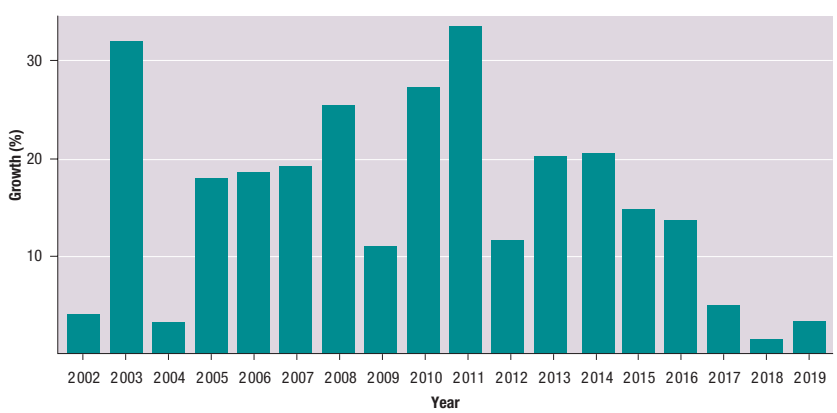


Figure 2.4.3e Australian cruise industry: growth in passenger numbers 2002–2019

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2.5 Sustainable biomes

2.5.1 BIOMES

A biome is a large geographical area with distinctive plant and animal species that are adapted to that particular environment. The climate and geography of a region determines what types of biomes are found there. The Earth's major biomes are shown in Figure 2.5.1a.

Each biome consists of many ecosystems whose communities have adapted to the small differences in climate and the environment within the biome.

All living things are closely related to their environment. Any change in one part of an environment causes a ripple effect of change through other parts of the environment. There are three kinds of change:

- *Habitat destruction*. People are directly destroying habitats, including cutting down forests, filling in wetlands and dredging rivers.
- *Habitat fragmentation*. Much of the world's remaining terrestrial habitat has been fragmented by road construction and other forms of 'development'. Aquatic species' habitats have been fragmented by dams and water diversions. Many of these habitat fragments may not be large or connected enough to support species that need a large territory. The loss and fragmentation of habitat make it difficult for migratory species to find places to rest and feed along their migration routes.
- *Habitat degradation*. Pollution, introduced species and disruption of eco-system processes (for example, changes in the intensity and frequency of fire) are some of the ways habitats are degraded. When this occurs the ability to support native plants and animals declines.

Table 2.5.1a Area of biomes

Biome	Percentage of the Earth's land surface
Tropical rainforest	8
Tropical savanna	24
Desert	21
Chaparral	2
Grasslands	7
Temperate (deciduous) forest	7
Coniferous (boreal) forest	14
Arctic and alpine tundra	5
Other (polar and cities)	12

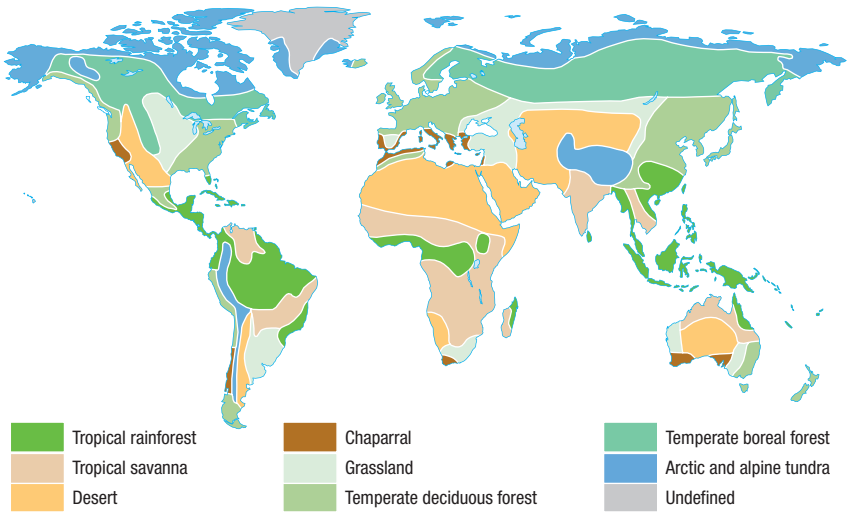

Figure 2.5.1a Biomes of the world

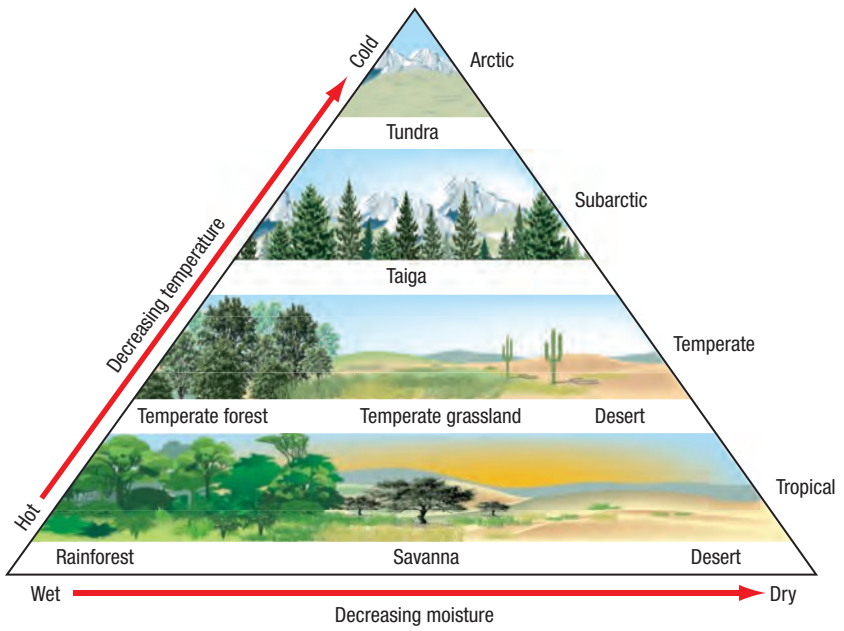

Figure 2.5.1b Land-based biomes are determined by climate (temperature and moisture).

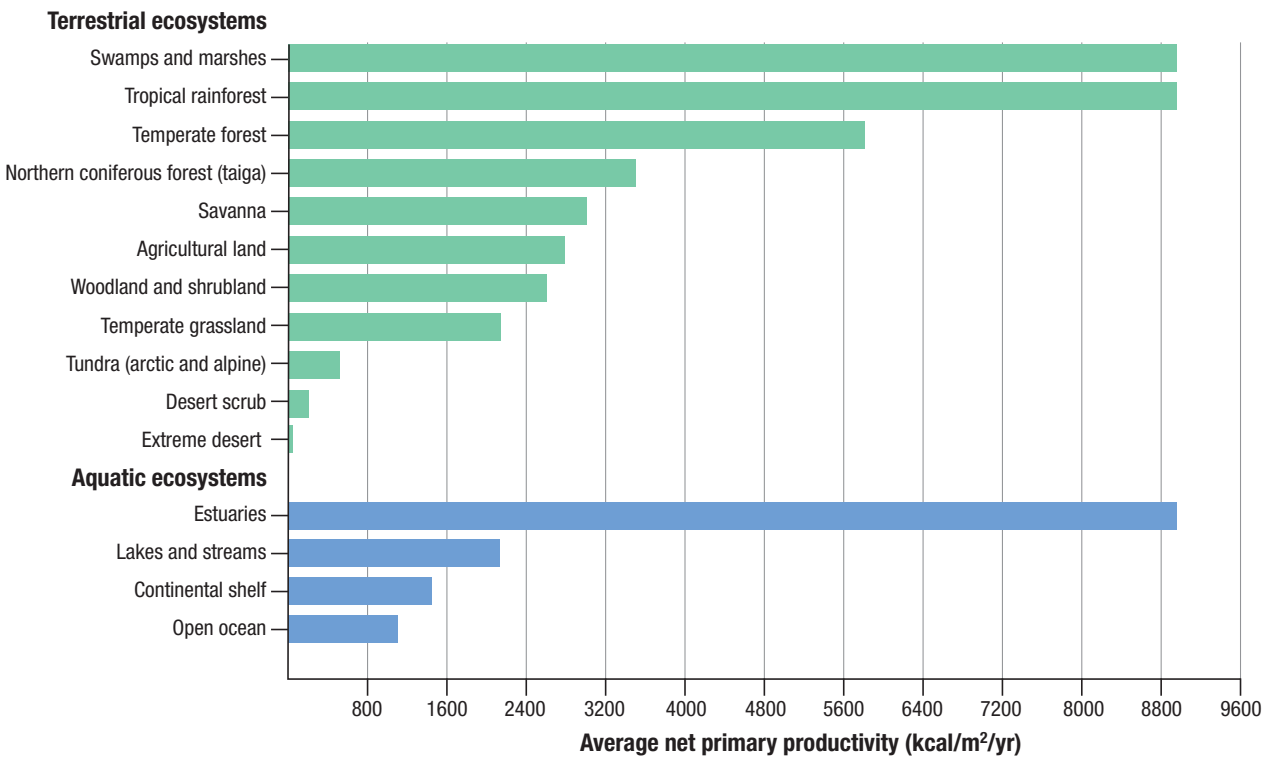

Figure 2.5.1c Average net primary productivity of ecosystems

Protecting biomes and ecosystems

Conservation is the practice of protecting endangered habitats and their associated plant and animal species. The establishment of *protected areas* through legal measures can serve to protect critical ecosystems. *Habitat restoration* is also possible in some cases, but is often very expensive.

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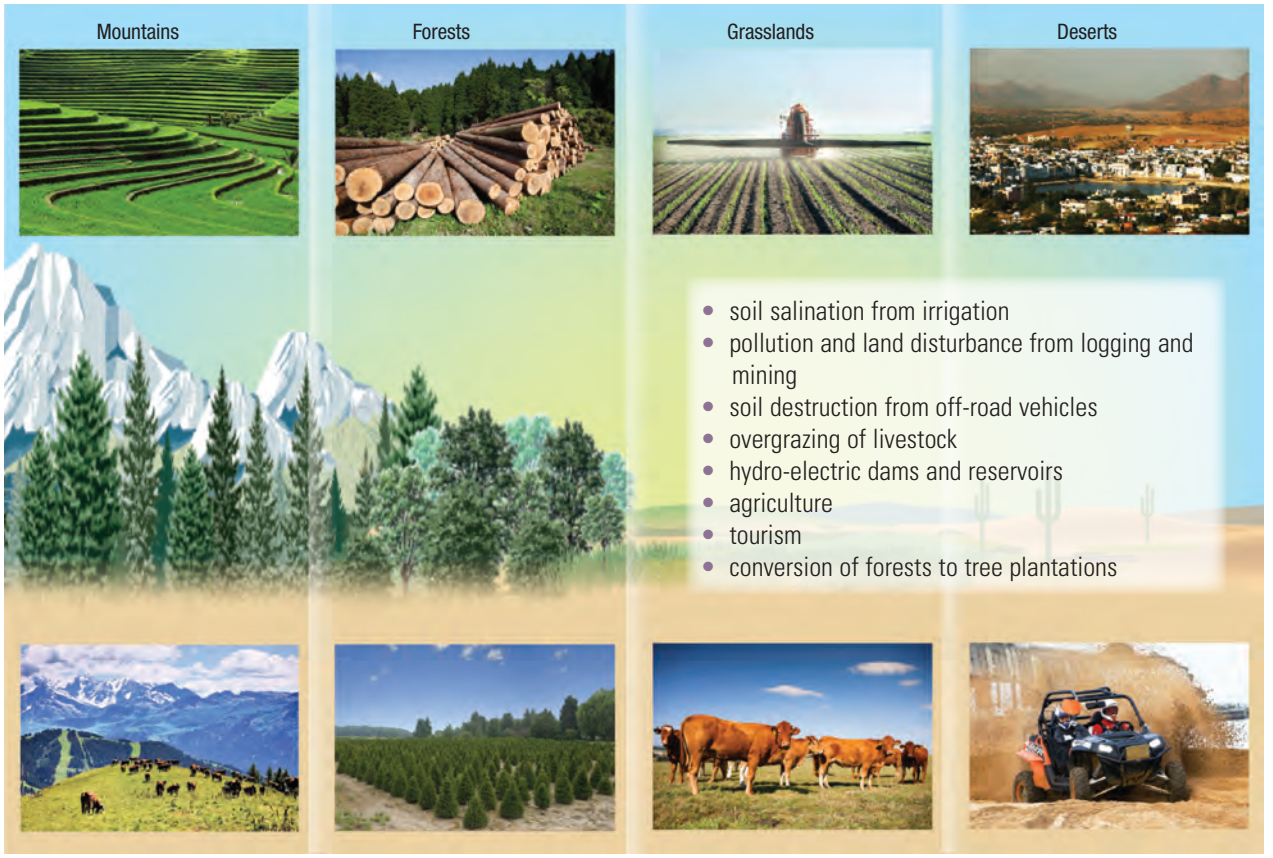

Figure 2.5.1d Major human effects on land-based (terrestrial) ecosystems

Figure 2.5.1e Major human effects on marine ecosystems and coral reefs (aquatic ecosystems)

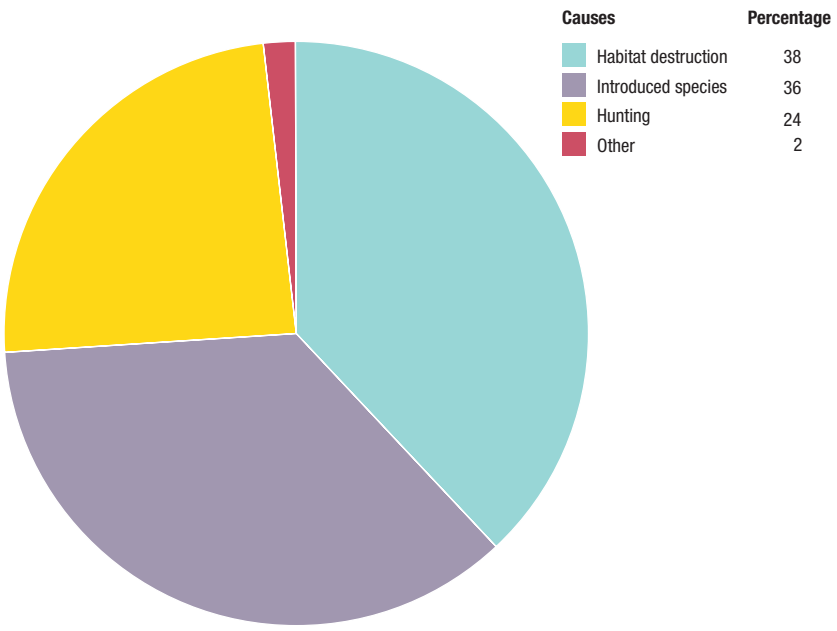

Figure 2.5.1f Causes of species loss

ACTIVITIES

1 Study Figures 2.5.1a, 2.5.1b and an atlas map showing the Earth's climate zones. Write a paragraph or two outlining the relationship between latitude, climate and the distribution of the Earth's major biomes.

2 Study Table 2.5.1a. Construct a pie graph showing the percentage of the Earth's surface occupied by each of the major terrestrial biomes.

3 Study Figure 2.5.1b. Which biomes exist under the following conditions:
- a high temperatures and dry conditions
- b high temperatures and wet conditions
- c high temperatures and moderate rainfall
- d low temperatures and moderate precipitation
- e moderate temperatures and high rainfall
- f low temperatures and variable rainfall?

4 Study Figure 2.5.1c. Which are the world's most productive ecosystems? Which is its least productive?

5 Where are the Earth's most productive aquatic ecosystems found?

6 Study Figures 2.5.1d and 2.5.1e. Use the information featured in the illustrations to construct your own mind map documenting human effects on terrestrial and aquatic environments.

7 Study Figure 2.5.1f. What is the principal cause of species loss? What percentage of species loss is a result of species introduction?

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2.5.2 AUSTRALIA'S VEGETATION

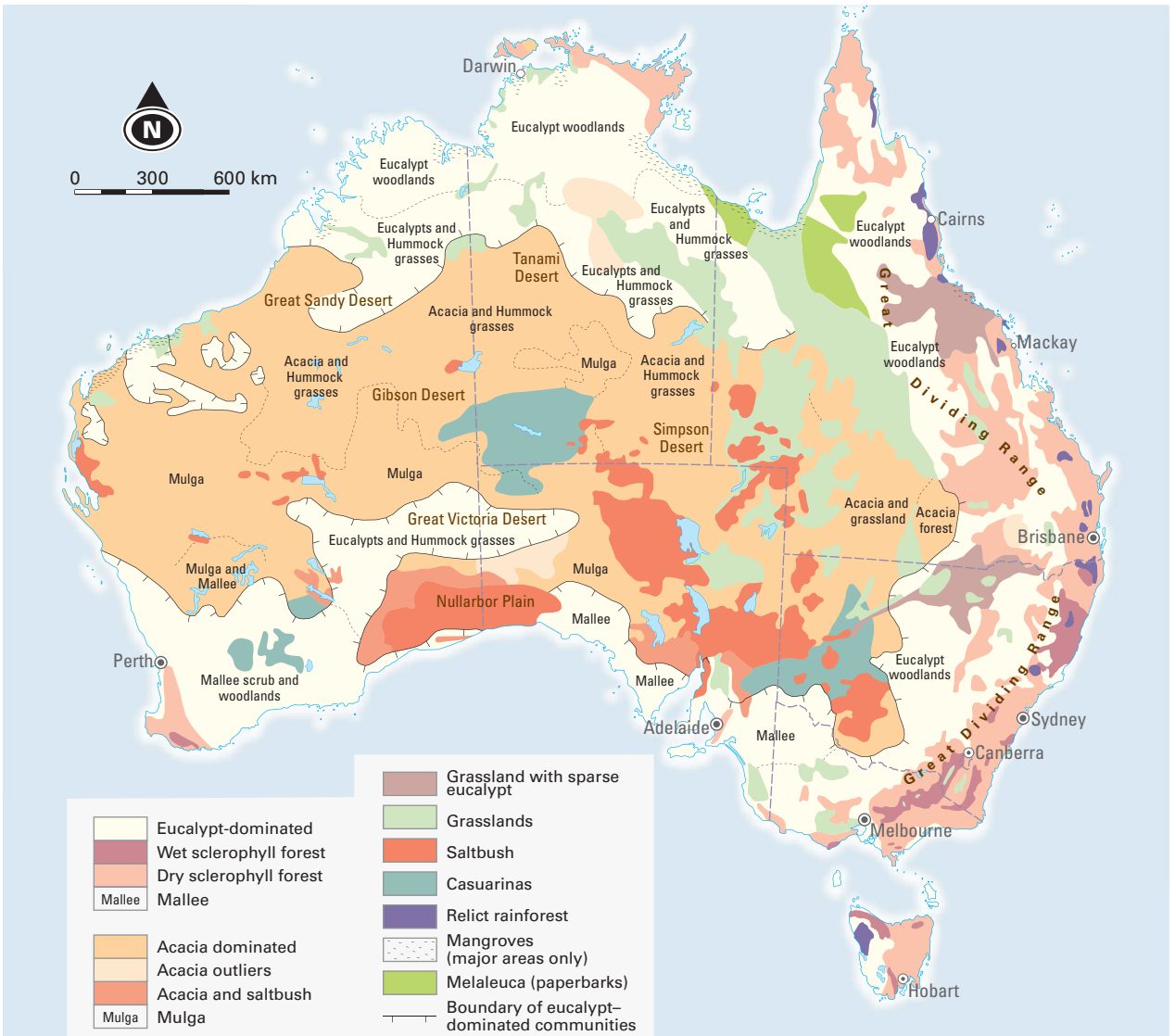


Figure 2.5.2a Australia's natural vegetation

Figure 2.5.2b Mallee

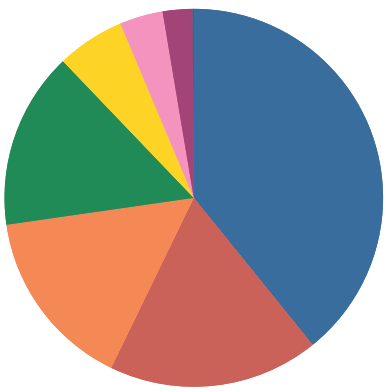
Figure 2.5.2c Acacia (wattle)

Figure 2.5.2d Mulga

Figure 2.5.2e Grassland

Figure 2.5.2f Saltbush (foreground)

Figure 2.5.2g Casuarinas



State/Territory	Percentage of total native forest
Queensland	39
Northern Territory	10
Western Australia	16
NSW	15
Victoria	6
South Australia	4
Tasmania	3
ACT	0.1

Total Area: 131 615 hectares

Figure 2.5.2h Native forest cover, by jurisdiction, 2018

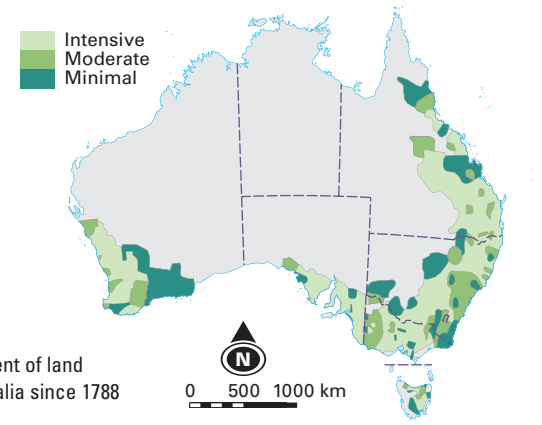


Figure 2.5.2i Extent of land clearing in Australia since 1788

ACTIVITIES

1. Study Figure 2.5.2a. In what parts of Australia are the major areas of mangroves located?
2. Using Figure 2.5.2a, describe the distribution of the vegetation types shown in Figures 2.5.2b to 2.5.2g.
3. Using the information on Australia's climate in Unit 2.3.1 (pages 40–42), comment on the type of climate conditions under which the vegetation types shown in the photographs develop.
4. Undertake library or internet research and complete the following tasks:
   a. Explain the difference between wet and dry sclerophyll forests.
   b. Describe the distribution of Australia's wet and dry sclerophyll forests. With reference to Figure 2.3.1i (page 42), state how this pattern relates to the distribution of rainfall.
5. Study Table 2.5.2a. Construct a pie graph showing the area of native forest types in Australia.

Table 2.5.2a Area of native forest in Australia by type

Forest type	Area ('000 ha)
Acacia	10 813
Callitris (Cypress Pine)	2011
Casuarina	1 236
Eucalypt	101 058
Mangrove	854
Melaleuca	6 382
Rainforest	3 581
Other native forest	5 679
Total native forest	131 615

Source: Australia's State of the Forests Report, 2018

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Figure 2.5.2j Primary* forest clearing by jurisdiction 2010–2018
* *'Primary' forest clearing refers to felling of forests at least 30 years old.*

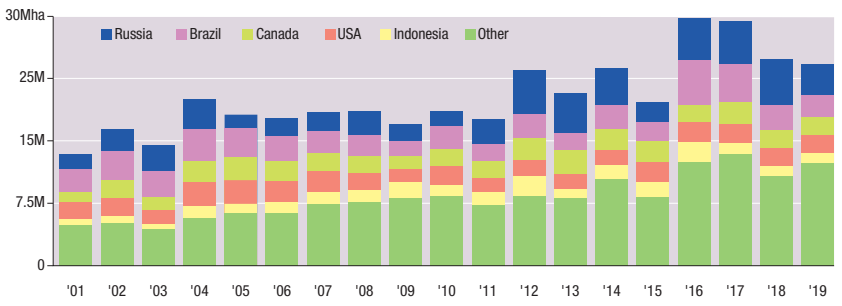
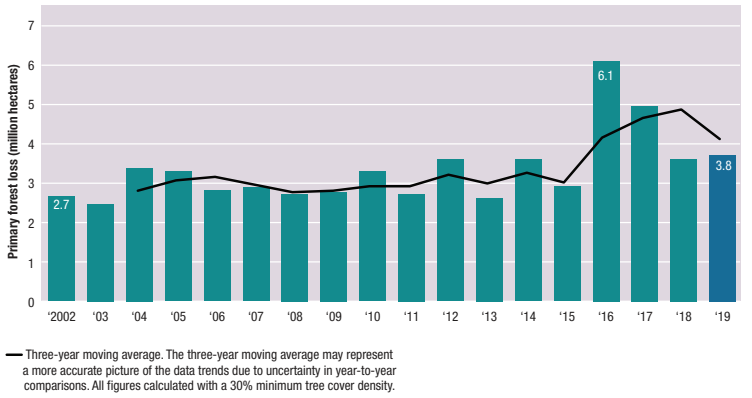


Figure 2.5.2k Global annual tree cover loss, 2001–2019
Source: Global Forest Watch



— Three-year moving average. The three-year moving average may represent a more accurate picture of the data trends due to uncertainty in year-to-year comparisons. All figures calculated with a 30% minimum tree cover density.

Figure 2.5.2l Tropical Primary Forest Loss, 2002–2019

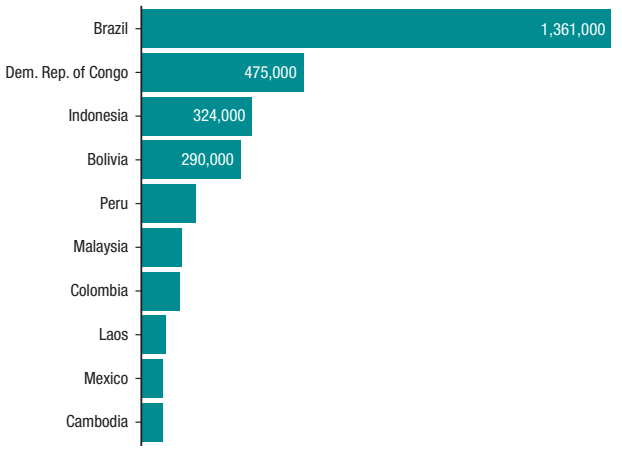


Figure 2.5.2m Top 10 tropical countries that lost the most primary forest in 2019 (hectares)

ACTIVITIES

6 Study Figure 2.5.2h (page 54) and answer the following questions:
- a What is the approximate area of native forest in Queensland and Western Australia?
- b Which state or territory has approximately 5000 ha of native forest?

7 Study Figures 2.5.2i (page 54) and 2.6.3b (page 67). Comment on the relationship between land clearing and the distribution of Australia's population.

8 Refer to Figures 2.5.2a and 2.5.2i (page 54). Which vegetation types have been most affected by land clearing?

9 Study Figure 2.5.2j and complete the following tasks:
- a Identify the state/territory that experienced the greatest loss of forest cover in the period 2010–2018.
- b How much forest was lost in Tasmania?

10 Study Figure 2.5.2k and complete the following tasks:
- a State the years in which tree cover loss equalled or exceeded 23 million hectares per annum.
- b Describe the general trend in tree cover loss since 2001.
- c Identify the country that made the greatest contribution to tree cover loss in 2016 and 2018.

11 Study Figure 2.5.2l and 2.5.2m and then complete the following tasks:
- a Identify the year in which tropical primary forest loss peaked.
- b Describe the general trend in forest loss since 2002.
- c Identify the four countries that account for the greatest amount of tropical forest loss.

12 In groups, brainstorm the likely effects of such large-scale land clearing. Share the main points raised in your group's discussion with the rest of the class.

13 As a class, list the activities of people that contribute to land degradation.

14 Study Figure 2.5.2o. Explain the effects of land clearance on salinity.

15 Study Figure 2.5.2p. Explain how irrigation can affect the level of salinity in river systems.

Land clearing and salinity

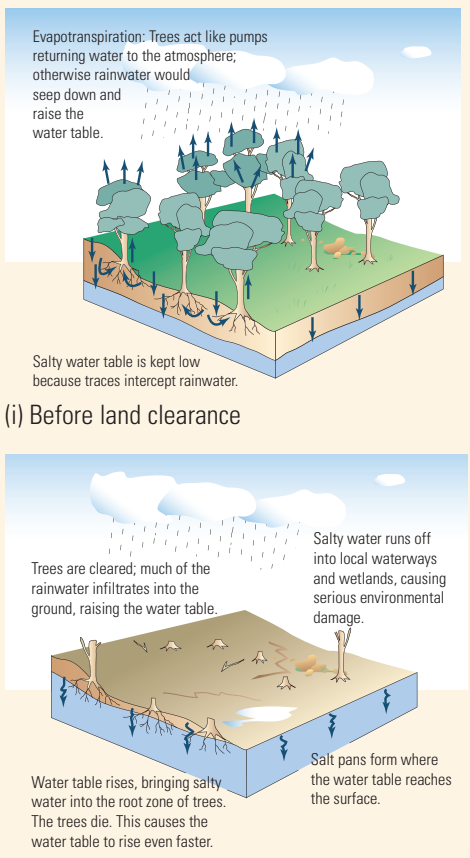


Figure 2.5.2o The effects of land clearance on salinity. The removal of deep-rooted native vegetation results in rising water tables and the salinisation of soils.

Irrigation salinity

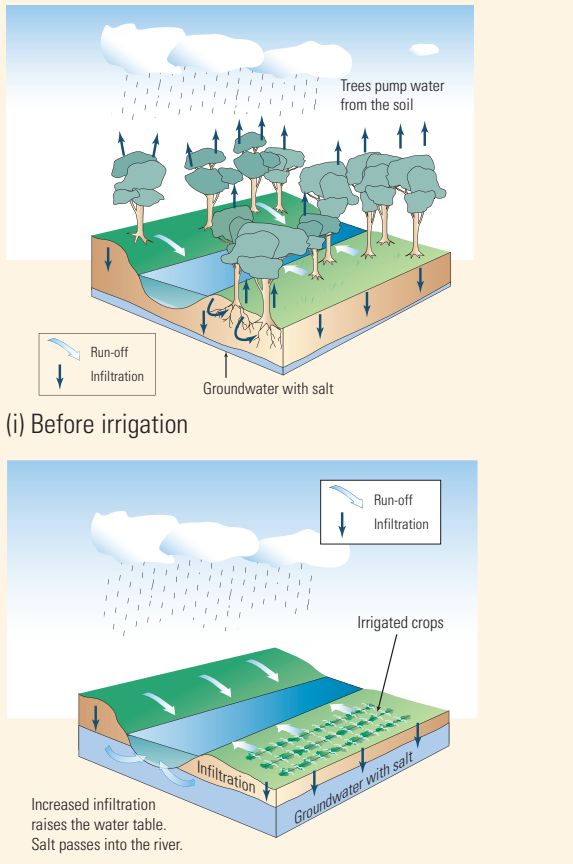


Figure 2.5.2p The effects of irrigation on salinity. Irrigation water causes the water table to rise, bringing dissolved salts to the surface.

Figure 2.5.2n Rainforest loss in the Amazon

ACTIVITIES

16 Undertake library and/or internet-based research. Investigate alternative methods of irrigation that minimise the amount of water added to the water table.

17 Undertake library and/or internet-based research. Investigate strategies to manage rising water tables and protect water quality in local river systems.

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2.5.3 FOOD SECURITY

Figure 2.5.3a One in nine people do not have enough food to eat. That's 793 million people who are undernourished. One third of all food produced is lost or wasted. That's around 1.3 billion tonnes of food.

Food security is achieved when all people at all times have physical and economic access to sufficient, safe, nutritious food to meet dietary needs and food preferences for a healthy and active life.

To be 'food secure' means that:

- enough good-quality food is available
- food is affordable and within the reach of all
- the right kind of food is available.
- The threats to food security are outlined in Figure 2.5.3d.

Food price increases

Rising food prices have pushed millions of people in developing countries further into hunger and poverty. However, it is not just high prices that are a problem. Prices are unpredictable and fluctuate widely, meaning that consumers cannot rely on regular prices, and producers are unable to plan their investments with certainty. The main causes of price increases are:

- reduced crop yields due to weather, possibly linked to climate change
- export restrictions and panic buying – usually caused by weather-related shocks
- increased demand, both for biofuels – which take land away from food production – and for food (especially meat)
- increased oil prices, which have driven up the cost of agricultural inputs such as fertilisers and transport.

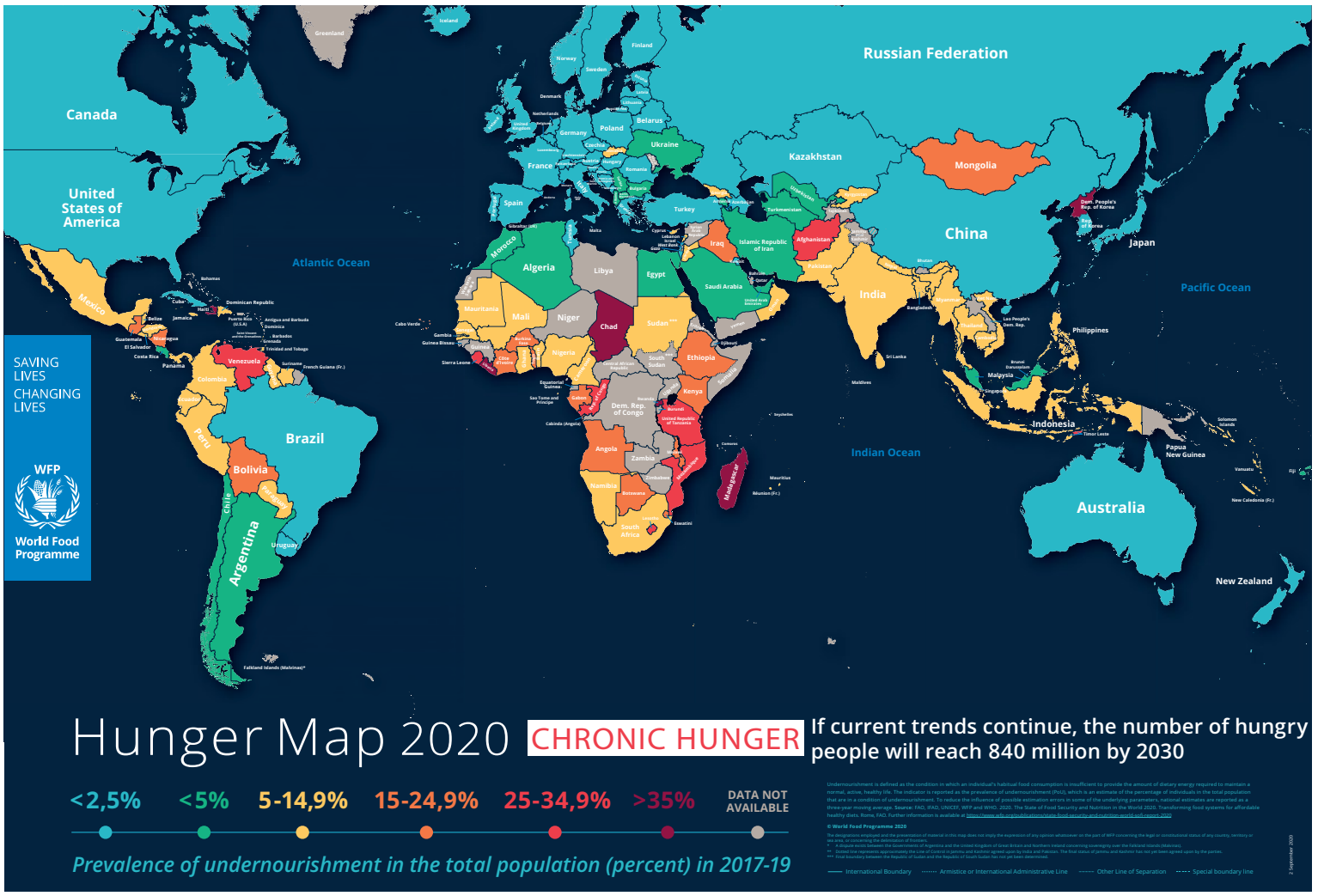

Figure 2.5.3b Incidence of undernourishment in the total population (per cent) in 2016–18

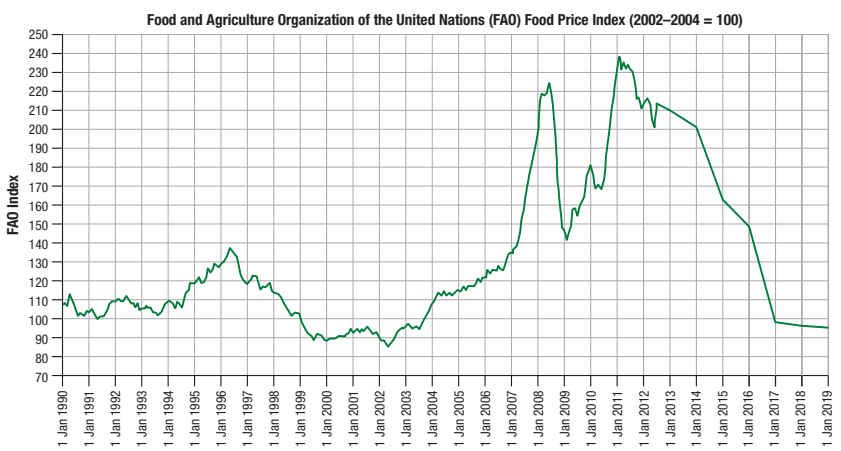

Figure 2.5.3c Trends in food prices 1990–2019

Table 2.5.3a Suitable land for agriculture

Region	Cultivated area (millions of hectares)	Area suitable for agriculture (millions of hectares)	Percentage of suitable land in cultivation
Asia	439	585	75
Latin America	203	1066	19
OECD	265	497	53
Russia	387	874	44
Sub-Saharan Africa	228	1031	22
West Asia and North America	86	99	87
World	1600	4152	39

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Barriers to increasing food production

Population growth: World population is expected to increase from 7.8 billion in 2020 to more than 9.9 billion by 2050. Every 13 years the world population grows by 1 billion, representing an extra billion mouths that need to be fed. Much of this growth is occurring in those parts of the world already experiencing food shortages, especially Asia and Africa.

Water shortages: The world is running out of fresh water. Food production currently accounts for about 70 per cent of the world's readily available fresh water. However, the growth of cities, with their need for huge amounts of water, is competing with farmers for this resource. By 2050, the urban population will consume half or more of all the world's availble fresh water. Unless major new sources or savings are found, farmers will have to make do with about half of the world's currently available fresh water supply while needing to grow twice as much food.

Land scarcity: The world is running out of good farmland. A quarter of all land is now so degraded that it struggles to produce food. At the same time, cities are smothering the world's most fertile soil in concrete and asphalt. Land is also lost to food production when polluted by toxic industrial wastes. The loss of the best food-producing land severely limits the possibility of increasing food production.

Nutrient loss: Soil nutrients are being lost at an accelerating rate. The annual losses resulting from soil erosion alone are enormous, and half the fertiliser used to boost nutrient levels is being wasted. The global nutrient cycle, which has sustained humanity throughout our history, has broken down.

Fossil fuel dependence: Advanced farming techniques depend entirely on fossil fuels, which are rapidly increasing in cost. As the price of such fuels increases, the demand for biofuels rises. Increasing amounts of grain are being grown to produce fuel rather than food.

Techonology: For three decades scientific research boosted crop yields, but the rate of innovation has slowed, leading to a decline in productivity gains.

Climate: The Earth is warming. Up to half the planet may face regular drought by the end of the century. Natural hazards such as storms, floods and droughts are predicted to become more frequent and intense. This will affect food security, create conflict and lead to waves of refugees.

Economics, politics and trade: Trade barriers and farm subsidies distort world markets and inflate the price of food. At the same time, the price received by farmers has been driven down. Some farmers are paid to grow fuel instead of food.

Figure 2.5.3d Barriers to increasing food production

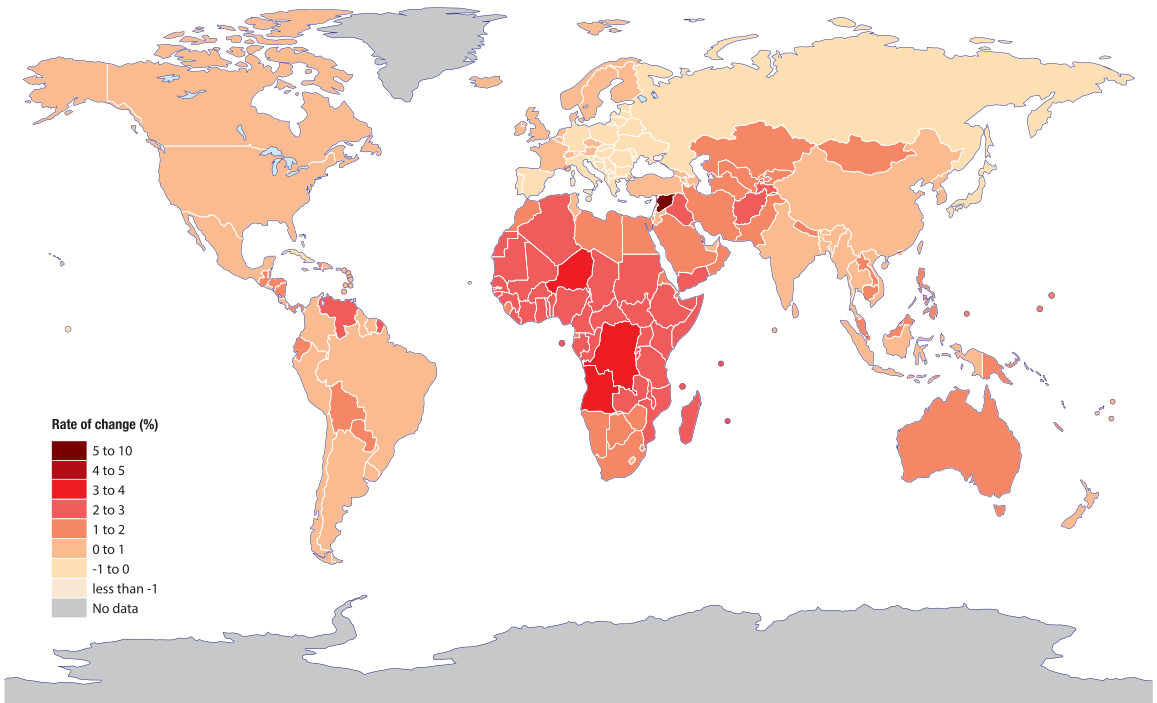

Figure 2.5.3e Projected average annual rate of population change, 2020–2025

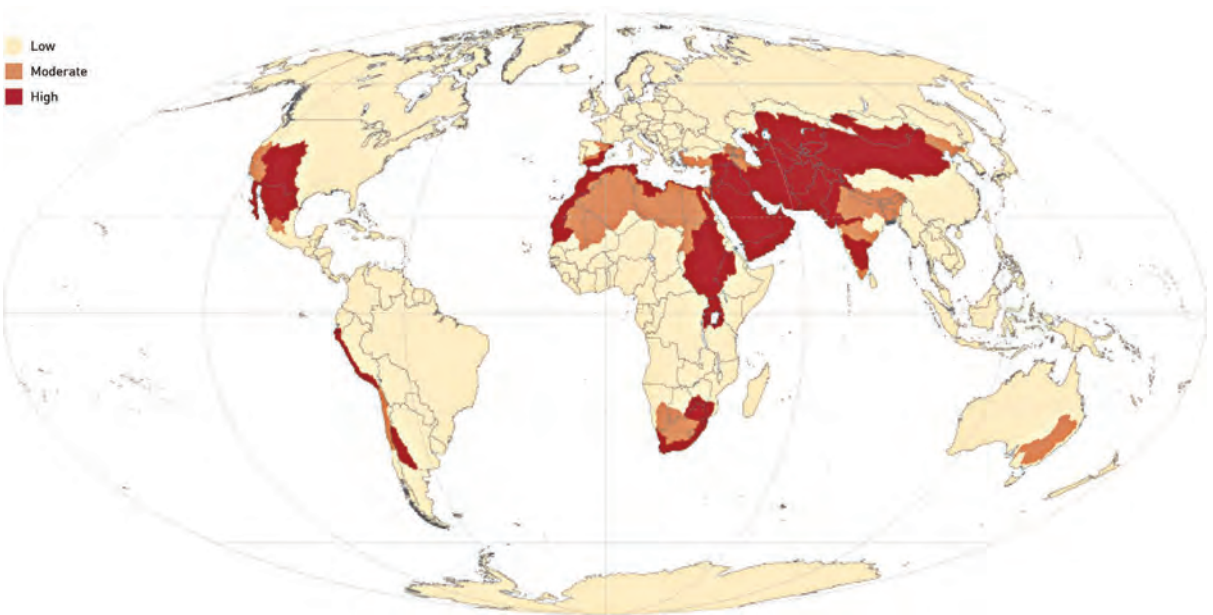

Figure 2.5.3f Distribution of physical water scarcity by major water basins

Figure 2.5.3g A malnourished Somali boy lies on his mother's hands. Millions of people in eastern Africa are affected by food shortage – a result of drought and famine.

Water scarcity

Water is essential for human wellbeing and the maintenance of healthy ecosystems. However, population increases raise the demand for groundwater and surface water by domestic, agricultural and industrial land uses, leading to tensions and conflicts among users and excessive pressure on the environment. Water scarcity occurs when there is an imbalance between water availability and demand, and the degradation of water quality.

Water use has been growing at more than twice the rate of population increase over the past century, and while there is no global scarcity of water, an increasing number of regions are experiencing water shortages. By 2025, 1800 million people will be living in countries or regions with absolute water scarcity. The situation is made worse as rapidly growing urban areas place a heavy demand on neighbouring water resources.

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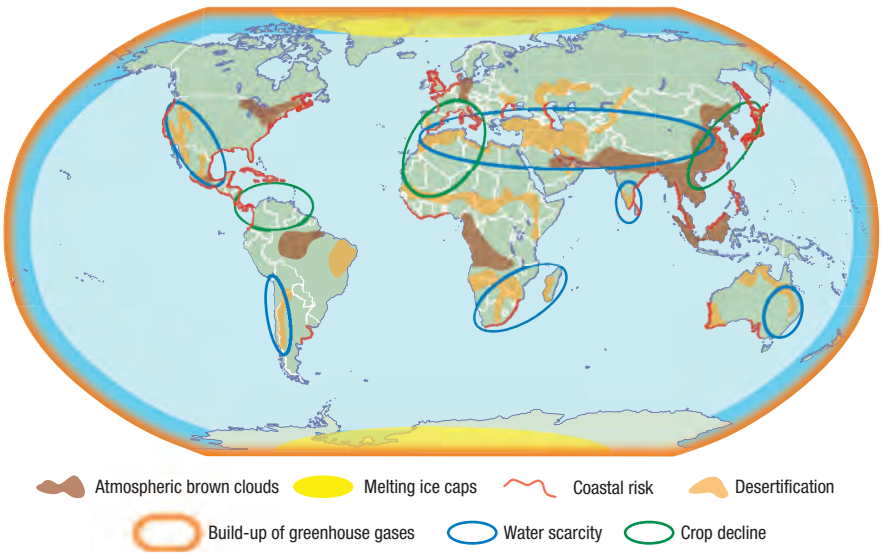

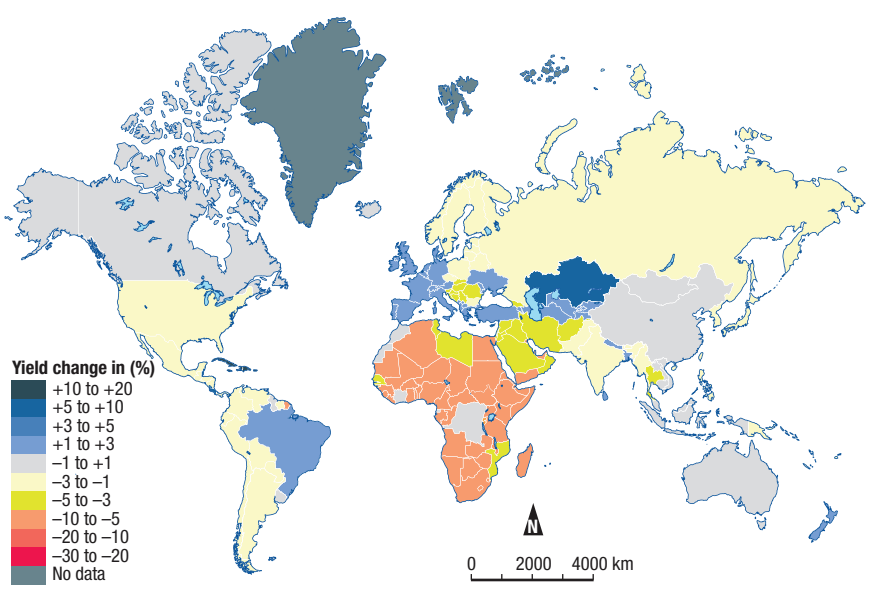

Figure 2.5.3h Environmental damages and risks from climate change

Figure 2.5.3i Effects of climate change on global food production (projected weighted average yield change in % for grain crops)

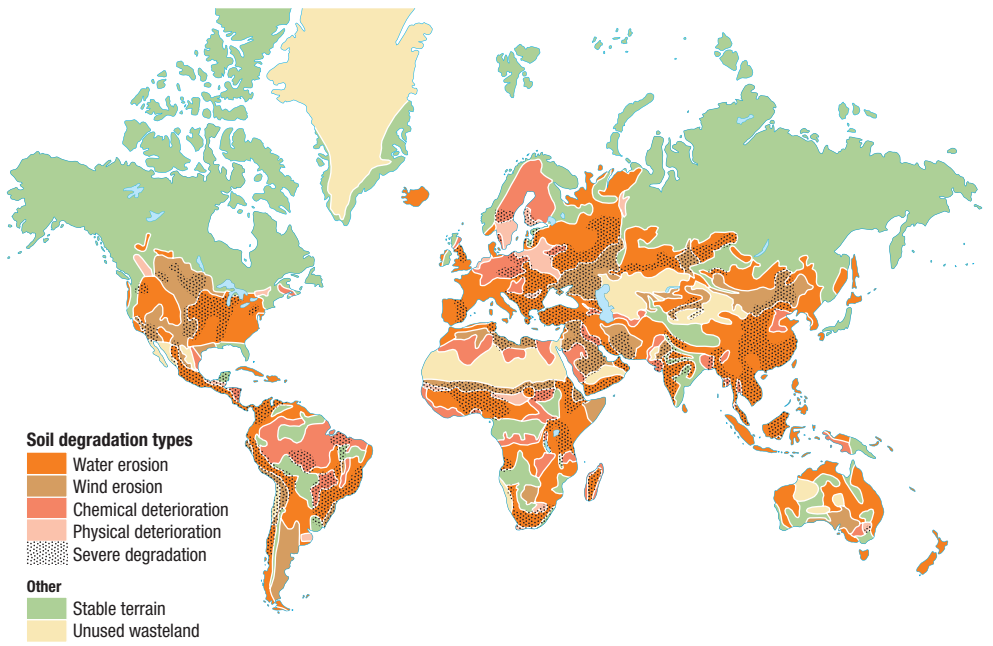

Figure 2.5.3j Land degradation by type

World biofuels production trends

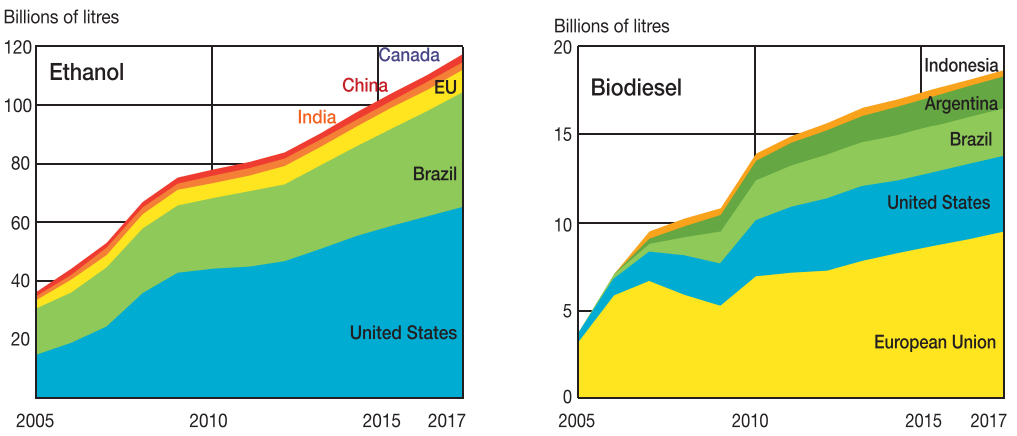

Figure 2.5.3k World biofuel production. Source GRID-Arendal

Climate change and food security

In the latter half of the 20th century, agricultural output increased at rates unprecedented in human history. Much of the productivity increases occurred as a result of the introduction of new, high-yielding crop varieties; the use of fertilisers and pesticides; the use of irrigation; and improved, capital-intensive farming practices. People, however, have begun to question the sustainability of such practices. Also of concern are soil erosion, groundwater contamination, soil compaction and the decline of natural soil fertility. New farm management processes have been developed. These include more sustainable and efficient cropping systems and farm management techniques.

Today, climatologists point to global warming as a threat to food security. The magnitude of such climate-induced changes may affect our ability to expand food production as the world's population heads towards 9 billion.

Land degradation

Land degradation is the process in which the biophysical environment is adversely affected by the activities of people. Land degradation consists of any change or disturbance to the land considered to be damaging or undesirable. It has been estimated that up to 40 per cent of the world's agricultural land has been seriously degraded.

The causes of land degradation include:

- land clearing
- depletion of soil nutrients resulting from poor farming practices
- overgrazing by livestock
- inappropriate irrigation practices
- soil contamination
- compaction by vehicles and livestock
- exposure of soil by farm machinery
- dumping of pollutants.

Biofuels

Biofuels are derived from recently dead biological material. They are different from fossil fuels, which are based on long-dead biological material. Many different plants and plant-based materials are used in biofuel production. Biofuels are commonly used to power motor vehicles.

Biofuels can produce energy without a net increase in carbon dioxide emissions because the plants used to produce the fuel have removed carbon dioxide from the atmosphere; unlike fossil fuels, which, when burnt, return carbon to the atmosphere. Biofuel is, therefore, nearly carbon neutral and less likely to increase atmospheric concentrations of greenhouse gases. The use of biofuels can also reduce dependence on petroleum.

There are two main ways of producing biofuels. One is to grow crops high in either sugar or starch and then to use yeast fermentation to produce ethanol. The second is to grow plants that contain high amounts of vegetable oil, such as oil palm. These can be chemically processed to produce fuels such as biodiesel.

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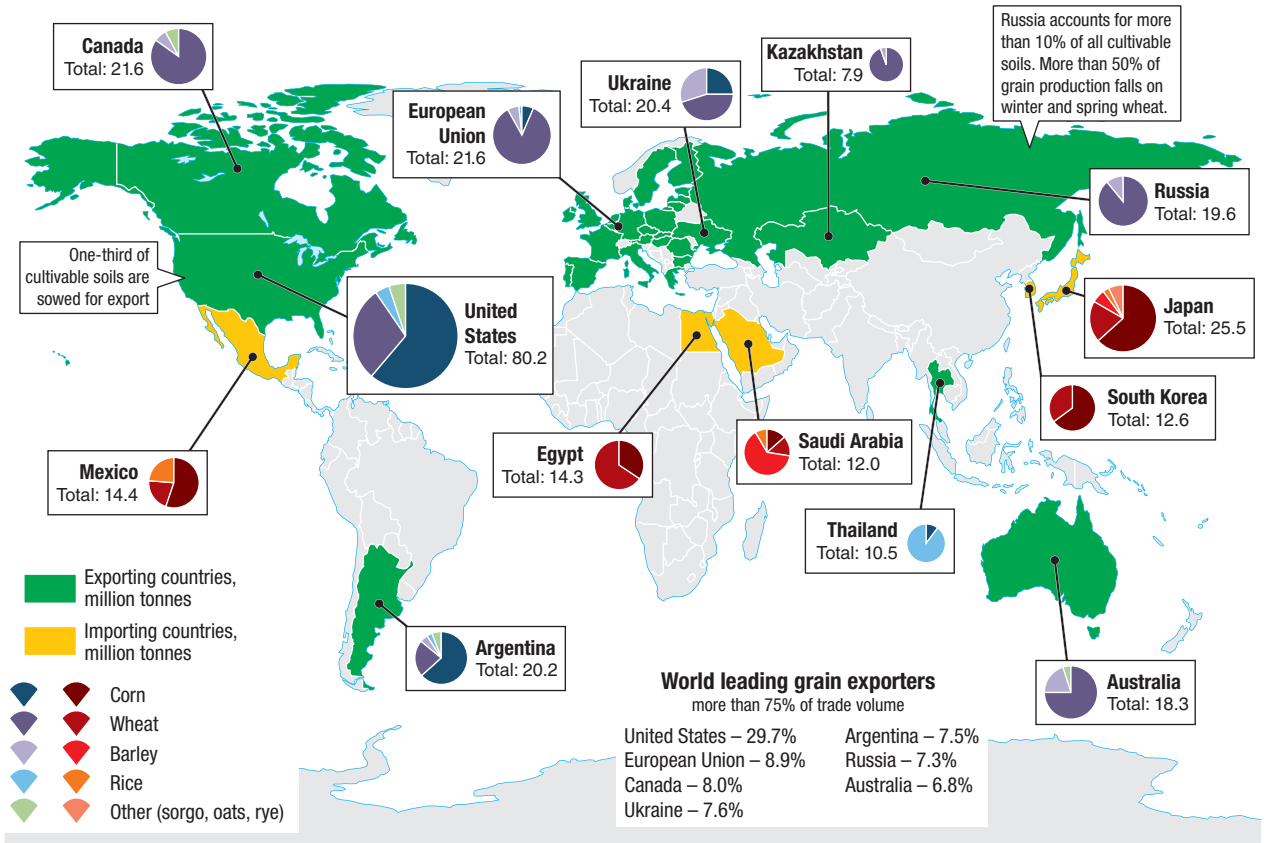

Figure 2.5.3l World grain exporters and importers

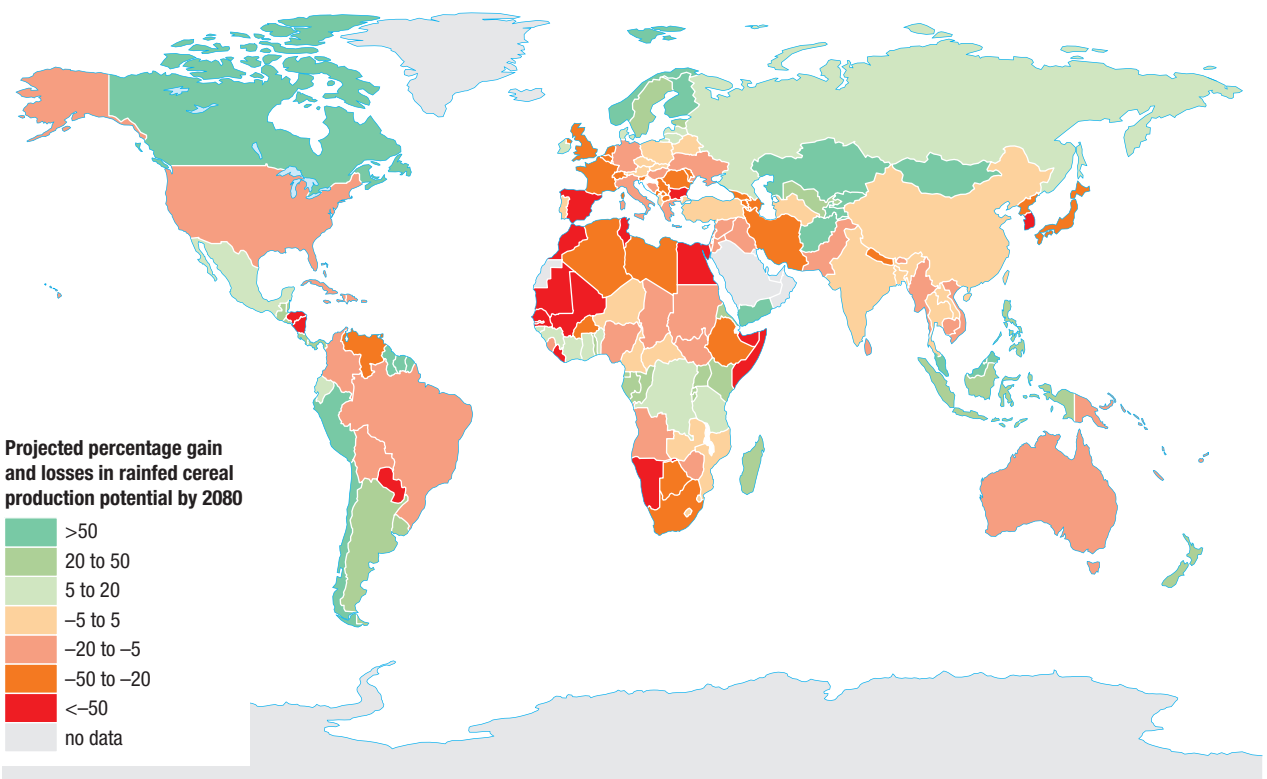

Figure 2.5.3m Projected global gains and losses in cereal production by 2080

ACTIVITIES

1 Study Figure 2.5.3b (page 56). Identify the regions of the world where the incidence of undernourishment exceeds 15–24%. To what extent does this pattern correspond with that shown in Figure 2.5.3e (page 57)?

2 Study Figure 2.5.3c (page 56). Using data from the graph, describe the trends in food prices since 1990. What are the likely effects of the trend identified on the level of under-nourishment experienced by people and food security?

3 Study Table 2.5.3a (page 56). Construct a series of proportional bar graphs showing the amount of suitable land in cultivation. Which region has the greatest potential to increase food production?

4 Study Figure 2.5.3d (page 57). Write an extended response outlining the barriers to increasing world food production. Use data from this unit to illustrate your response.

5 Study Figure 2.5.3e (page 57). Identify the countries in which average annual population growth rates exceed 2.0 per cent. In which regions of the world are average annual growth rates greatest?

6 Study Figure 2.5.3f (page 57). With the aid of an atlas, identify the regions of the world with high levels of water scarcity.

7 Study Figure 2.5.3h (page 58). With the aid of an atlas, identify the regions of the world likely to experience desertification, water scarcity and crop decline as a result of climate change.

8 Study Figure 2.5.3i (page 58). With the aid of an atlas, identify the regions of the world where crop yields are projected to decrease as a result of climate change and those areas likely to see increased yields.

9 Study Figure 2.5.3j (page 58). With the aid of an atlas, identify those regions of the world experiencing 'severe' degradation.

10 Study Figure 2.5.3k (page 58) and then answer the following questions:
- a Which two countries produce the largest amounts of ethanol? How much ethanol is produced by the United States?
- b Which are the three largest producers of biodiesel?
- c How much biodiesel is produced by Germany?

11 Study Figure 2.5.3l and then answer the following questions:
- a Identify the world's largest exporter of grain.
- b Name the country that is the world's largest grain importer.
- c Name the principal grain export from the United States.
- d Identify the country whose principal grain export is wheat.
- e Identify the principal grain import of Japan.
- f Name the principal grain export of Thailand.

12 Study Figure 2.5.3m. Identify the countries in which gains in rainfed cereal production losses are projected to exceed 50 per cent by 2080.

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2.6 Changing places

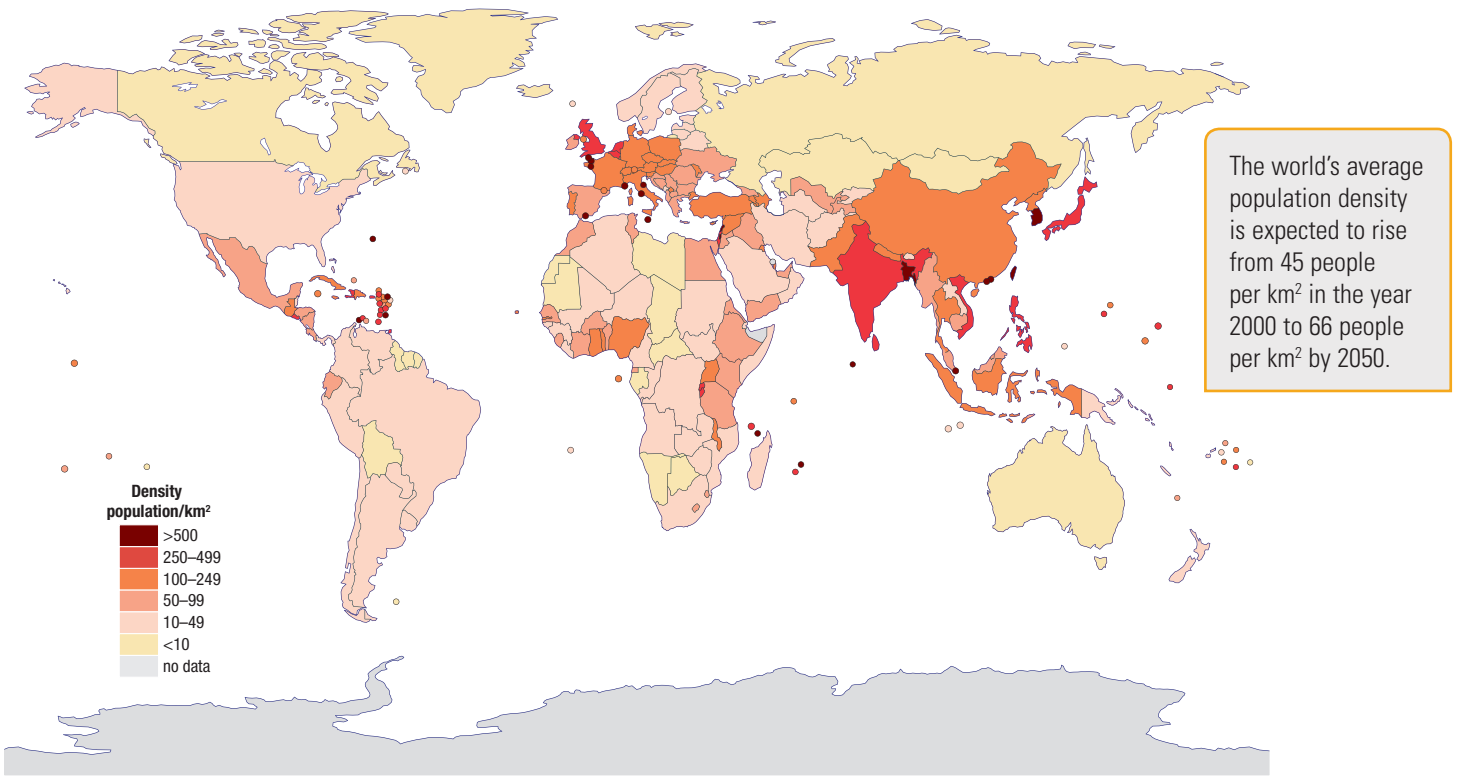
2.6.1 POPULATION AND URBANISATION

During the 20th century the world's population grew at a rate never before experienced. In late 1999, the world's population reached 6.0 billion. By the middle of 2020 it was more than 7.8 billion.

This is a dramatic rise from 1900, when there were only 1.6 billion people on Earth, and from 1950 when there were 2.5 billion. It took from the dawn of history to the year 1820 for the world's population to reach 1 billion. It took just 12 more years to add the latest billion to the tally.

This growth is expected to continue well into the 21st century, although more slowly. The world's population is expected to grow to 9.9 billion by 2050, an increase of 50 per cent in 50 years.

Most of this future growth will take place in the countries of the developing world, which are least able to cope.



The world's average population density is expected to rise from 45 people per km² in the year 2000 to 66 people per km² by 2050.

Figure 2.6.1a Population density, 2015

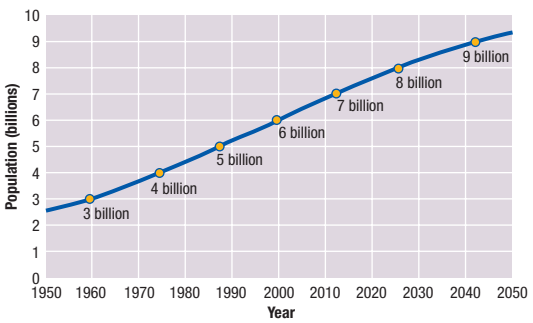


Figure 2.6.1b World population growth, 1950–2050

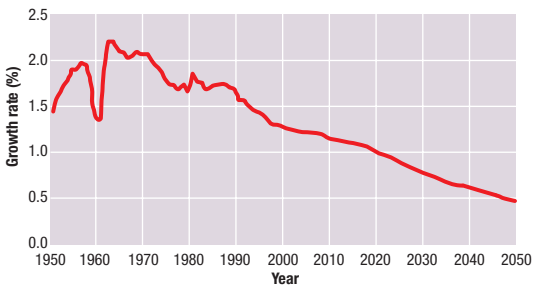


Figure 2.6.1c World population growth rates, 1950–2050

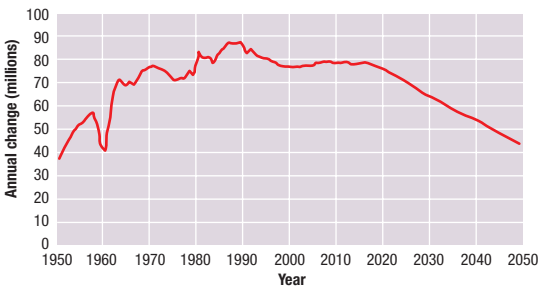
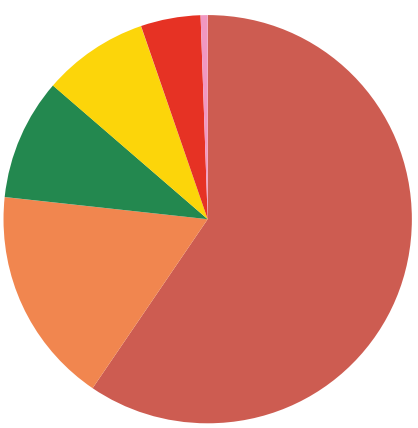


Figure 2.6.1d Annual world population change, 1950–2050



Region	Population mid-2020 (millions)
Asia	4626
Africa	1338
Europe	747
Central & South America	651
North America	368
Oceania	43
Total	7773

Figure 2.6.1e Distribution of the world's population, 2020

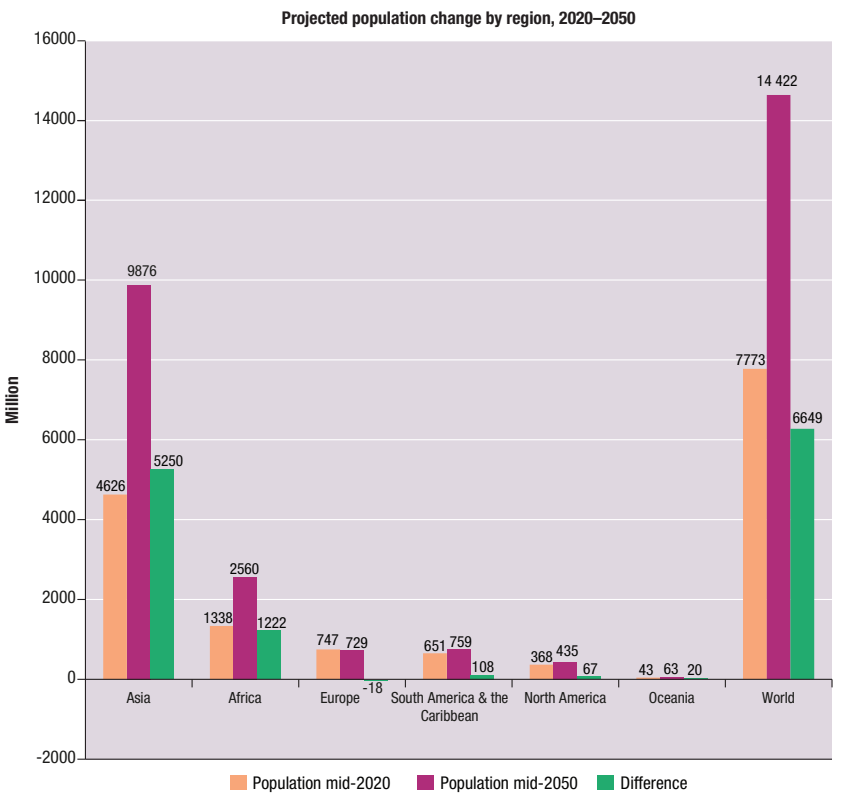


Figure 2.6.1f Projected population change by region, 2020–2050

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Figure 2.6.1g A densely-populated district in Tokyo during rush hour

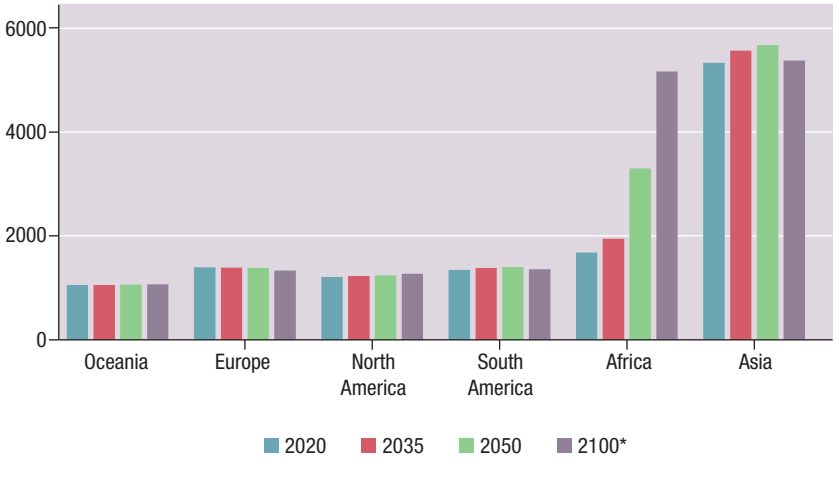
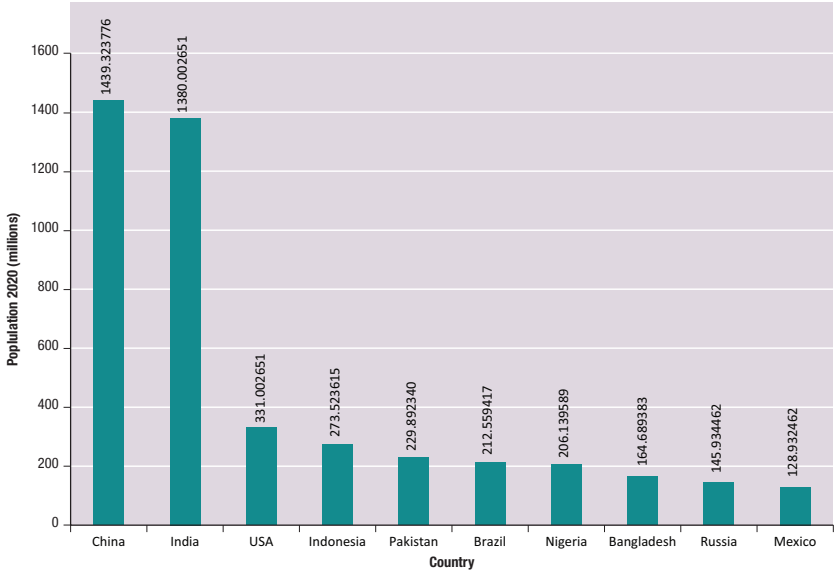


Figure 2.6.1h Global population distribution (percentage of world's population by region), 1750–2100
*Based on UN's medium population scenario



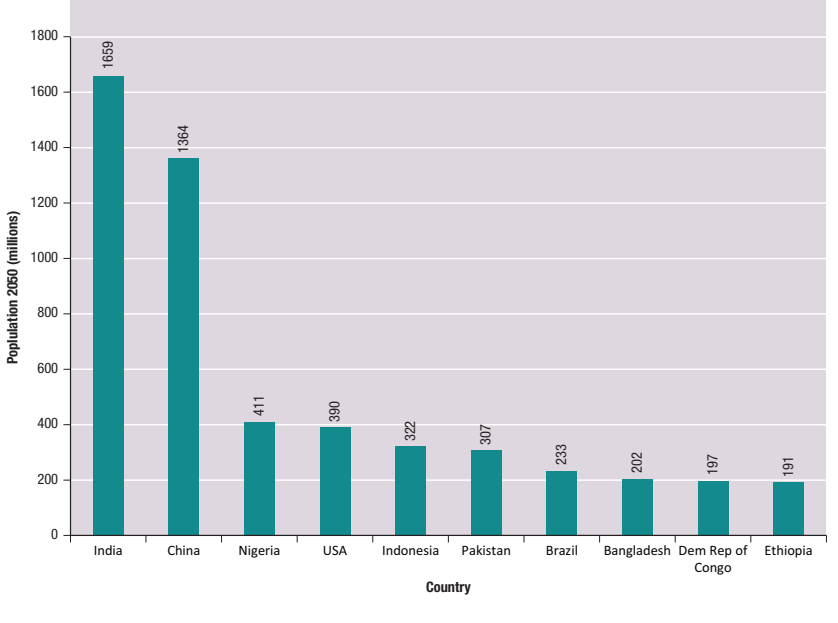


Figure 2.6.1i World's most populous countries 2020 and 2050

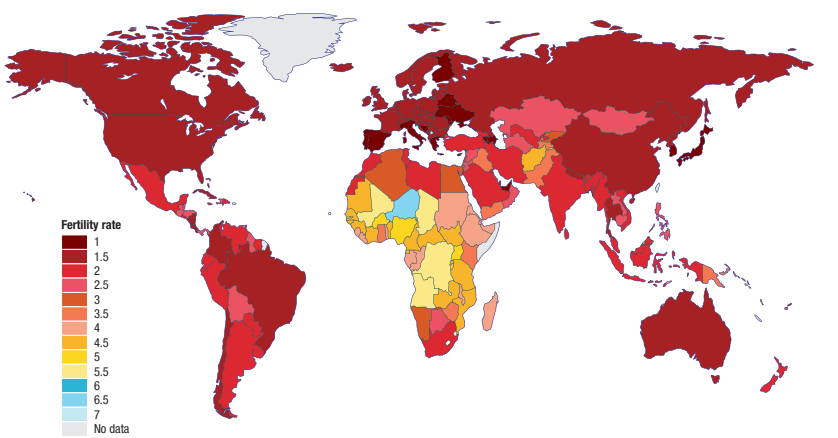


Figure 2.6.1j Total fertility rate, 2021

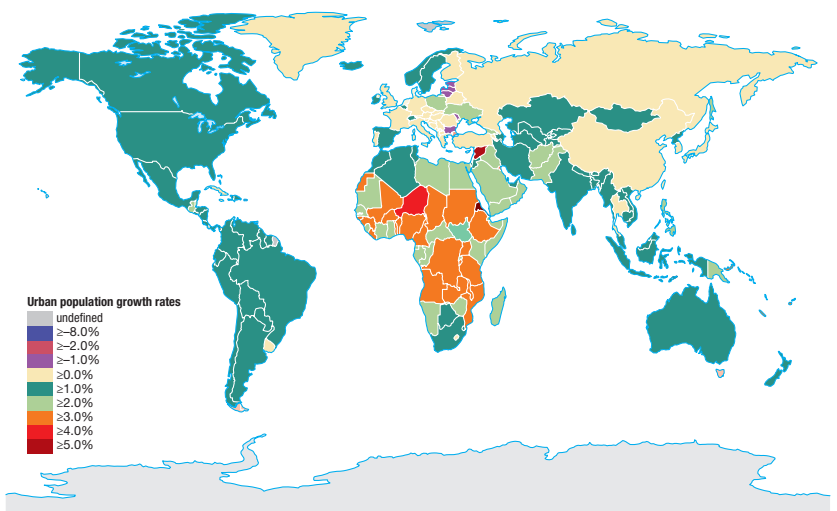


Figure 2.6.1k Average annual rate of population increase, 2020

Figure 2.6.1l Crowds of people at Ipanema Beach, Rio de Janeiro, Brazil

The world's total fertility rate has fallen due to a number of cultural changes. These include worldwide efforts to make contraception and reproductive health services available. While this decline is encouraging, it is important to note that if the fertility rate remains at the present level instead of continuing to decline, the world's population will grow to 12.7 billion by 2050 instead of the projected 9.9 billion.

Population growth rates are highest in those parts of the world that are least able to cope. The countries of the developing world have 80 per cent of the world's population, yet they account for 98 per cent of the world's annual population increase.

Megacities

A *megacity* is defined as an urban area with a population in excess of 10 million people. A megacity can be a single metropolitan area or two or more metropolitan areas that converge. The term 'megapolis' is sometimes used synonymously with megacity, but it denotes a semi-continuous chain of large metropolitan cities. In 2020 there were more than 37 megacities in existence. Some of these, such as Mumbai, Tokyo, Seoul, New York City, Karachi and Jakarta are conurbations – they were formed by various cities joining together – and now have populations in excess of 20 million people.

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Ageing population

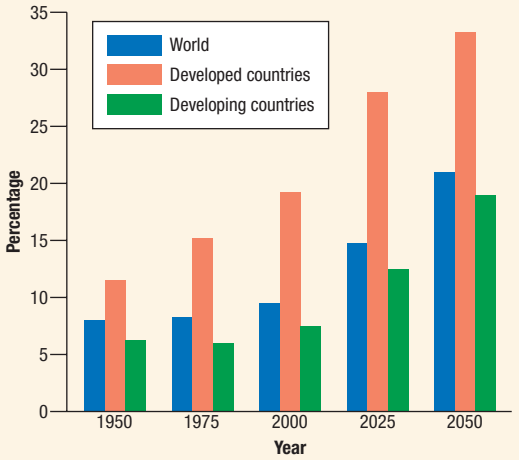

Figure 2.6.1m Proportion of the population aged 60 or over, 1950–2050

The number of older persons has tripled over the past 50 years; it will more than triple again over the next 50 years. Decreasing fertility along with increasing life expectancy has reshaped the structure of the population in most parts of the world.

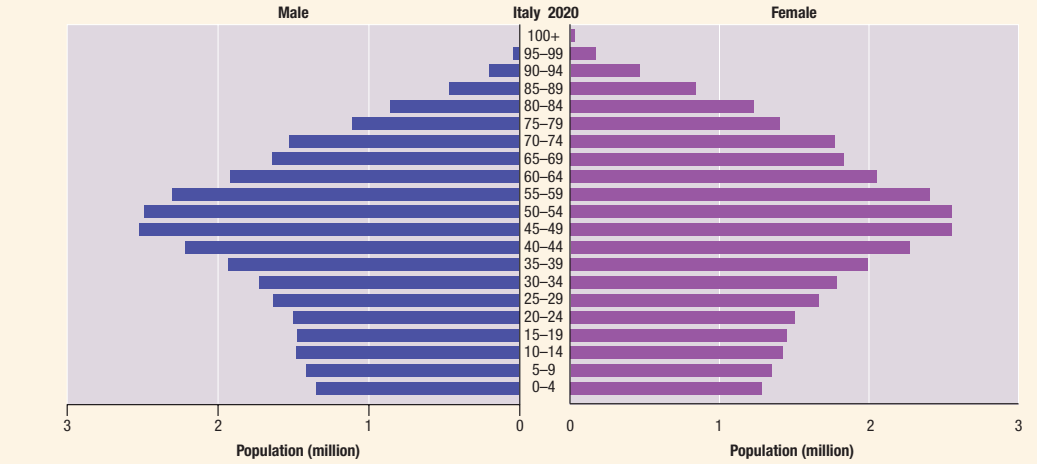

Figure 2.6.1n Population pyramids, Italy and Nigeria, 2020

Urbanisation

Urbanisation refers to the increasing share of a country's population living in towns and cities. It involves a shift of population from rural to urban areas. The 'push' and 'pull' factors responsible for this movement are shown in Figure 2.6.1o.

The majority of the world's urban population – in common with most of the world's total population – lives in developing countries. In 2020, developing countries had 3.2 billion urban dwellers, compared with only 993 million in developed regions.

Over the forthcoming 30 years, virtually all population growth will be in the urban areas of developing countries. Unfortunately, many cities in the developing world find it difficult to cope with the rate of population growth. Too many of the urban poor are forced to live in vast squatter settlements, and the disposal of waste and the supply of clean water are major challenges.

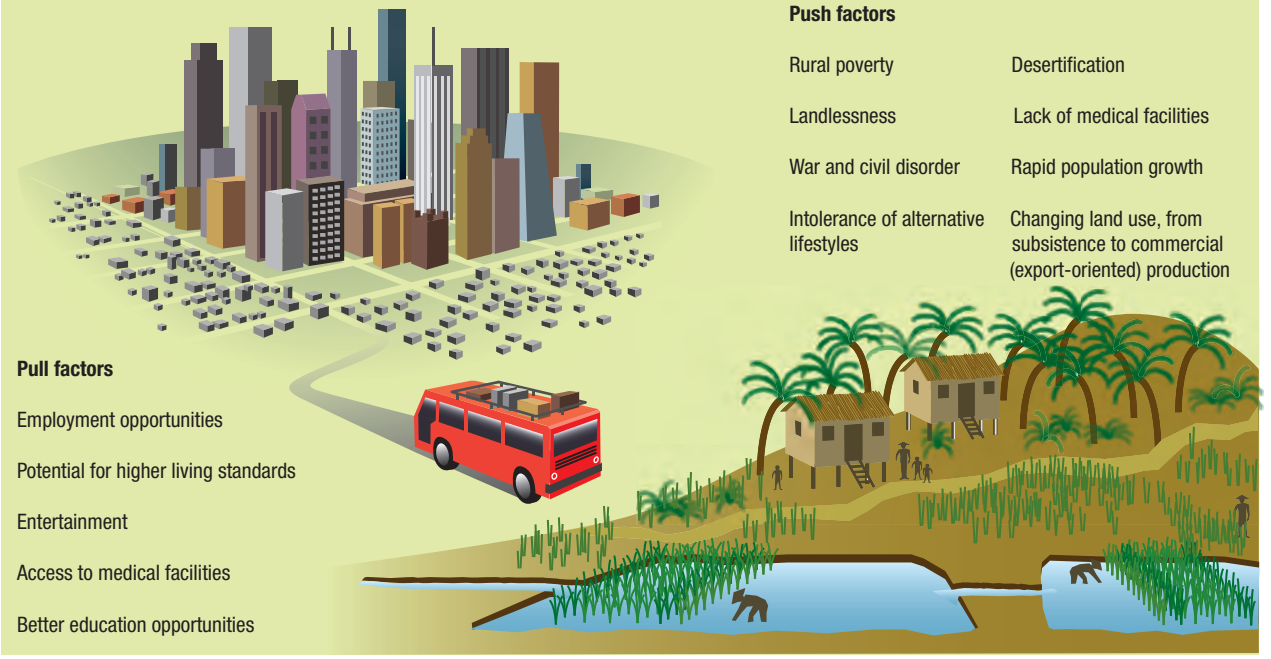

Figure 2.6.1o Factors in the process of urbanisation

Figure 2.6.1p New York City

Figure 2.6.1q Favela (low-income, informal settlement), Rio De Janeiro, Brazil

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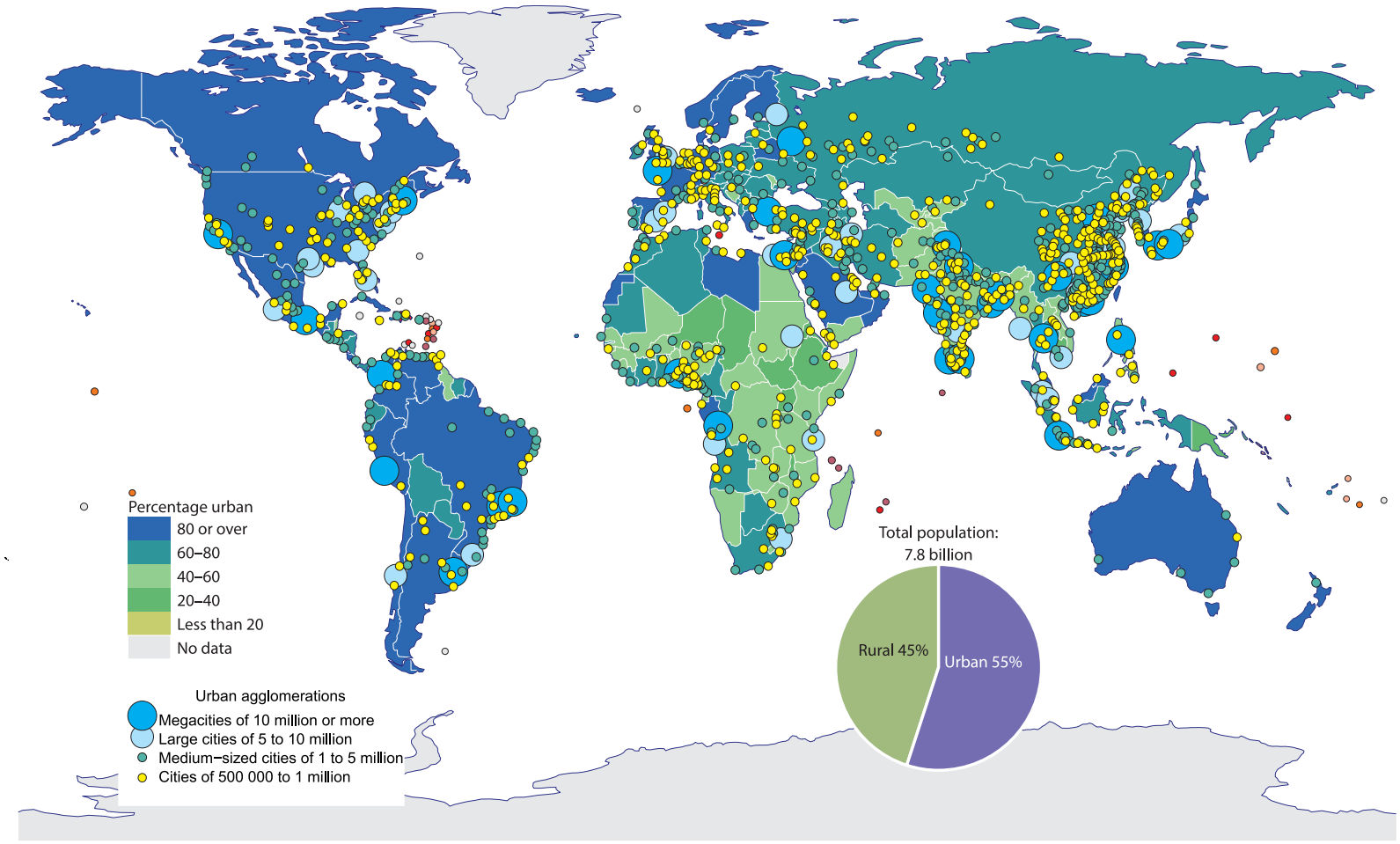

Figure 2.6.1r Urbanisation, 2016. The inset graph shows the percentages of urban and rural populations, 2015.

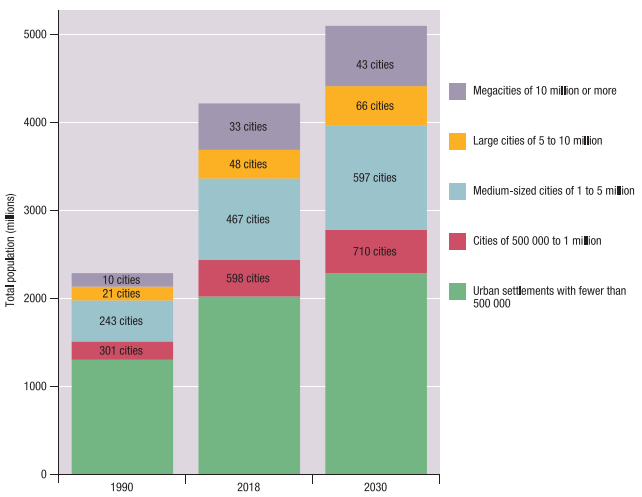

Figure 2.6.1s Population and number of urban agglomerations of the world by class of urban settlement, 1990, 2018 and 2030

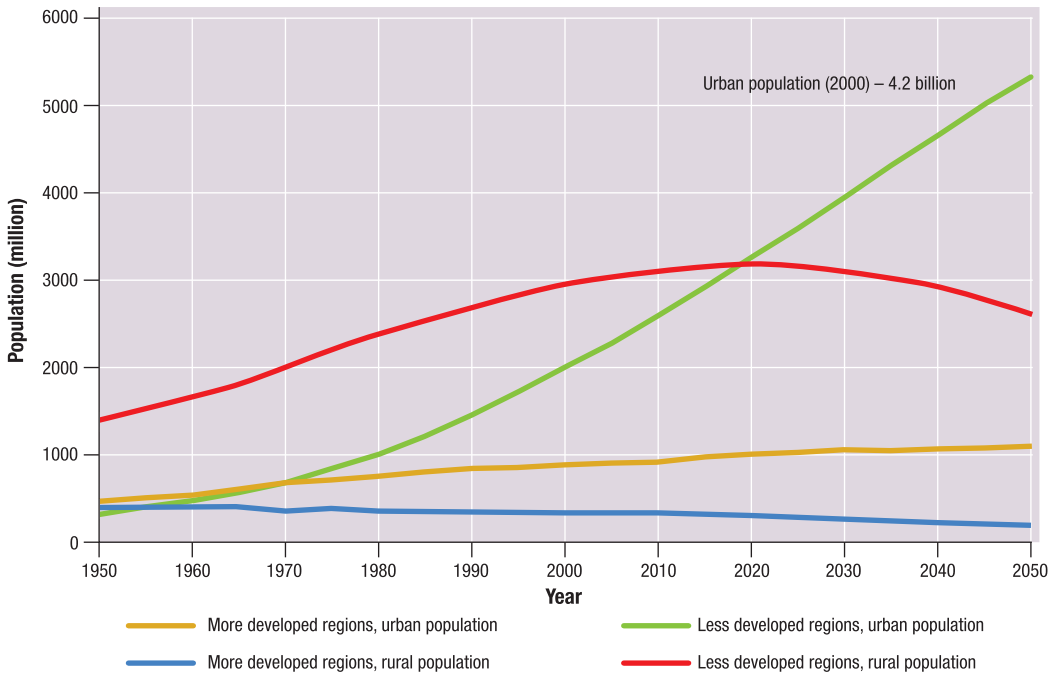

Figure 2.6.1t Urban and rural population by development group, 1950–2050

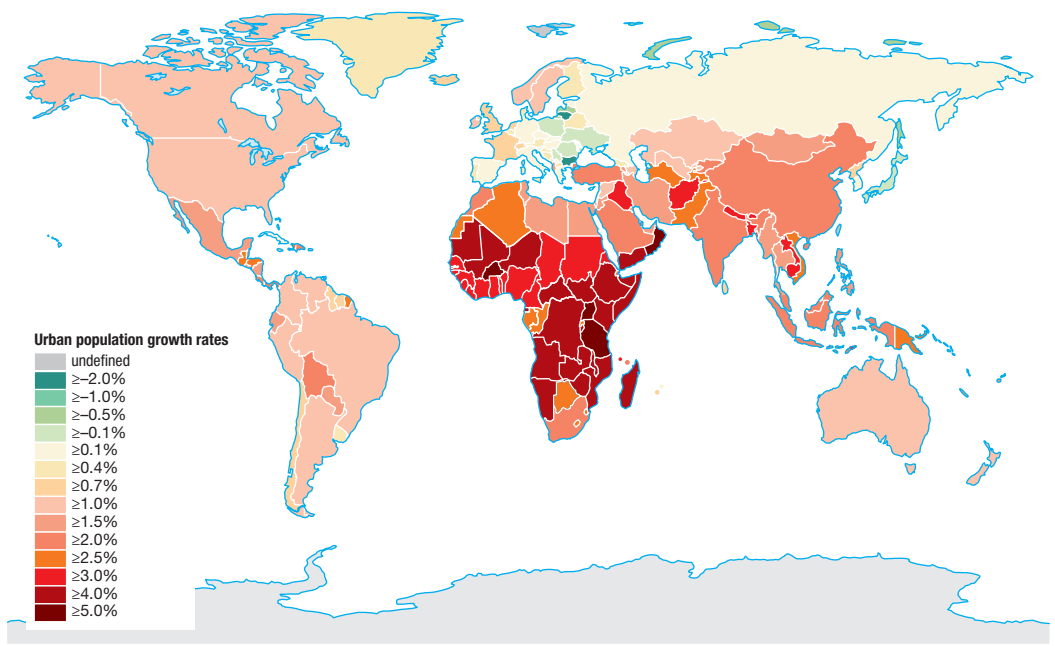

Figure 2.6.1u Urban population growth rates, 2018

Figure 2.6.1v African girls standing among rubbish, Kibera slum, Kenya, East Africa

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Figure 2.6.1w Squatter settlement in the Philippines

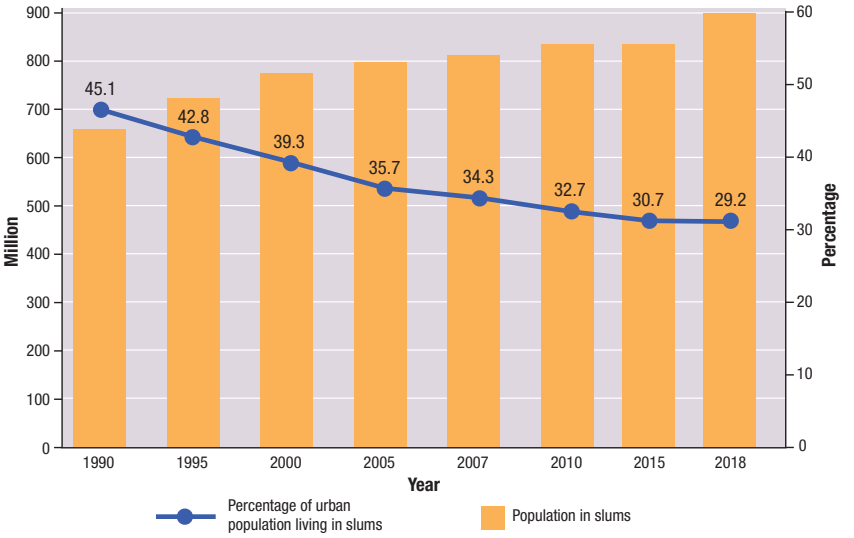

Figure 2.6.1x Population living in slums and proportion of the urban population living in slums, developing regions, 1990–2018

ACTIVITIES

1 Study Figure 2.6.1a (page 60) and then, with the aid of an atlas, identify those parts of the world that have the highest and lowest population densities.

2 Study Figure 2.6.1b (page 60) and then answer the following questions:
- a In what year did the world's population exceed 6 billion?
- b In what year is the world's population expected to exceed 9 billion?
- c How many years did it take for the population of the world to double from 3 billion to 6 billion people?

3 Study Figure 2.6.1c (page 60) and then answer the following questions:
- a In what year did world population growth rates peak?
- b What has been the general trend in world population growth rates since the mid-1960s?
- c What was the world population growth rate in 2000?

4 Study Figure 2.6.1d (page 60) and then answer the following questions:
- a In what year did the annual growth of world population peak? How many people were added to the world's population in that year?
- b In what year is the annual growth of the world's population expected to begin its long-term decline?
- c What is the level of annual world population growth expected to be in 2050?

5 Study Figure 2.6.1e (page 60) and then answer the following questions:
- a On which continent is the greatest share of the world's population located?
- b How many people live in Asia?
- c What percentage of the world's population lives in Africa?

6 Study Figure 2.6.1f (page 60). Which region is projected to have the greatest percentage change in its population between 2020 and 2050? Which continent will experience a decline in its population?

7 Study Figure 2.6.1h (page 61). Identify the regions with an increasing share of the world's population and those with a declining share between 2000 and 2150. Which region's share of the world's population will increase most rapidly?

8 Study Figure 2.6.1i (page 61). Which countries will increase their ranking between 2020 and 2050?

9 Study Figure 2.6.1j (page 61). With the aid of an atlas, identify those parts of the world with the highest total fertility rate.

10 Compare Figure 2.6.1k (page 61), which shows the pattern of population growth, with Figure 2.8.1a (page 77), which shows gross national income per capita. Describe the nature of the relationship.

11 Study Figure 2.6.1m (page 62) and then answer the following questions:
- a What percentage of the world's population was aged 60 years and over in 2000?
- b What percentage of the world's population is projected to be over 60 years in 2050?
- c In what part of the world is the rate of population ageing projected to be fastest in the period 2000–2050?

12 Study Figure 2.6.1n (page 62) and then answer the following questions, giving your answer as a whole number (no decimal places):
- a What percentage of Italy's population was under the age of 15 years in 2020?
- b What percentage of Italy's population was over the age of 65 years in 2020?
- c What percentage of Nigeria's population was under the age of 15 years in 2020?
- d What percentage of Nigeria's population was over the age of 65 years in 2020?
- e How many Italians are there under the age of 15 years?
- f How many Nigerians are there under the age of 15 years?

13 Study Figure 2.6.1o (page 62). Write two to three paragraphs outlining the factors driving the process of urbanisation.

14 Study Figure 2.6.1r (page 63) and, with the aid of an atlas, identify those regions of the world that have the highest and lowest rates of urbanisation.

15 Study the inset graph in Figure 2.6.1s (page 63). What was the size of the world's urban population in 2018?

16 Study Figure 2.6.1s (page 63). Using data from the graph write a paragraph or two describing the distribution of the world's urban population by size of settlement.

17 Study Figure 2.6.1t (page 63) and answer the following questions:
- a Which population is growing most rapidly?
- b In what year will the rural population of less developed regions start declining?

18 Study Figure 2.6.1u (page 63). With the aid of an atlas, identify the regions with the highest and lowest urban population growth rate in 2018.

19 Study Figures 2.6.1q (page 62) and 2.6.1v (page 63). Write a paragraph describing the nature of the urban environment shown in the photographs. As a class, discuss the reasons people are forced to live in such conditions.

20 Study Figure 2.6.1x. Describe the trends in the world's slum population.

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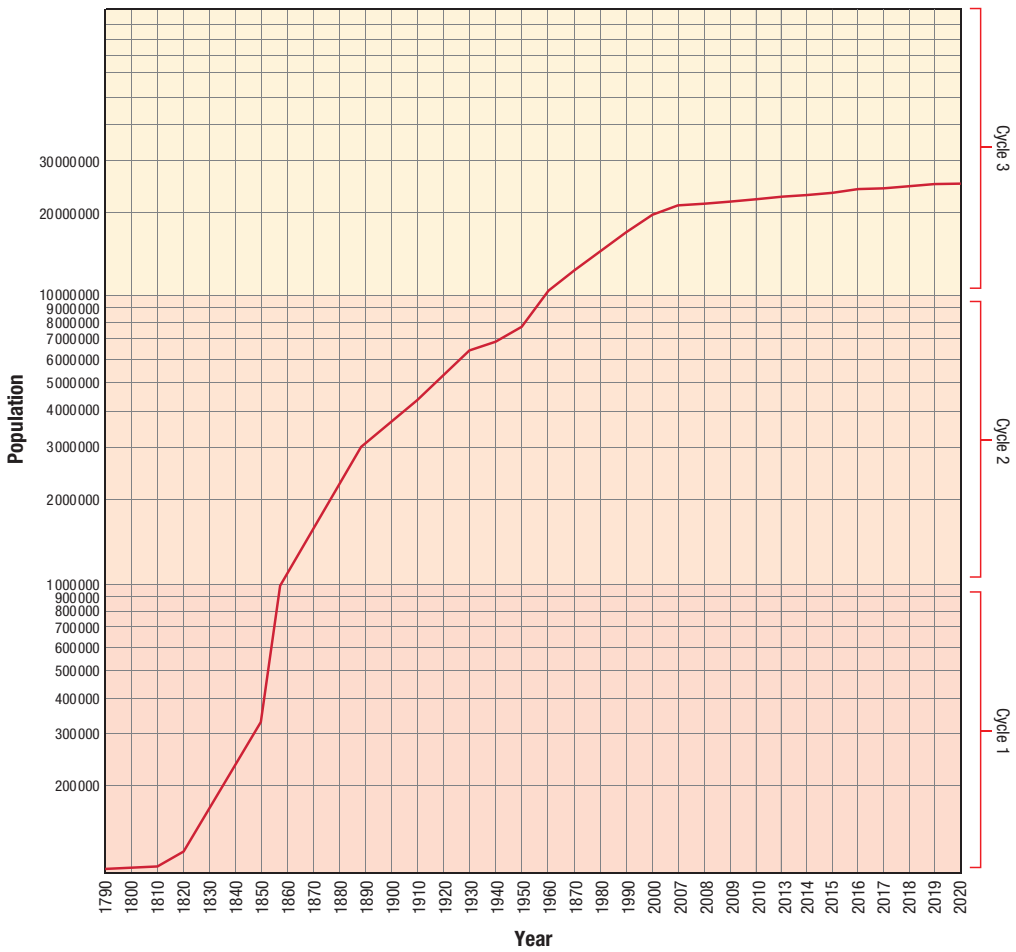
2.6.2 AUSTRALIA'S POPULATION

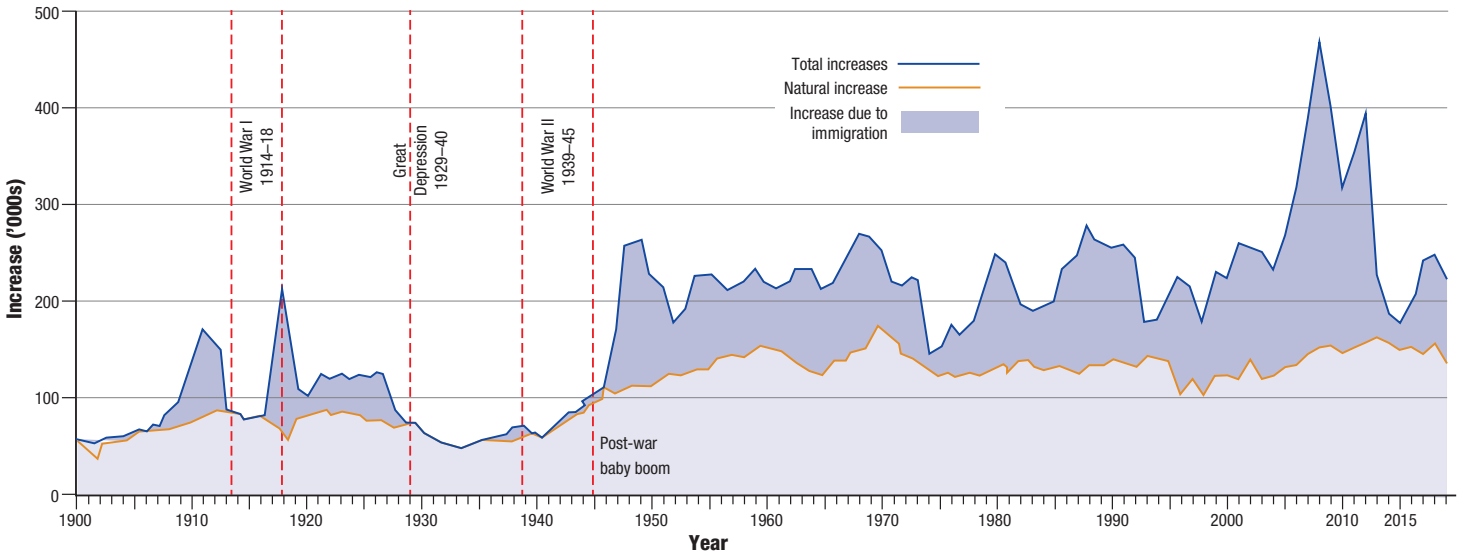


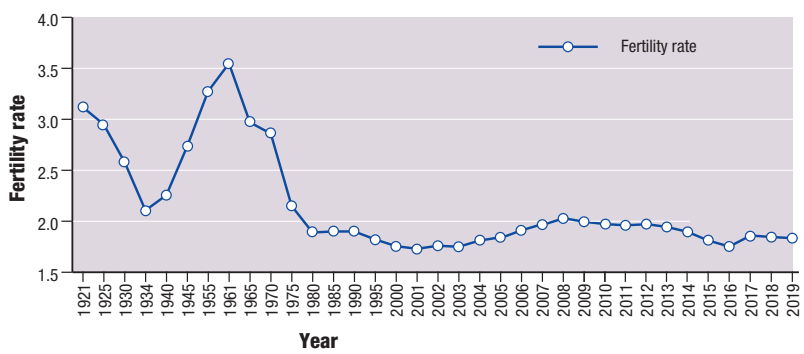
Note: Indigenous Australians were not included in official population statistics until 1967.

Figure 2.6.2a A semi-logarithmic graph showing the growth in the Australian population, 1790–2020

In June 2016, Australia's population reached 24.16 million. This is nearly three times the population in 1950 and five times the population in 1900. The main drivers of population increase are natural increase and net migration. *Natural increase* is the difference between the birth rate and the death rate. *Net migration* is the difference between the number of permanent departures from Australia and the number of people arriving to live in Australia on a permanent basis.

Figure 2.6.2c British migrants arriving in Sydney, c. 1963





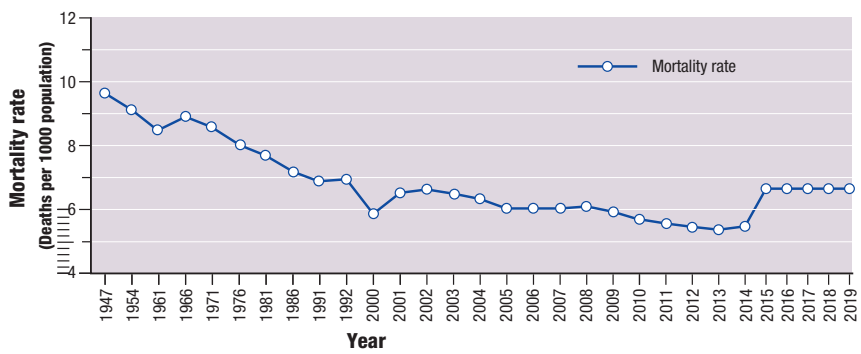


Figure 2.6.2b Components of Australia's population growth, 1900 to 2015: Australia's fertility rate, 1921 to 2014; Australia's mortality rate, 1947 to 2014

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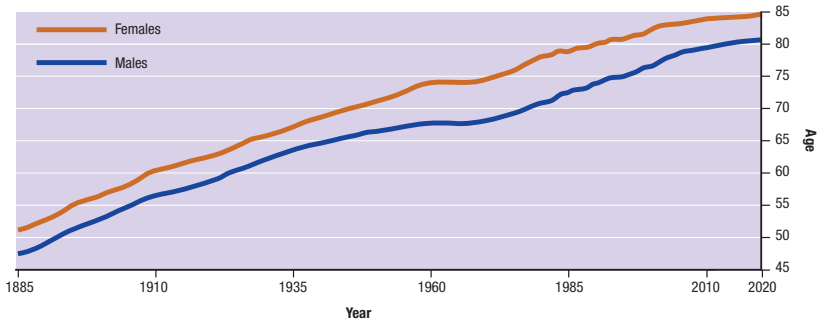

Figure 2.6.2d Life expectancy 1885–2020

Figure 2.6.2f Melbourne's Moomba parade celebrates multicultural diversity. Practically every nationality that lives in the city is represented in the parade.

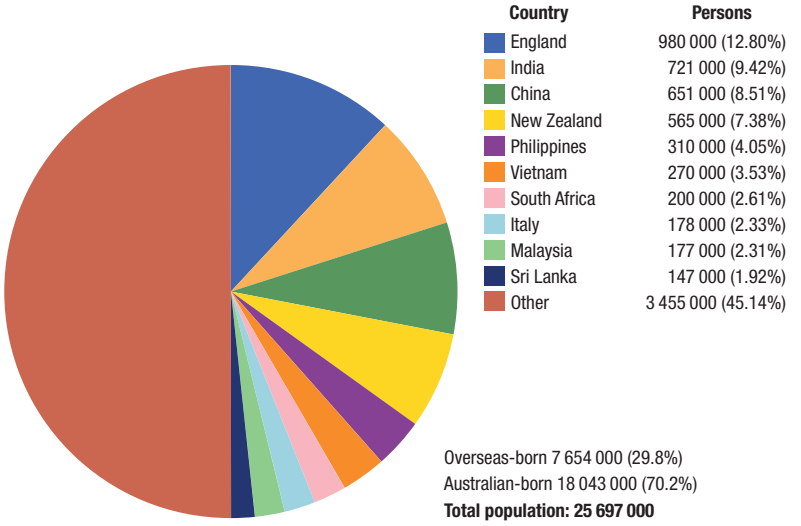

Figure 2.6.2e Top 10 countries of birth of Australian residents, 2020

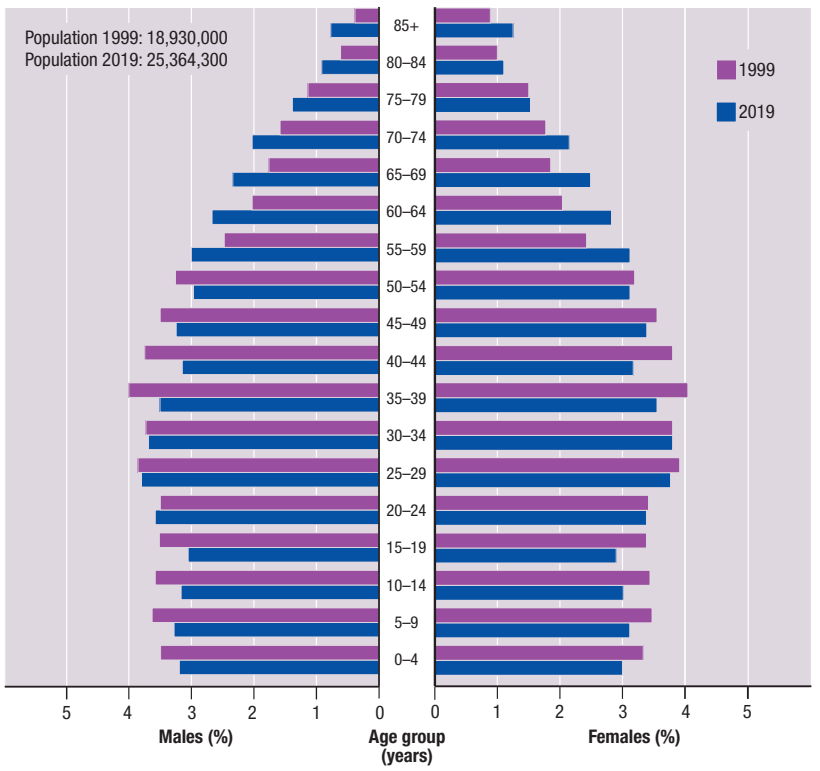

Figure 2.6.2g Population structure of Australia, by age and sex, 1999 and 2019

ACTIVITIES

1 Study Figure 2.6.2a (page 65) and then answer the following questions:
   - a What was the population of Australia in: i 1850 ii 1900 iii 1950?
   - b Which decade experienced the most rapid population growth?
   - c Which decade of the 20th century experienced the slowest rate of population growth?

2 Study Figure 2.6.2b (page 65) and then answer the following questions:
   - a In which year did the rate of natural increase peak?
   - b What effect did the world wars and the Great Depression have on population growth? What was affected more: natural increase or immigration?
   - c Explain why there was a significant increase in population growth in 1918 and 1946.
   - d Estimate the contribution made by immigration to total population growth in 1980.
   - e In what year did Australia's fertility rate exceed 3.5?
   - f Describe the trend in fertility rates since 1961.
   - g Describe the trend in mortality since 1947.
   - h Undertake library research. Investigate the reasons for the declines experienced in Australian fertility and mortality rates in the periods shown in Figure 2.6.2b.

3 Study Figure 2.6.2e and then answer the following questions:
   - a What was the most common birthplace of overseas-born residents in Australia in 2020?
   - b What percentage of Australian residents were born in New Zealand in 2020?
   - c How many Chinese-born Australian residents were there living in Australia in 2020?
   - d How many Australians were born in either China or India in 2020?
   - e What percentage of all Australians were born in either China or India?

4 Study 2.6.2f. By how much has life expectancy for Australian males and females increased since 1910?

5 Study Figure 2.6.2g and then complete the following tasks:
   - a Estimate the percentage of Australians under the age of 15 years in 1999.
   - b Estimate the percentage of Australians under the age of 15 years in 2019.
   - c Calculate the number of Australians under the age of 15 years in 1999.
   - d Calculate the number of Australians under the age of 15 years in 2019.
   - e Estimate the percentage of Australians over the age of 65 years in 1999.
   - f Estimate the percentage of Australians over the age of 65 years in 2019.
   - g Calculate the number of Australians over the age of 65 years in 1999.
   - h Calculate the number of Australians over the age of 65 years in 2019.
   - i What do the figures suggest about the changing structure of the Australian population?
   - j What other evidence is there that Australia has an ageing population?

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2.6.3 AUSTRALIA'S POPULATION MOVEMENTS

The distribution of Australia's population is changing. Economic change (especially the decline of manufacturing and the growth in mining), immigration, the ageing of the population and the lifestyle choices made by individuals are the main drivers of this change.

The 'tyranny of distance' is dead

Distance is no longer the barrier it once was. Developments in communications and transport technologies have brought Australia closer to the Northern Hemisphere's centres of business and culture. Australians can now interact with others no matter where they live.

The flight to the suburbs

During the 1960s to 1980s, Australians abandoned the inner city for the suburban lifestyle. This was the era of the single, detached suburban home with the Holden Kingswood or Ford Falcon in the driveway.

Turning our back on the suburban dream

Since the 1990s the number of people choosing to live in the inner suburbs of all Australia's large cities has increased significantly. Attracted by benefits of inner-city living, these people (mainly young professionals and older 'empty nesters') have created a demand for new high-rise apartments within walking distance of the central business district or major public transport nodes.

Filling the gaps

Urban infill is the development of land in already-developed areas, either by building housing on land that was previously vacant or used for non-residential purposes, or by replacing low-density housing (detached single homes) with higher-density dwellings (townhouses, villas or apartments). Infill development is becoming more common on transport corridors, near major commercial centres, in suburbs where there are older houses on large blocks of land, and on former inner-city industrial sites. The process is commonly known as urban consolidation.

Deserting the bush

The share of the population living in rural areas is declining. As a result, many small rural communities are struggling to survive.

Heading to the beach

Australians' love affair with the beach continues. Towns along Australia's coastline have grown as retirees, families and singles seeking a lifestyle change, and those in search of more affordable housing, move from the capital cities to beach-side communities.

Queensland's Gold Coast has been the most popular destination for Australians on the move over the past 20 years. The Gold Coast barely existed in 1945. By 2000 it had 404 000 residents. By 2020 the population had grown to 699 266.

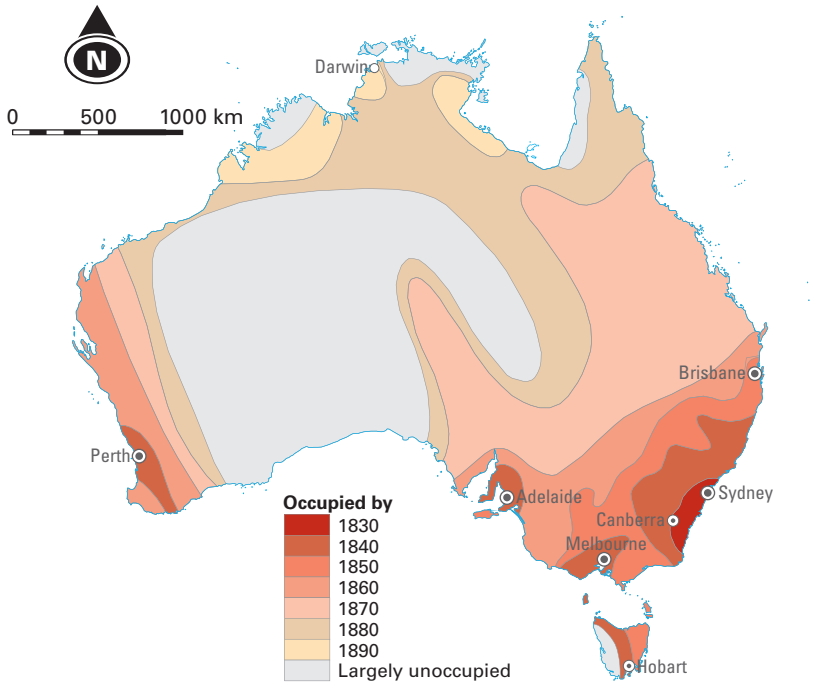

Figure 2.6.3a Spread of European settlement in Australia since 1788

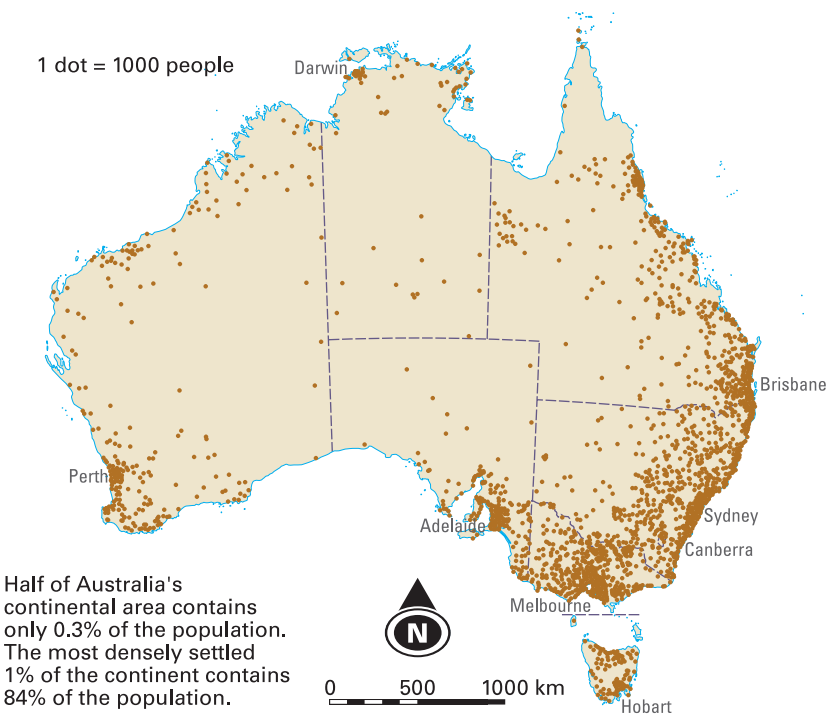

Figure 2.6.3b Dot map showing the distribution of the Australian population, 2020

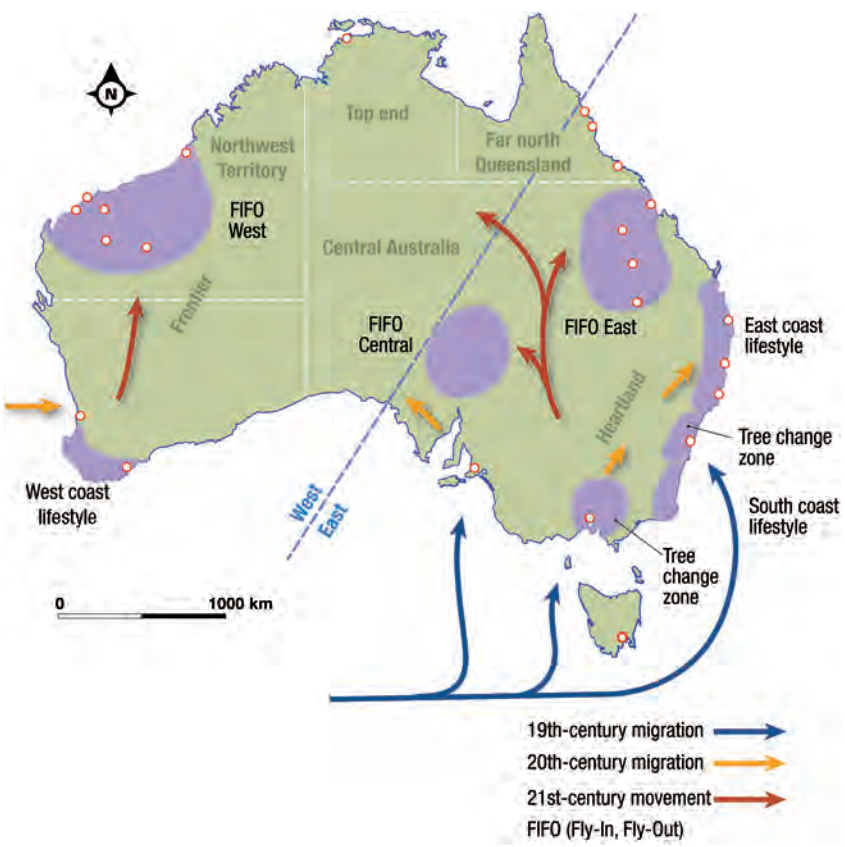

Figure 2.6.3c Population movements over time

Regional centres back in favour

Cities such as Dubbo, Tamworth and Wagga Wagga in New South Wales, Horsham in Victoria, as well as Narrogin in Western Australia have grown in recent years, attracting people from smaller, surrounding rural communities.

The new frontier

Australia's mining boom – fuelled by the rapid economic growth being experienced by China – is attracting people to those parts of Australia where the minerals are found and mining developments are taking place. The use of 'fly-in, fly-out' and 'drive-in, drive-out' labour means that the growth of communities in remote parts of Australia may not be as great as experienced in earlier mining booms.

Moving interstate

The proportion of people living in the Australian Capital Territory, Victoria, Western Australia and Queensland has increased, while the proportion living in New South Wales and the Northern Territory has declined.

The attractions of Queensland's south-east include jobs, climate and lifestyle.

New arrivals, old choices

In the year ending 30 June 2020, net overseas migration added 86,200 to the population of NSW, followed by Victoria (84,500) and Queensland (20,490). The Northern Territory received just 700 persons. Sydney is using immigrants to replace departing residents.

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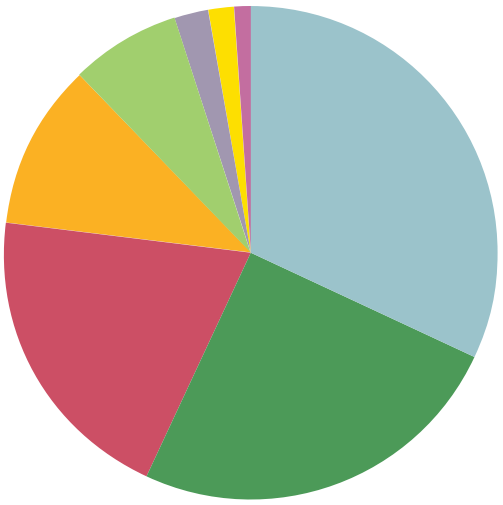

State/Territory	Population (31 March 2020) '000
New South Wales	8157.7
Victoria	6689.4
Queensland	5160.0
Western Australia	2656.2
South Australia	1767.2
Tasmania	539.6
Australian Capital Territory	429.8
Northern Territory	245.4
Australia[a]	**25 650.0**

(a) Includes other Territories comprising Jervis Bay Territory, Christmas Island

Figure 2.6.3d Distribution of Australia's population by state and territory, 31 March 2020

Indigenous Australia

In 1788, Australia's population was thought to be about 315 000, divided into 250 nations. While most parts of the continent were occupied, population densities were greater in areas where water and food were more widely available.

Each Indigenous nation had its own traditional lands, with which its people had a deep spiritual bond. Each nation also had its own language and traditions. Each nation was typically divided into several clans, with as many as 30 or 40 members. Today, Australia's Indigenous population is concentrated in northern and central parts of Australia. Twenty-six per cent of Indigenous Australians live in semi-remote and remote areas (compared with just 1.7 per cent of the total population).

Table 2.6.3a The distribution of the Australian population 1901 and 2020

	1901	2020
Rural	52%	17%
Inner city	25%	6%
Suburban	15%	57%
Coastal	8%	20%

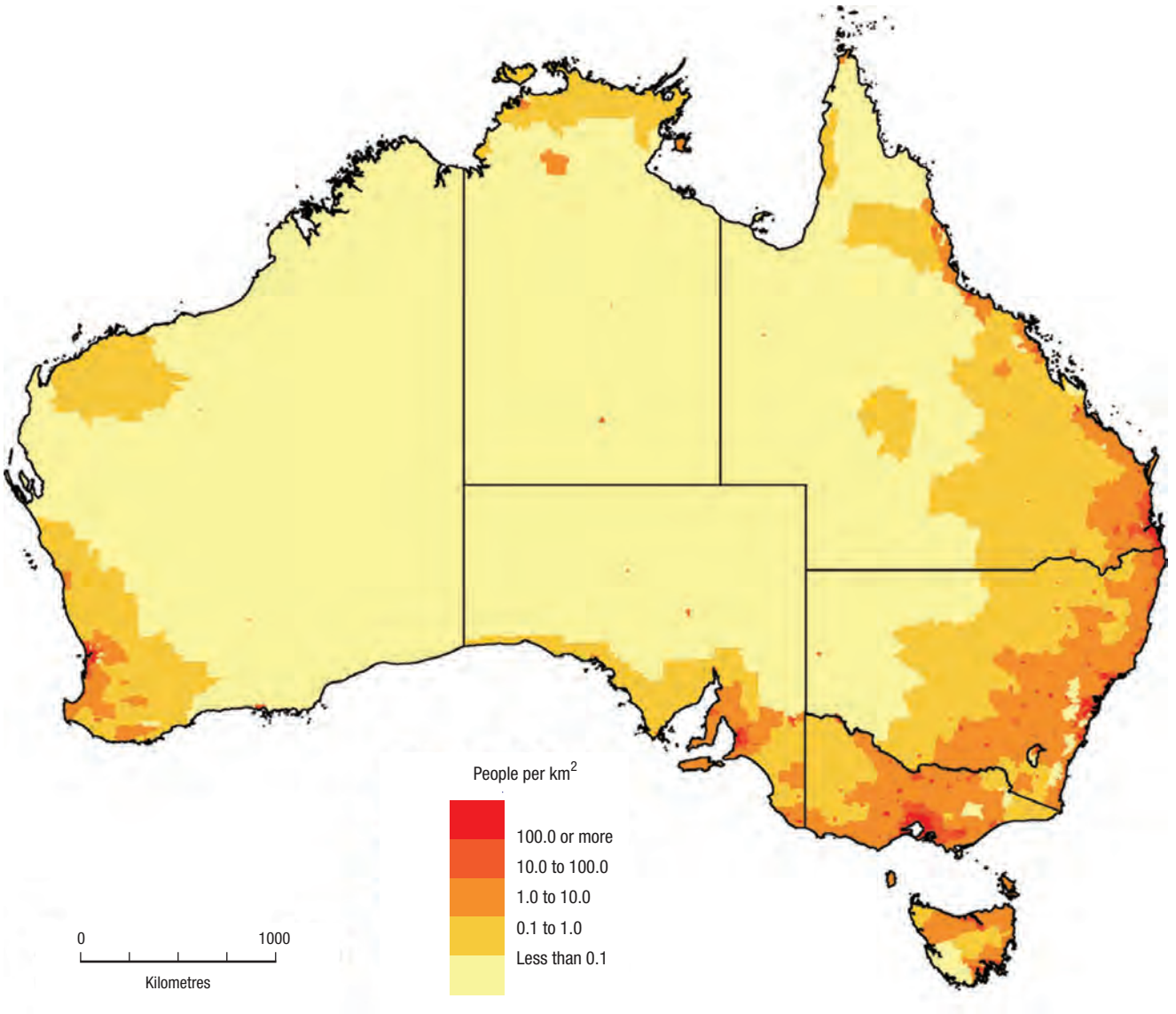

Figure 2.6.3e Population density, 2020

Table 2.6.3b Population change by state and territory, 2011–20

State/territory	Total population 2011 ('000)	Total population 2020 ('000)	Percentage change
NSW	6917.7	8157.7	17.9
Victoria	5354.0	6689.4	24.9
Queensland	4332.7	5160.0	19.1
South Australia	1596.6	1767.2	10.7
Western Australia	2239.2	2656.2	18.6
Tasmania	495.4	539.6	8.9
Northern Territory	211.9	245.4	15.8
ACT	357.2	429.8	20.3
Australia	21 504.7	**25 650.0**	19.3

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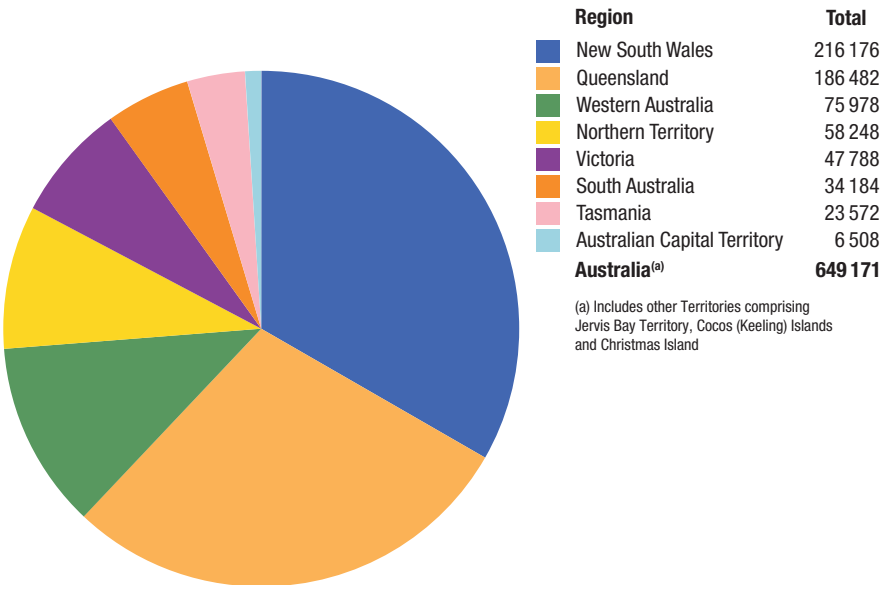

Figure 2.6.3f The distribution of Indigenous Australians by state and territory, 2016 Census

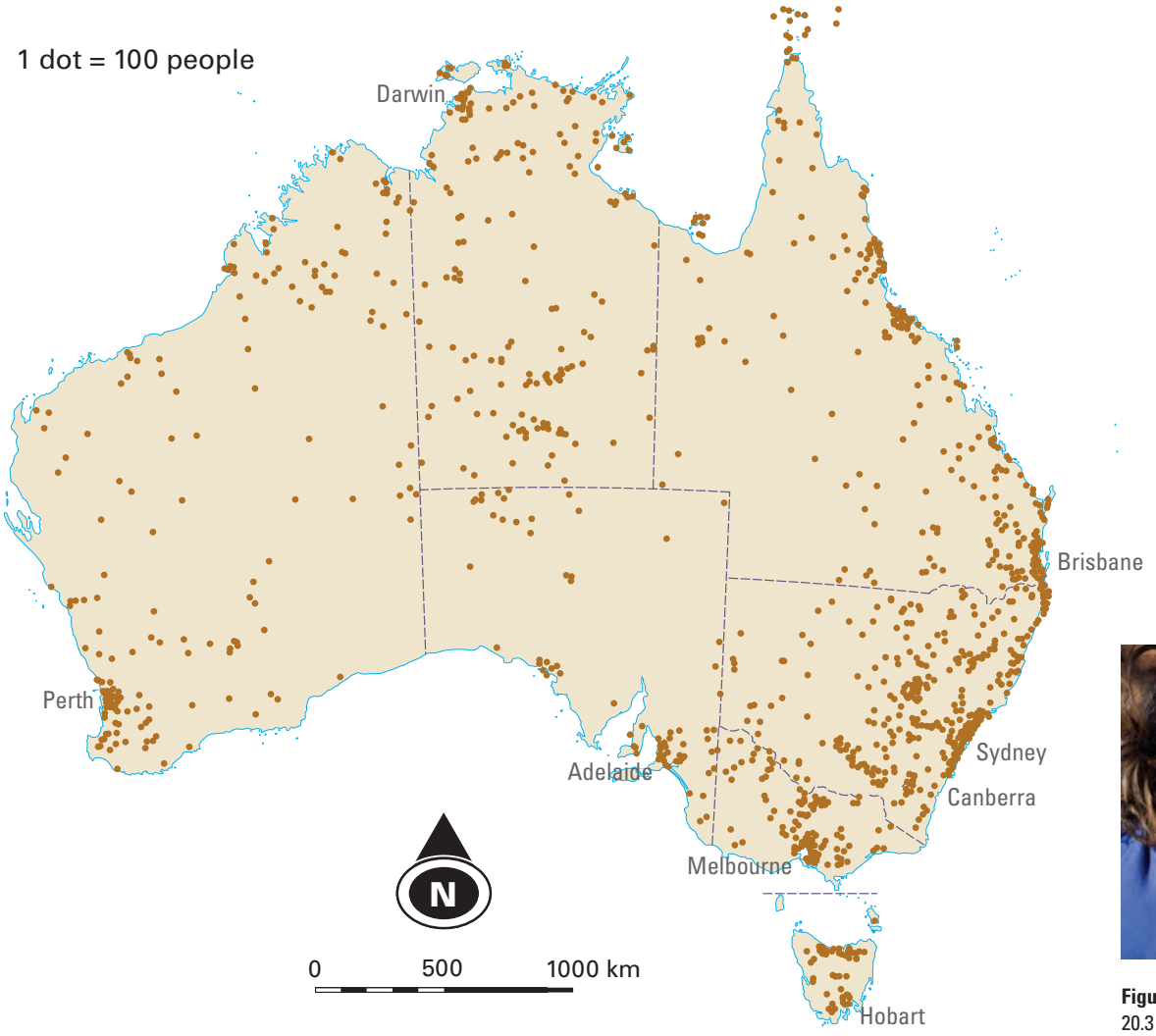

Figure 2.6.3g Dot map showing the distribution of Indigenous Australians

Aboriginal and Torres Strait Islander people are more likely to live in urban and regional areas than remote areas. Of the Aboriginal and Torres Strait Islander population at the 2016 Census:

- about 4 in 5 (81%, or about 649 600 people) lived in *Major cities*, *Inner regional* or *Outer regional* areas
- about 1 in 5 (19%, or about 148 700 people) lived in *Remote* or *Very remote* areas.

Figure 2.6.3h The Indigenous population (median age 20.3 years) is relatively young compared with that of the total population (median age 37.8 years).

ACTIVITIES

1 Study Figure 2.6.3a (page 67). Write a paragraph describing the spread of European settlement since 1788.

2 Study Figure 2.6.3b (page 67). Describe the distribution of the Australian population. Working in groups, brainstorm the reasons for the pattern identified.

3 Study Figure 2.6.3d (page 68) and then answer the following questions:
- a What percentage of Australia's population lives in New South Wales?
- b How many people live in Victoria?
- c Which state has the smallest share of the total Australian population?

4 Study Figure 2.6.3e (page 68) and answer the following questions:
- a Where are population densities the highest?
- b Which parts of Australia have population densities of 1.0 to 10.0 people per km^2?

5 Study Figures 2.6.3f and 2.6.3g. Write a paragraph describing the distribution of Indigenous Australians.

6 Study Figure 2.6.3f and then answer the following questions:
- a What percentage of Indigenous Australians live in:
  - i New South Wales?
  - ii Queensland?
  - iii Northern Territory?
- b How many Indigenous Australians live in:
  - i Northern Territory?
  - ii Queensland?
  - iii Victoria?

7 Write an extended response outlining the nature of internal migrations taking place within Australia.

8 Study Table 2.6.3a (page 68) and describe how the distribution of the Australian population changed between 1901 and 2020.

9 Study Table 2.6.3b (page 68). Construct a column graph to illustrate the population change by state and territory, 2011–20. Account for the population growth experienced by Western Australia.

10 Study Table 2.6.3b (page 68). Identify the states and territories that experienced a growth rate greater than that of Australia as a whole.

11 Write an extended response outlining the principal movements of Australia's population.

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2.6.4 UNITED STATES: POPULATION AND URBAN CONCENTRATIONS

By 2060 the population of the United States will be considerably older and more ethnically and racially diverse than it is today. Consider the following:

- The total population is projected to exceed 400 million by 2051 and 420 million by 2060.
- Minority groups,* which now account for 37 per cent of the US population, will grow to 57 per cent by 2060. The white population will be in a minority.
- Unlike other racial or ethnic groups, the non-Latino, white population is expected to fall by nearly 20.6 million between 2024 and 2060. Meanwhile other groups with higher birth rates will increase.
- The number of Latinos will more than double, from 56.6 million in 2015 to 129 million in 2060. That is, one in three Americans – up from one in six today.
- The African American population is projected to increase from 46 million to 61.8 million by 2060 (up from 13.3 per cent of the population to 14.7 per cent).
- The Asian population is expected to more than double, from 15.9 million to 34.4 million.
- By 2060, one in five people in the United States will be 65 years or older. The share of the population between 18 and 64 years is expected to fall from 62.7 per cent to 56.9 per cent. There will be more people over the age of 65 than under 18 years of age.

* Minorities are defined as all groups other than single-race, non-Latinos.

United States census

The United States conducts a census every 10 years. The last one was in 2020, and the Census Bureau is due to start releasing demographic data from August 2021.

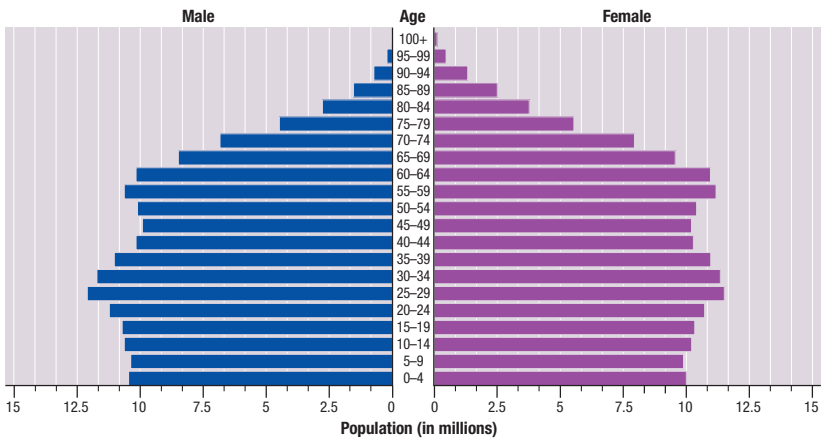

Figure 2.6.4b The age and sex structure of the US population, 2020

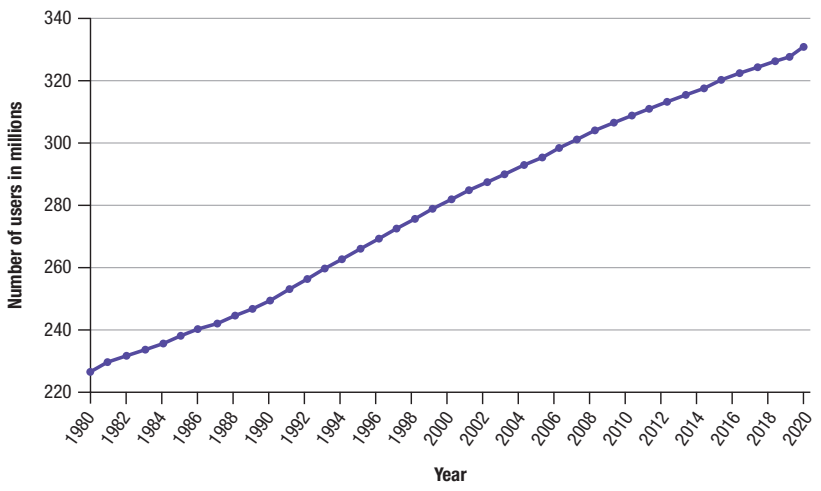

Figure 2.6.4a Growth of the US population, 1980–2020

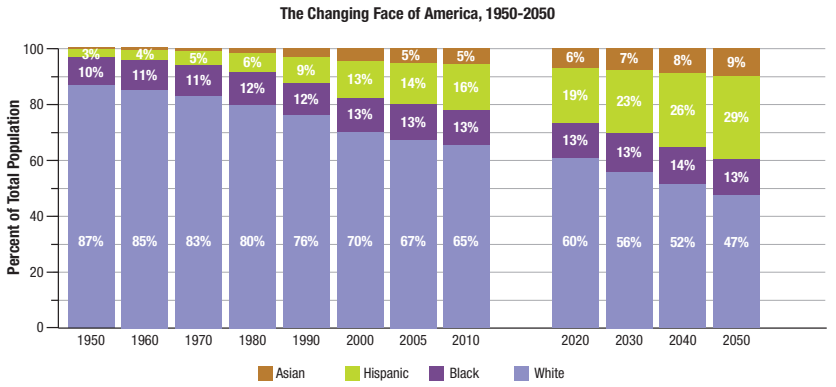

Figure 2.6.4c The changing ethnic composition of the US population, 1950–2050

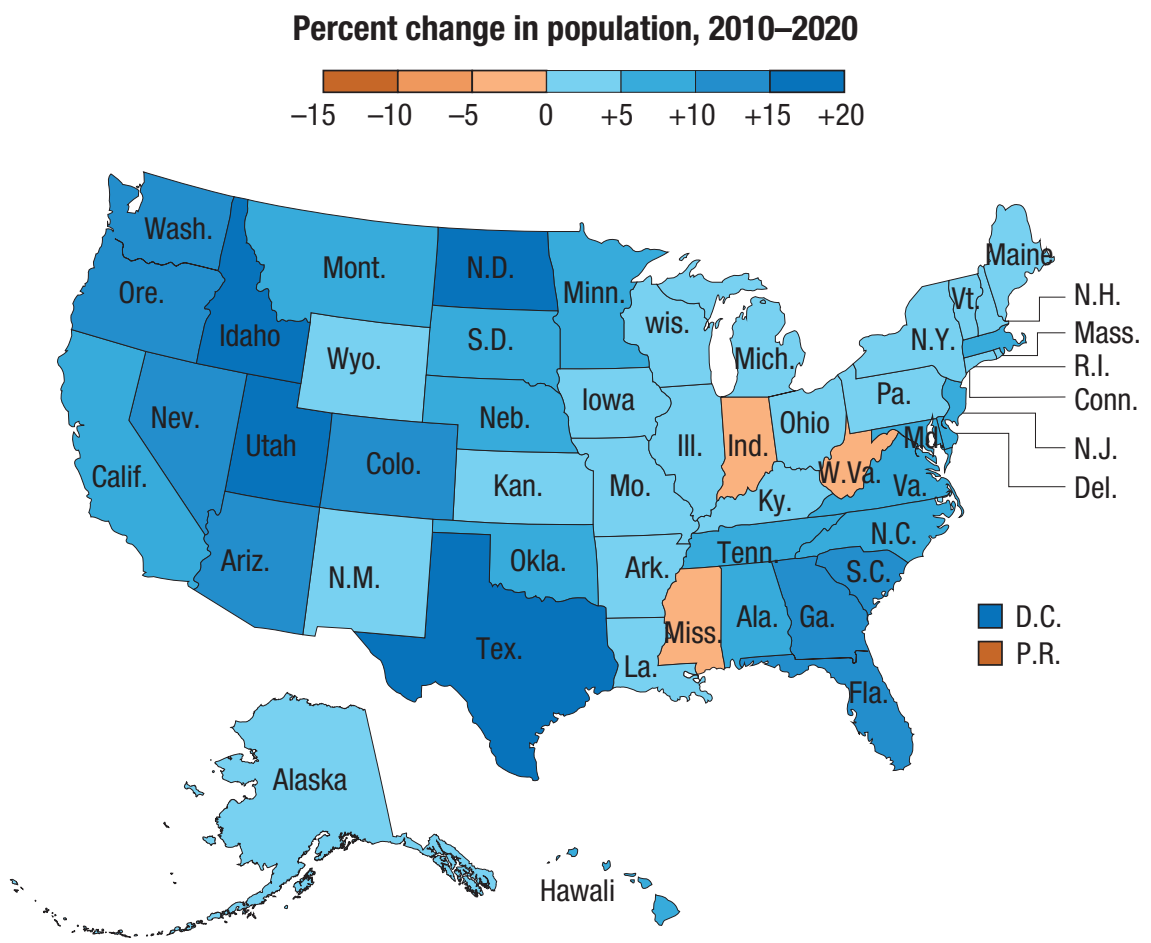

Figure 2.6.4d Percentage change in population, 2010–2020, 2020 Census

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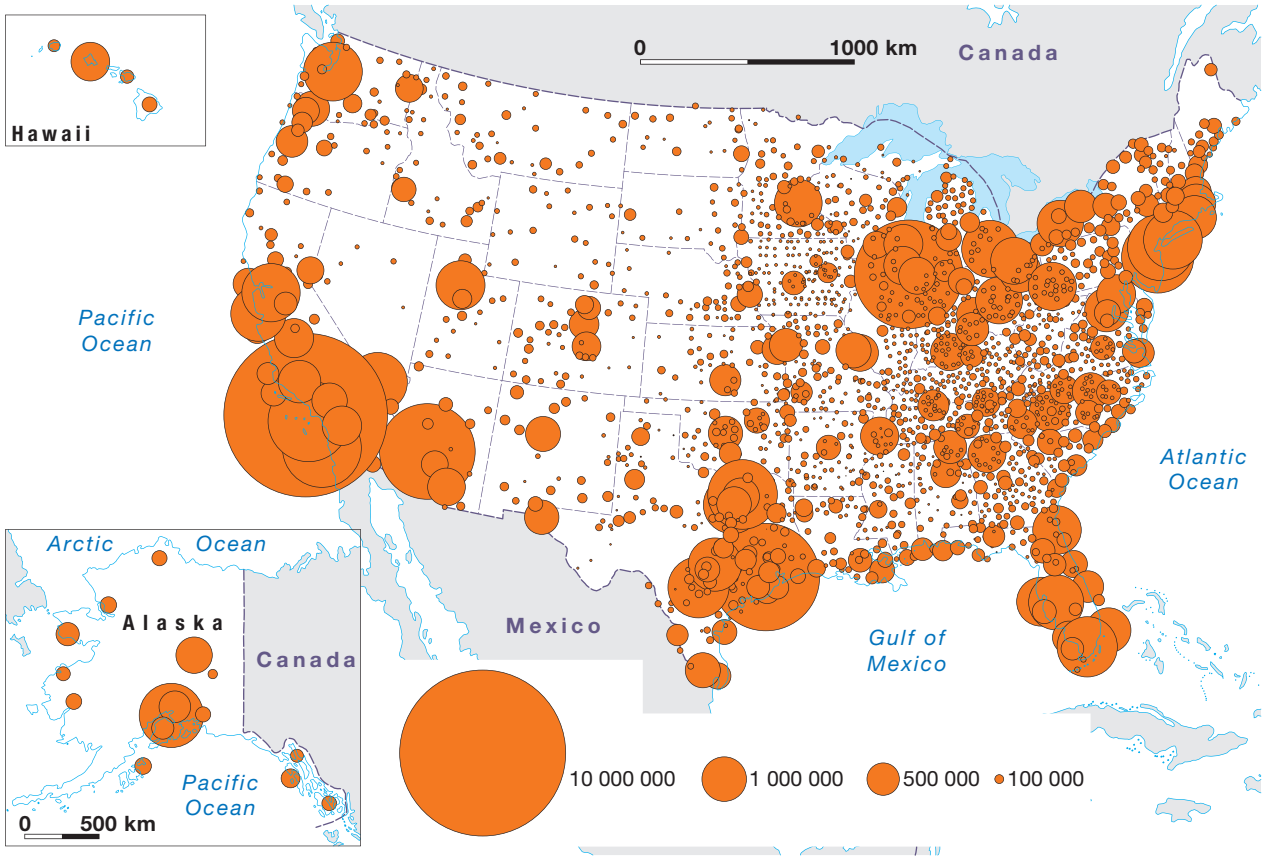

Figure 2.6.4e Distribution of the US population, 2010 Census

Population distribution of the United States

The population of the United States is not evenly distributed. It tends to concentrate in urban areas, leaving the spaces between them more sparsely inhabited. Most Americans live in or near cities. Today 53 per cent live in the 20 largest cities. Seventy-five per cent of Americans live in metropolitan areas. This means that more than three-quarters of the US population shares just 3 per cent of the land area.

The most densely settled parts of the United States are the northeast, the southeast (especially Florida), the state of Texas in the Gulf of Mexico, and the west coast (one in nine Americans live in the west coast state of California, the United States' most populous state). The central plains of the United States are the least densely settled parts of the country. Coastal areas are home to more than half the US population.

African Americans are heavily concentrated in the southern states (in the east), where they once worked as slaves on plantations. America's Hispanic population is concentrated in the states lining the Mexican border (in the west). Indigenous Americans are concentrated in the Plains states east of the Rocky Mountains.

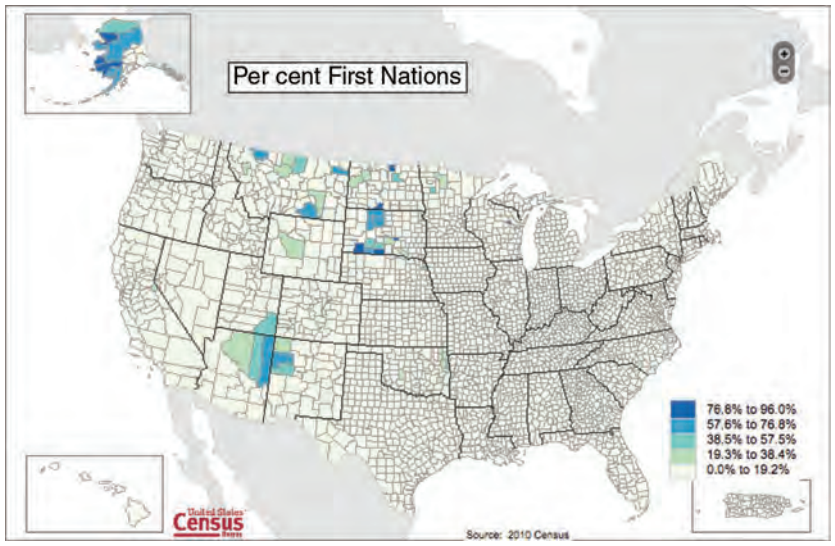

Figure 2.6.4f Distribution of the US' indigenous peoples, 2010 Census

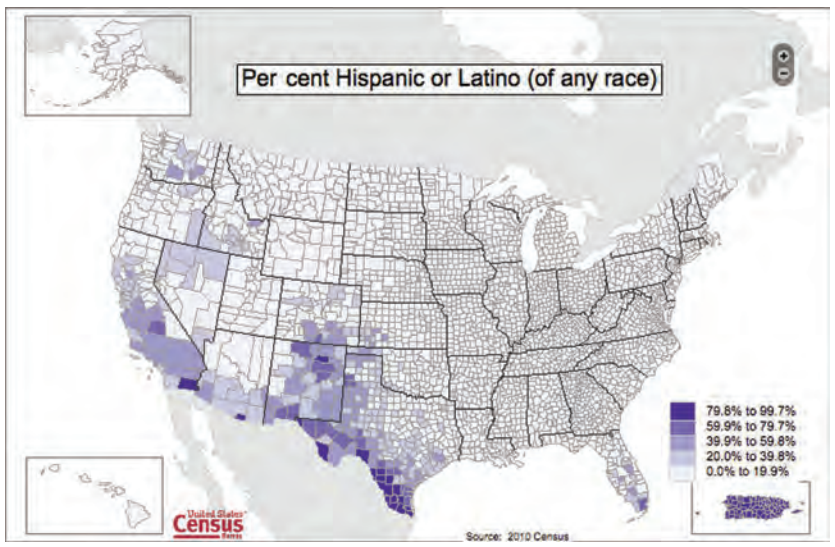

Figure 2.6.4h Distribution of Hispanic Americans, 2010 Census

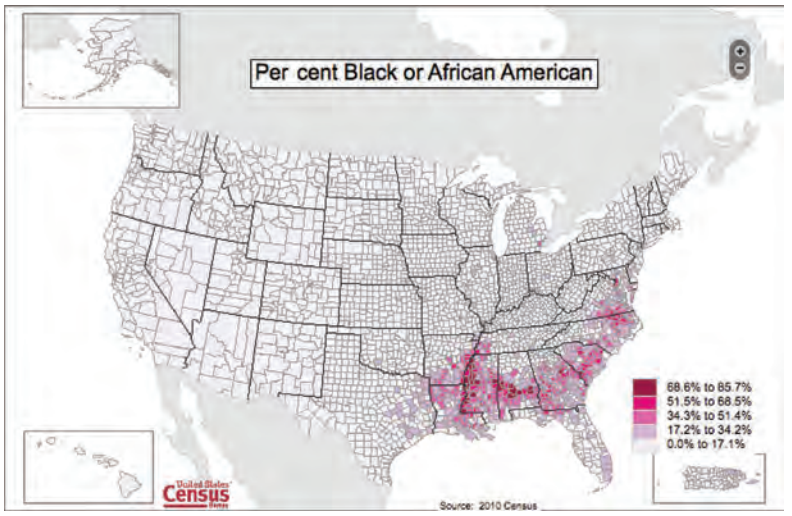

Figure 2.6.4g Distribution of African Americans, 2010 Census

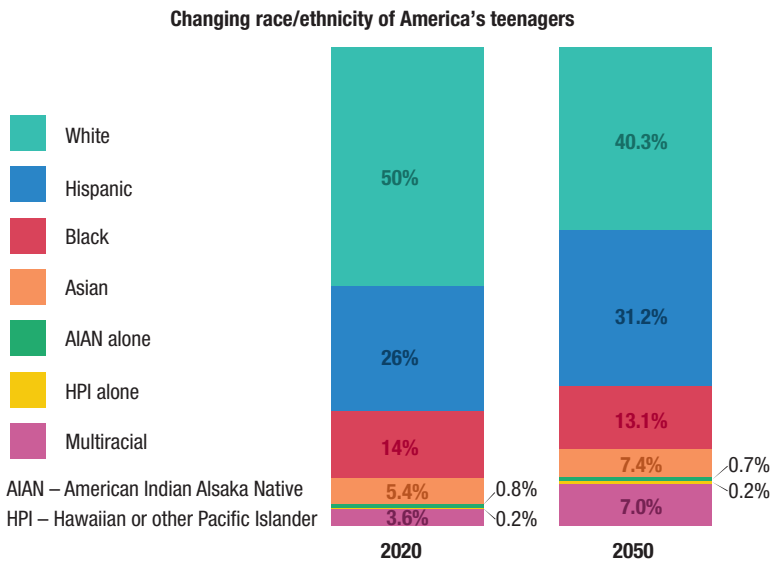

Figure 2.6.4i The proportion of adolescents who are racial and ethnic minorities is expected to rise in the future. More than half of US adolescents (50 per cent) were white in 2020, but by 2050 that proportion is projected to drop to 40 per cent as Hispanic and multiracial teens, in particular, come to represent a larger share of the population.

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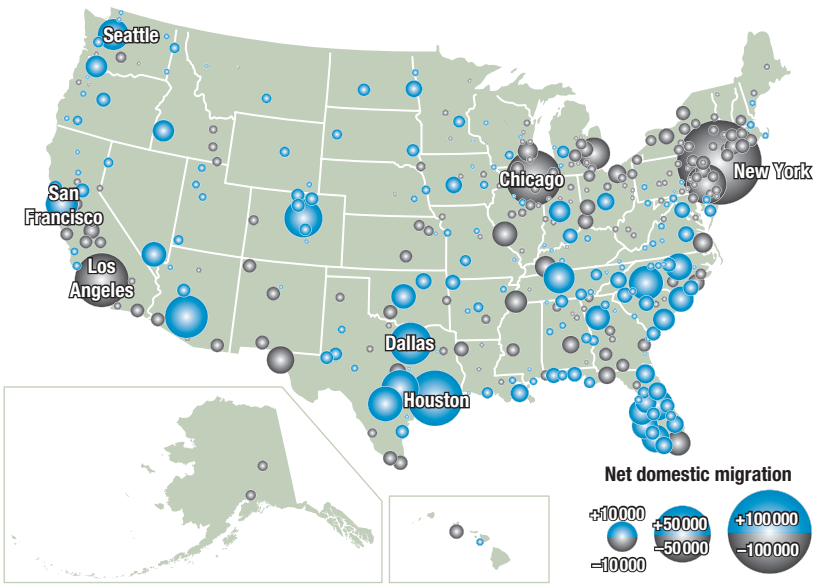

Figure 2.6.4j United States: net domestic migration, 2012–13

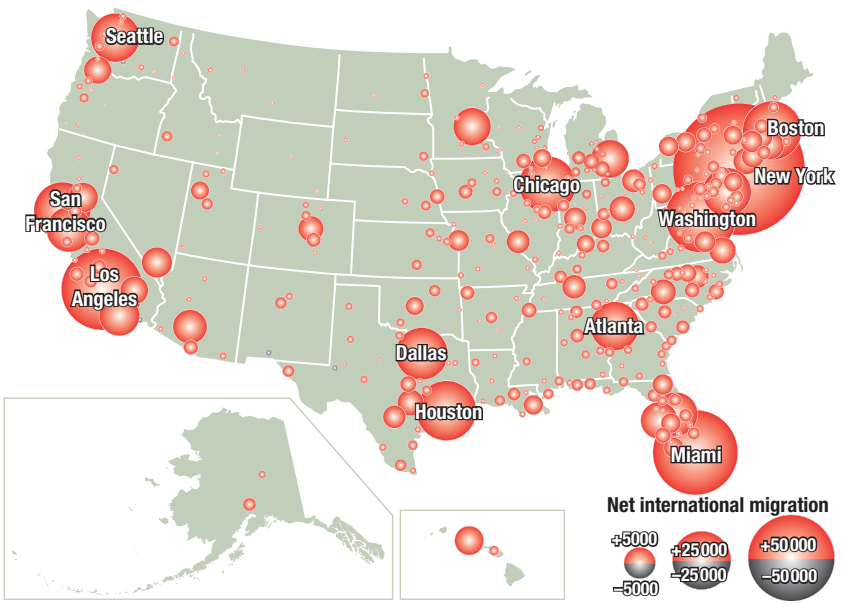

Figure 2.6.4k United States: net international migration, 2012–13

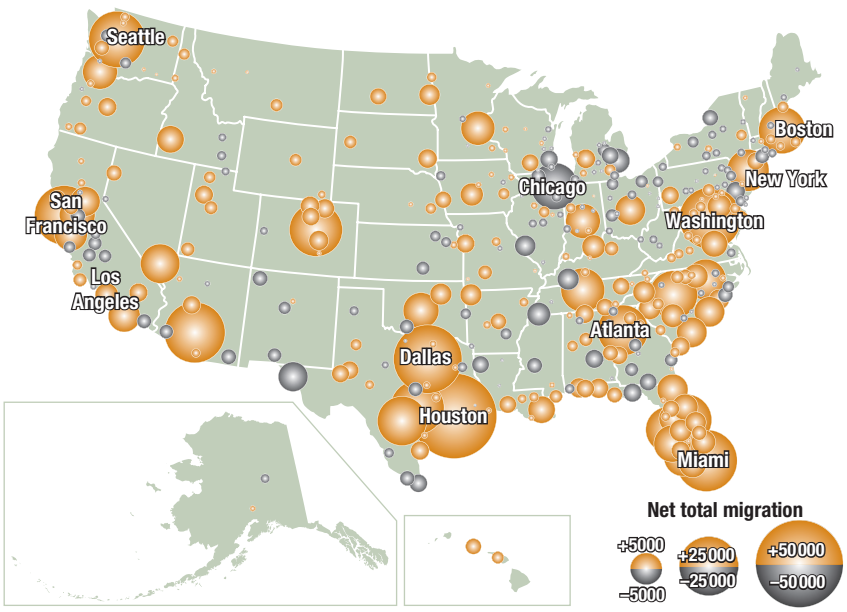

Figure 2.6.4l United States: total net migration, 2012–13. New York and Los Angeles are losing more Americans than they're gaining, but the flood of immigrants more than makes up for it.

Population movements

America's largest cities, which are currently gaining population at impressive rates, are driving much of the population growth across the nation. But that growth is the result of two very different migrations – one coming from the location choices of Americans themselves, the other shaped by where new immigrants from outside the United States are heading.

While many cities are attracting a net inflow of migrants from other parts of the United States, in several large cities, for example, New York, Los Angeles and Miami, there is actually a net outflow of Americans to the rest of the country. Immigration is driving population growth in these places. Sunbelt cities such as Houston, Dallas and Phoenix, and knowledge hubs like Austin, Seattle, San Francisco and Washington, DC are gaining much more from domestic migration.

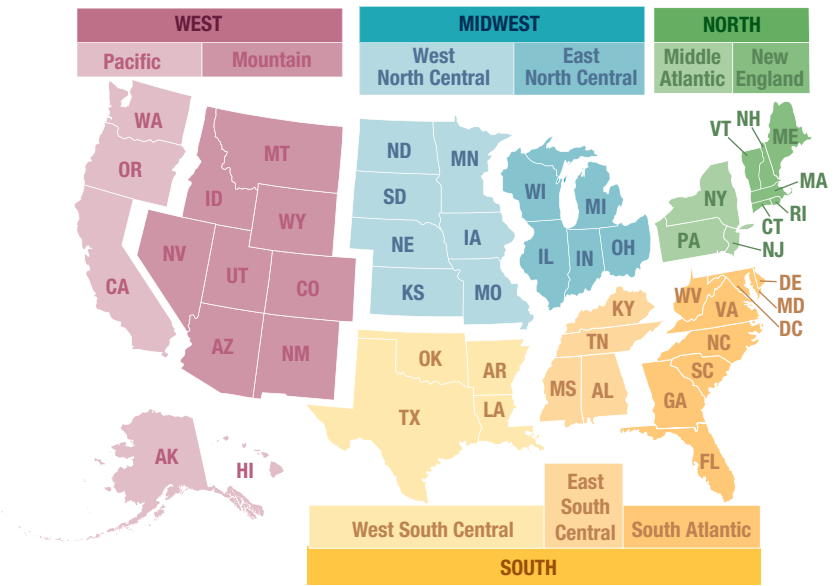

Figure 2.6.4m Regions of the United States

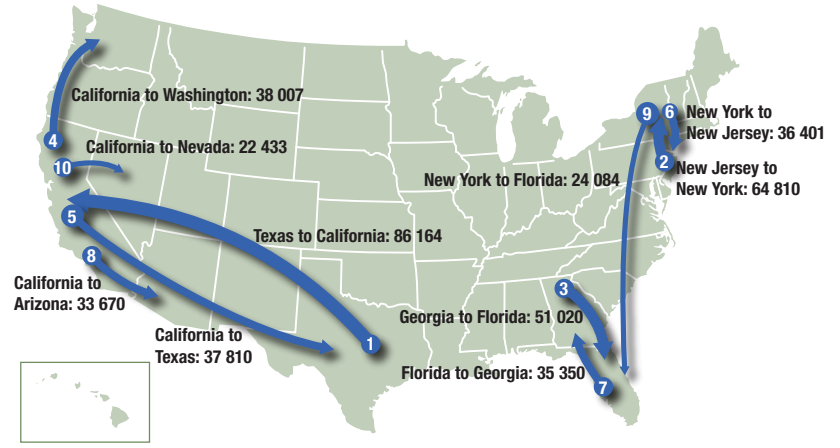

Figure 2.6.4n Top state-to-state migration flows, 2018

Figure 2.6.4o The ethnic diversity of the American population is increasing

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North America's urban concentrations

The distribution of large urban centres in North America is quite different from that found in Australia. North America has a significant number of large, inland cities. Other than Canberra, Australia has none. About 80 per cent of the population of the United States lives in urban areas. These occupy just 2 per cent of the country's land surface. The majority of urbanised residents live in the suburbs; those living in the inner city make up just 30 per cent of the urban population (about 60 out of 210 million people).

The largest city in the United States is New York City. The population of its metropolitan area is almost 19 million. The next five largest urban areas are Los Angeles, Chicago, Houston, Philadelphia and Phoenix.

Canada's largest city is Toronto (6.2 million). Of the others, only Montreal (4.2 million), Vancouver (2.6 million) (see Unit 7.2, page 164) and Calgary (1.6 million) have more than a million residents.

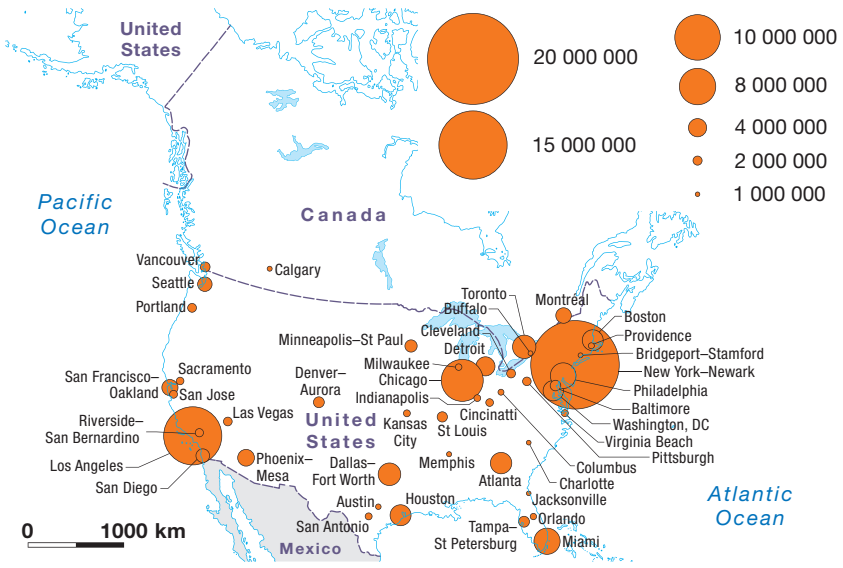

Figure 2.6.4p Proportional circle graph showing distribution of major North American urban concentrations

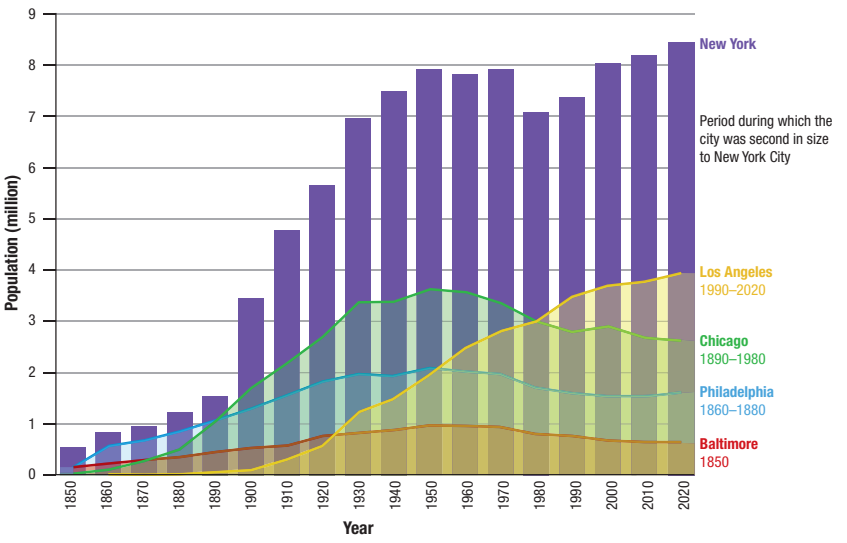

Figure 2.6.4q Population trends: selected US cities, 1990–2020

Table 2.6.4a Changing structure of the US workforce, 2007–2017 ('000)

Sector	2007	2017	% change
Educational services	2976	3680	23.6
Health care and social assistance	15948	19574	22.7
Accommodation and food services	11557	13694	18.5
Professional and business services	18051	20870	15.6
Arts, entertainment and recreation	1993	2285	14.7
Transportation and warehousing	4548	5121	12.6
Other services	5516	5785	4.9
Financial activities	8282	8483	2.4
Federal government	2756	2814	2.1
Retail trade	15571	15815	1.6
Local government	14481	14456	–0.2
Utilities	557	553	–0.7
State government	5139	5091	–0.9
Wholesale trade	6038	5944	–1.6
Mining and logging	740	717	–3.1
Construction	7490	6930	–7.5
Manufacturing	13746	12481	–9.2
Information	3024	2716	–10.2
TOTAL	**138413**	**147010**	**6.2**

Figure 2.6.4r New York City is the largest city in the United States.

ACTIVITIES

1 Study Figure 2.6.4a (page 70). Describe the general trend in the rate of US population growth since 1980.

2 Study Figure 2.6.4b (page 70) and answer the following questions:
- a Estimate the number of Americans under the age of 15 years in 2020. What percentage of the total population did this represent?
- b Estimate the number of Americans over the age of 65 years in 2020. What percentage of the total population did this represent?

3 Using data from Figure 2.6.4c (page 71) describe the projected changes in the ethnic composition of the US population between 1950 and 2050.

4 Study Figure 2.6.4e (page 70). With the aid of Figure 2.6.4m and Figure 2.6.4p describe the distribution of the US population in 2010. Explain how the population distribution of the United States differs from that of Australia.

5 Study Figures 2.6.4f to 2.6.4h (page 71). Describe the distribution of:
- a Indigenous Americans
- b African Americans
- c people of Hispanic origin.

6 Undertake research into the reasons for the distribution of African Americans and those of Hispanic origin.

7 Study Figure 2.6.4i (page 71). Using data from the graph describe the projected change in the race/ethnicity composition of American teenagers between 2020 and 2050.

8 Figures 2.6.4j and 2.6.4k. Explain what these maps tell us about the impact of domestic and international migration on the population distribution of the United States as shown in the map showing total net migration (Figure 2.6.4l).

9 Study Figure 2.6.4n. Identify the two largest inter-state movements of people in 2018.

10 Study Figure 2.6.4p. Identify North America's largest urban concentrations. Describe their distribution.

11 Study Figure 2.6.4q. Describe how the trends in New York's population compare with those of Los Angeles, Chicago, Philadelphia and Baltimore.

12 Study Table 2.6.4a. Using data from the graphic, describe the change in the structure of US industry and employment in the period 2007 to 2017.

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2.7 Environmental change and management

2.7.1 CLIMATE CHANGE AND ITS IMPACTS

Rising global temperatures, melting glaciers, shrinking areas of sea ice and rising sea levels: the evidence is now overwhelming. The Earth's climate is changing, and scientists are convinced that human activities are to blame.

A number of human activities pump heat-trapping gases (greenhouse gases) into the atmosphere. These practices range from burning fossil fuels, which releases carbon dioxide (CO_2) into the atmosphere, to farming. Once these gases have entered the atmosphere they remain there for thousands of years. They absorb the heat that comes from the Earth and re-radiate it back to the surface, enhancing Earth's natural greenhouse effect.

Since the early 20th century (1906), Earth's mean surface temperature has increased by between 0.6–0.9°C, with about two-thirds of the increase occurring since 1980. In October 2020, atmospheric greenhouse gas concentrations reached 411.79 parts per million – their highest level in at least the past 650 000 years. If this trend continues, scientists believe that temperatures are likely to increase 2–6°C by the end of this century. This might seem like a small change, but it will probably lead to significant changes in our environment.

Global climate change is likely to lead to more frequent heatwaves, more widespread drought and bigger storms, including more intense tropical cyclones (or hurricanes). Just small increases in average temperatures can threaten entire ecosystems. The world's coral reefs and animal species such as the polar bear are threatened with extinction. Higher sea levels (a result of melting of glaciers and the polar ice caps) increase coastal erosion. As much as 10 per cent of the world's population lives in vulnerable coastal regions with an elevation less than 10 m above sea level.

Rising sea levels will flood these low-lying areas, forcing people to flee their homes.

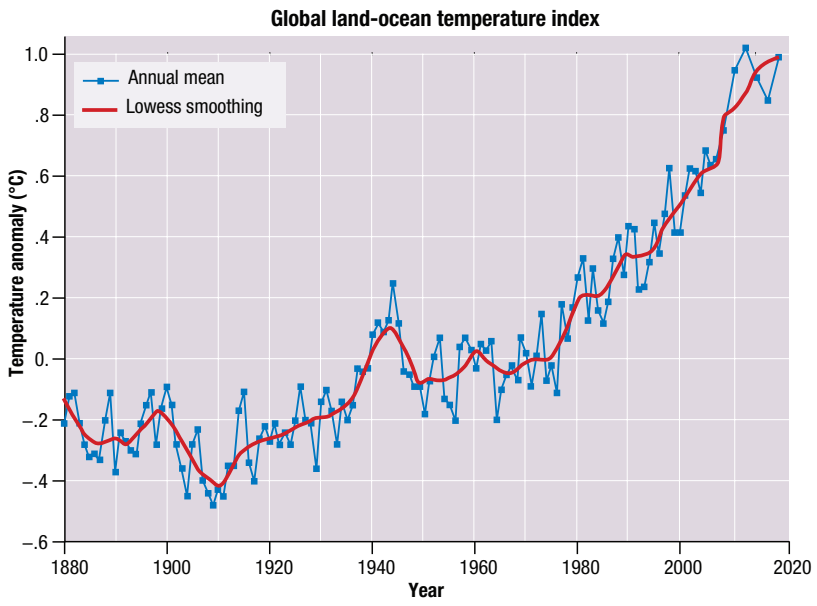

Figure 2.7.1a Trends in global temperatures, 1880–2019; how much warmer or colder a year was compared with the average temperature between 1951 and 1980.

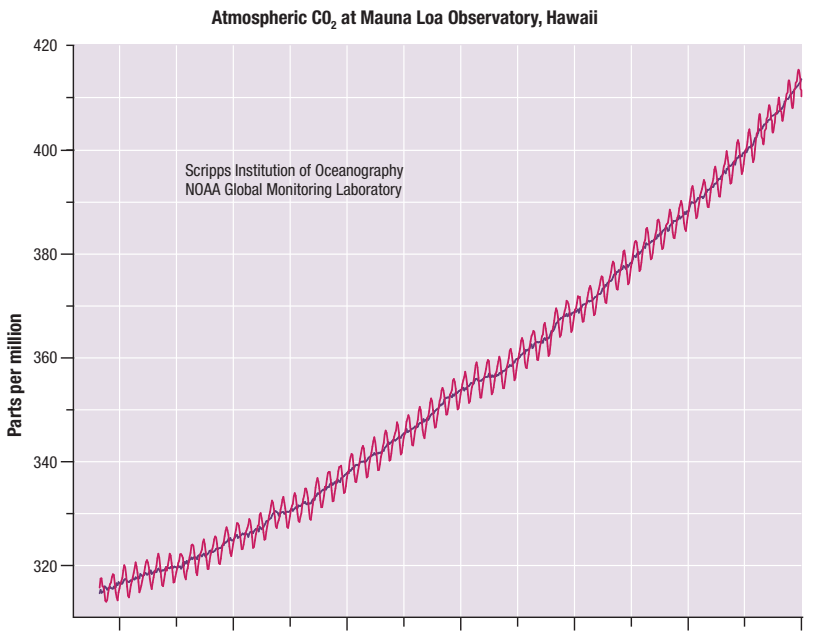

Figure 2.7.1b Atmospheric CO_2 at Mauna Loa Observatory, Hawaii, 1960–2020

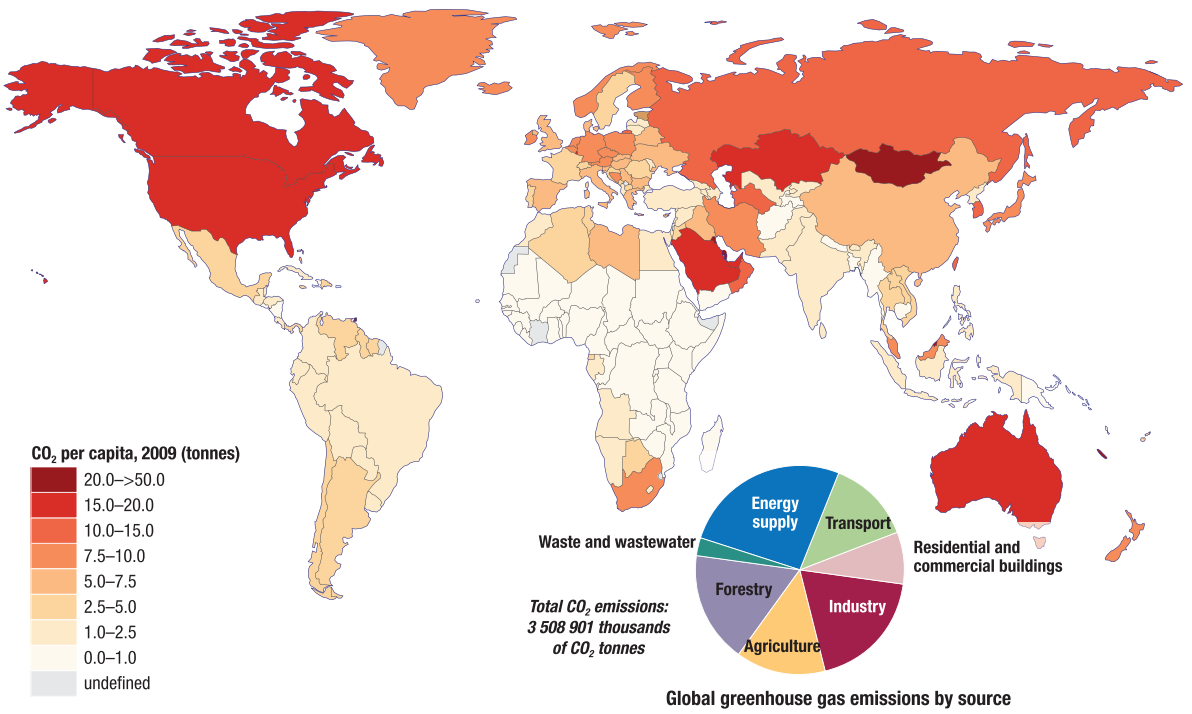

Figure 2.7.1c CO_2 emissions per capita, 2018. The insert graph shows the sources of CO_2 emissions

Table 2.7.1a Top 10 CO_2 emitting countries and Australia's rank, 2019

Rank	Country	Emissions ('000 tons)	Per capita emissions (tons)
1	China	10 174 681	7.10
2	United States	5 284 697	16.06
3	India	2 616 449	1.91
4	Russia	1 678 367	11.51
5	Japan	1 106 664	8.72
6	Iran	779 527	9.40
7	Germany	701 955	8.40
8	Indonesia	617 513	2.28
9	South Korea	611 263	11.93
10	Saudi Arabia	582 150	16.99
15	Australia	411 016	16.31

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Going, going ... the arctic ice sheet in retreat

Average temperatures in the Arctic region are rising twice as fast as they are elsewhere in the world. The region's ice sheet is shrinking and becoming thinner. Images from NASA satellites show that the area of permanent ice cover in the Arctic is now contracting at a rate of 9 per cent each decade. If this trend continues, summers in the Arctic could become ice-free by the end of the 21st century.

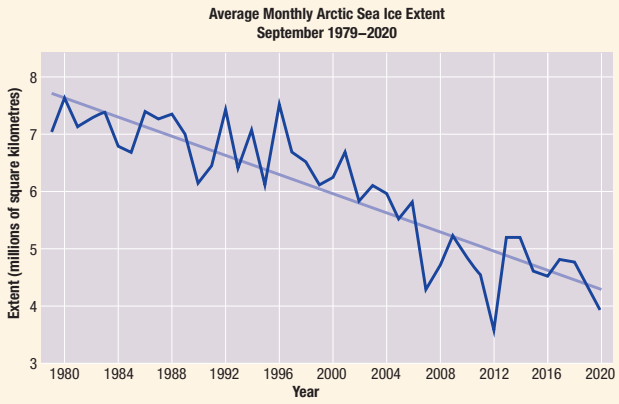

Figure 2.7.1d Extent of Arctic sea ice, 1979–2020

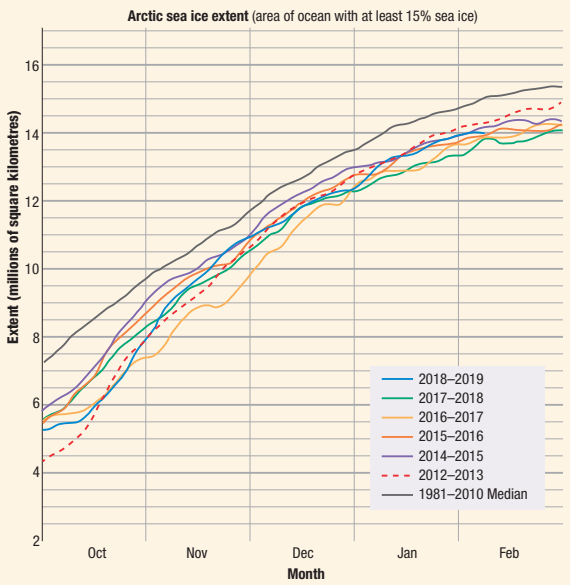

Figure 2.7.1e Annual Arctic sea ice extent (area of ocean with at least 15% sea ice)

Figure 2.7.1f Arctic sea ice extent, September 2020 compared to median ice edge, 1981–2010

Rising sea levels

Sea levels are rising for two reasons. First, with increasing average global temperatures, the water in the Earth's oceans expands in volume. This occurs because, when heated, the molecules that make up a body of water move more rapidly and collide more often.

Second, when glaciers and ice sheets melt, the water that had previously been locked up in them enters the oceans. An increase in global temperatures of 1.5–4.5°C will, scientists estimate, result in a sea level rise of 15–95 cm by the end of this century.

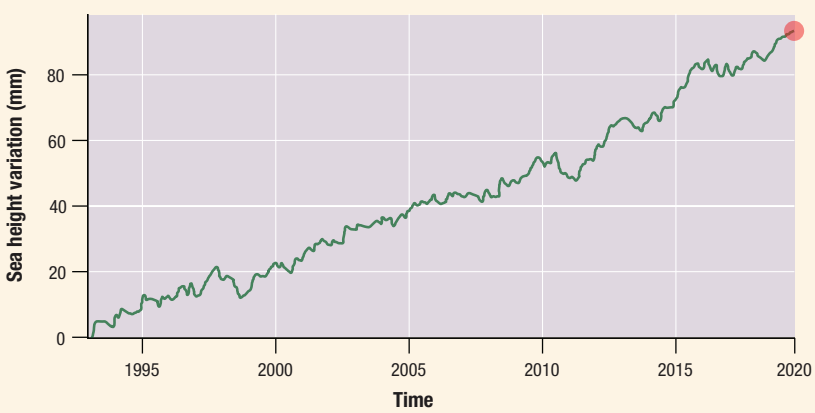

Figure 2.7.1g Global sea level change, 1993–2020

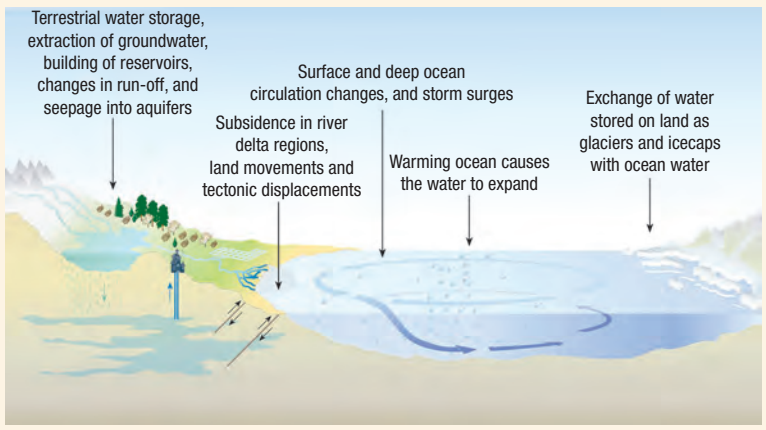

Figure 2.7.1h Causes of sea-level change. Source: GRID-Arendal

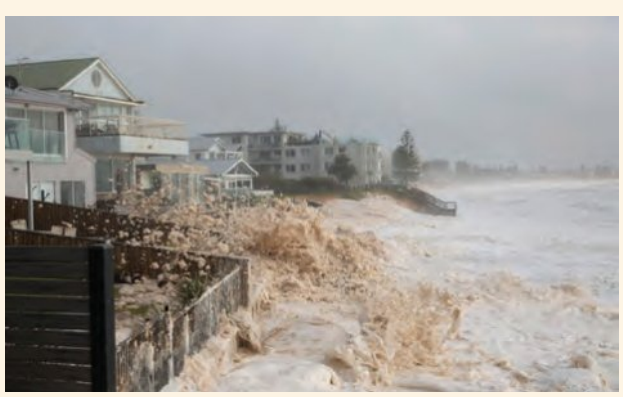

Figure 2.7.1i Rising sea levels pose a threat to coastal settlements.

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Glaciers in retreat

There are approximately 160 000 glaciers throughout the Earth's polar regions and high mountain environments. Like great rivers of ice, these glaciers have sculpted mountains and carved out great valleys. Since 1980, however, glacial retreat has become increasingly rapid and widespread. This process has sped up markedly since 1995. In the past three decades, Peru's glaciers have lost almost one-quarter of their surface area. This trend is most apparent in the mid-latitude mountain ranges, such as the Himalayas.

More than 110 glaciers have disappeared from the United States' Glacier National Park over the past 150 years, and researchers estimate that the park's remaining 37 glaciers may be gone in another 25 years.

Half a world away, on the African equator, the snows of Kilimanjaro are steadily melting and could completely disappear in the next 20 years. And in the European Alps, glaciers are retreating and disappearing every year, much to the dismay of mountain climbers, tourism agencies and environmental researchers.

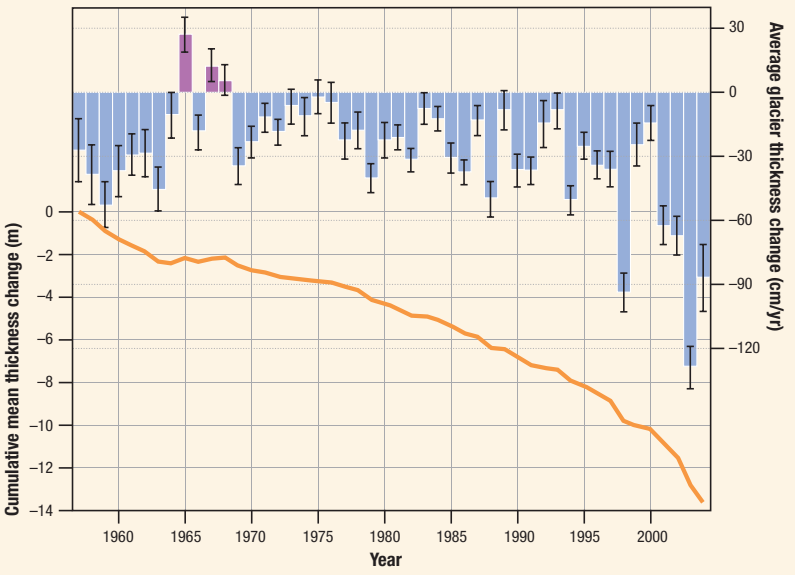

Figure 2.7.1j Change in glacial volume worldwide, 1955–2009

Figure 2.7.1k Muir Glacier, United States, photographed from the same vantage point in 1941 (top), 1950 (left) and 2004 (bottom). Between 1941 and 2004 the glacier retreated more than 12 km and thinned by more than 800 m. During this time, ocean water has filled the valley, replacing the glacier ice. The glacier's retreat has exposed scars where the ice once scraped high up against the hillside. In 2004, vegetation grew thickly in the foreground, whereas in 1941 and 1950 there was only bare rock.

ACTIVITIES

1 Study the introductory text on page 74 and then answer the following questions:
   - a What are the key signs that the global climate is changing?
   - b What effects do CO_2 emissions have on the atmosphere?
   - c What are the likely effects of global climate change?

2 Study Figure 2.7.1a (page 74) and then answer the following questions:
   - a How much hotter was it in 2019 than the average temperature between 1951 and 1980?
   - b In what year did the sustained upwards trend in global temperatures become established?

3 Study Figure 2.7.1b (page 74) and then answer the following questions:
   - a By how much did atmospheric CO_2 concentrations increase between 1960 and 2020?
   - b In what year did the atmospheric concentrations of CO_2 first exceed 360 parts per million?

4 Study Figure 2.7.1c (page 74) and then complete the following tasks:
   - a With the aid of an atlas, identify five countries with CO_2 emissions per capita greater than 15 tonnes in 2018.
   - b Describe the distribution of countries with CO_2 emissions per capita below 1 tonne.

5 Study the pie graph in Figure 2.7.1c (page 74) and then complete the following questions:
   - a What is the largest single source of CO_2 emissions?
   - b Estimate the percentage of total emissions that is energy related, compared to that which comes from industry.
   - c Estimate the total amount of CO_2 produced by agriculture.
   - d What is the total amount of CO_2 emitted by energy supply?

6 Study Table 2.7.1a (page 74). Construct a column graph showing the 10 largest CO_2-emitting countries. Add Australia to this graph.

7 Study Figure 2.7.1d (page 75) and then answer the following questions:
   - a By how much did the average monthly extent of sea ice change between 1979 and 2020?
   - b In what year did sea ice extent reach its lowest level?
   - c In what year did sea ice extent last exceed 7 million km²?

8 Study Figure 2.7.1e (page 75). Compare the Arctic sea ice extent in the years since 2010 with the 1981–2010 median.

9 Study Figure 2.7.1f (page 75). Describe the difference in the sea ice extent in September 2020 with the median ice edge, 1981–2020.

10 Study Figure 2.7.1g (page 75). By how much did mean sea level change between 1993 and 2020?

11 Study Figure 2.7.1h (page 75). Write a report outlining the factors that cause sea level to change.

12 Study Figure 2.7.1j and then complete the following tasks:
   - a By how much has the thickness of glacial ice changed between 1955 and 2009?
   - b Has the decline in glacial volume accelerated or slowed since 1980? Explain how you arrived at this answer.

13 Study Figure 2.7.1k. Construct a series of comparative photo sketches to highlight the trends in glacial retreat shown in the photographs.

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2.8 Human wellbeing

2.8.1 GLOBAL INEQUALITIES

The differences in people's quality of life is largely determined by the country in which they live. While variations also occur within countries, this is not apparent when we look at data that have been averaged. The differences in the quality of life in one country compared with another, and between groups within countries, are referred to as inequalities.

Sometimes they are also referred to as socio-economic inequalities because they refer to the unequal distribution of both wealth and a range of social benefits, such as healthcare and education.

Table 2.8.1a World's wealthiest countries by GDP per capita, 2021

Country	Gross Domestic Product per capita ($US) – IMF ranking
Luxembourg	131 782
Switzerland	94 696
Ireland	94 556
Norway	81 995
United States	68 309
Denmark	67 218
Iceland	65 273
Singapore	64 103
Australia	62 724
Qatar	59 143
Sweden	58 977
Netherlands	58 003
Finland	54 330
Austria	53 859
Germany	51 860
Belgium	50 103
San Marino	49 765
Canada	49 222
Israel	47 602
New Zealand	47 499

Table 2.8.1b World's poorest countries by GDP per capita, 2021

Country	Gross Domestic Product per capita ($US) – IMF ranking
Afghanistan	592
Dem. Rep. of the Congo	588
Central African Republic	552
Sierra Leone	542
Madagascar	521
Malawi	432
Mozambique	425
Somalia	347
South Sudan	314
Burundi	265

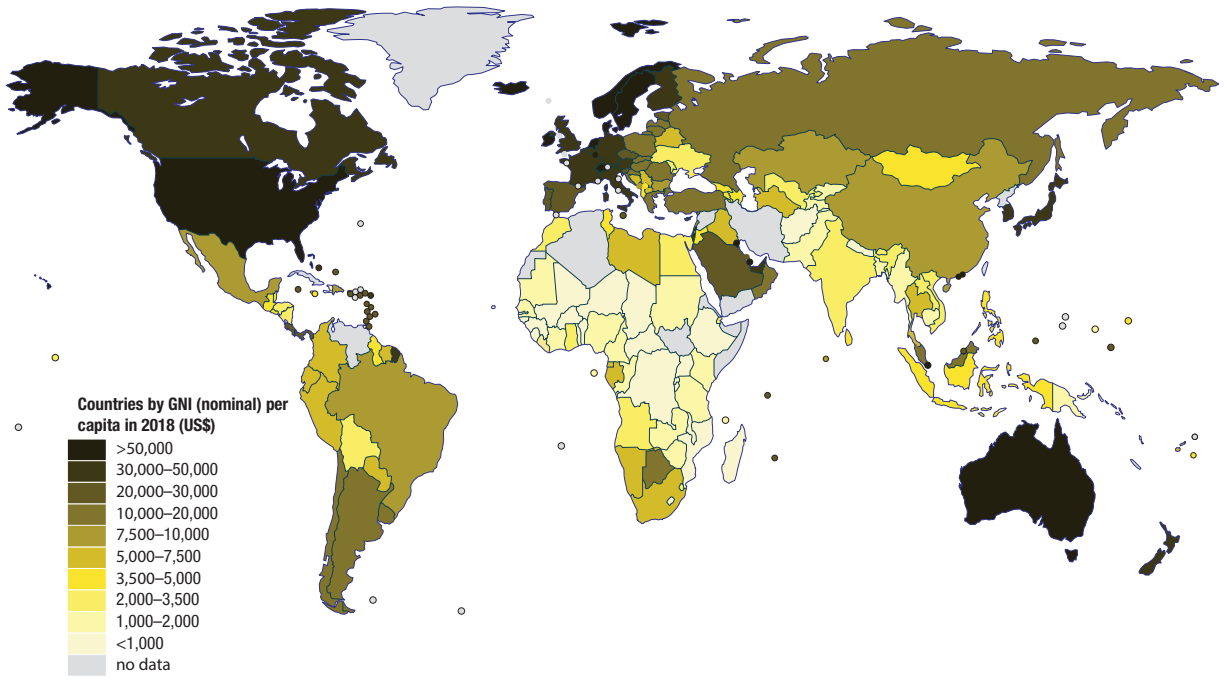

Figure 2.8.1a Gross national income (GNI) per capita, 2018

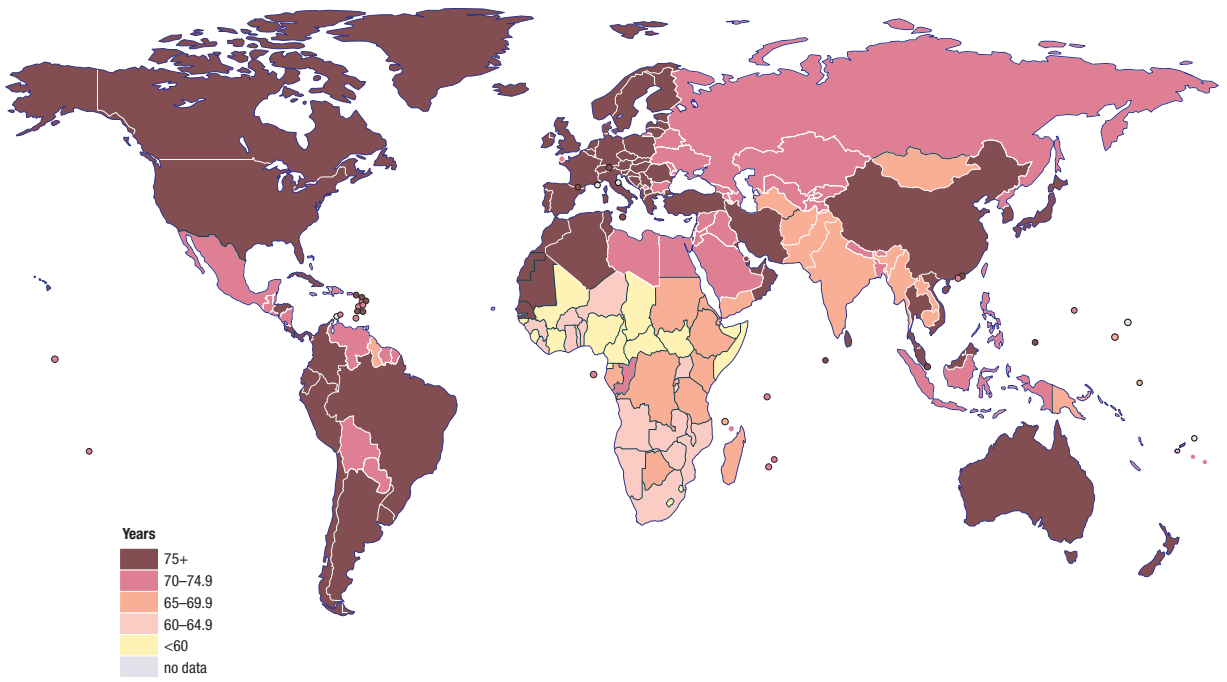

Figure 2.8.1b Life expectancy at birth, 2018

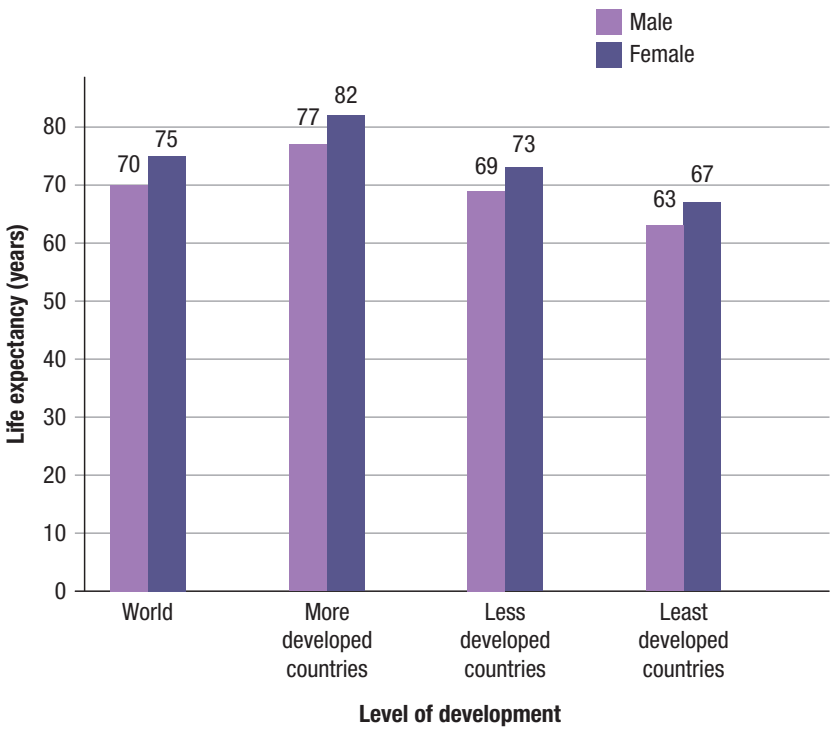

Figure 2.8.1c Life expectancy at birth by region, based on level of development, 2019

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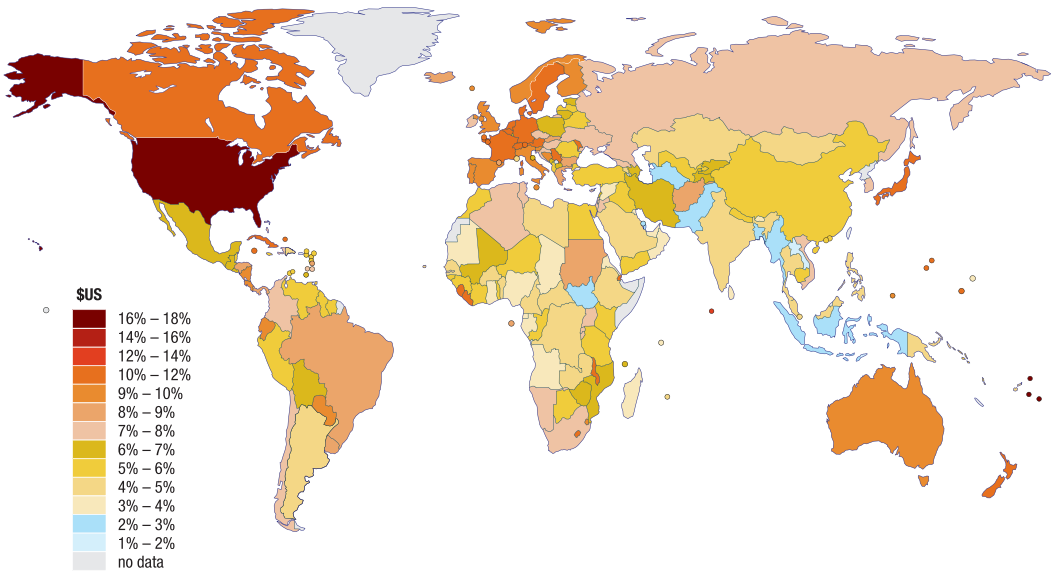


Figure 2.8.1d Health care expenditure, 2014

Infant mortality is the annual number of deaths of infants aged under 1 year per 1000 live births.

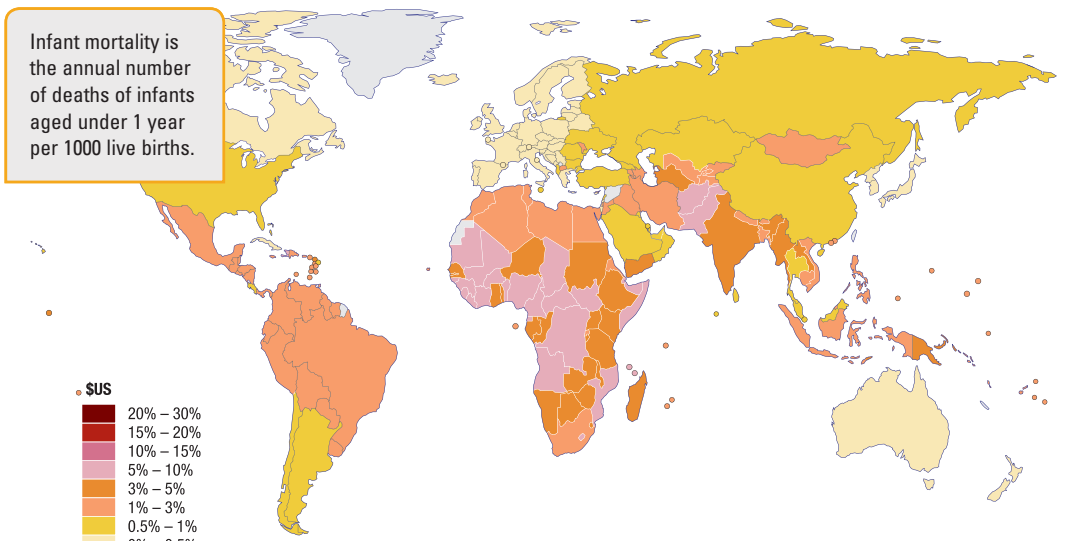


Figure 2.8.1e Infant mortality per 1000 live births, 2017

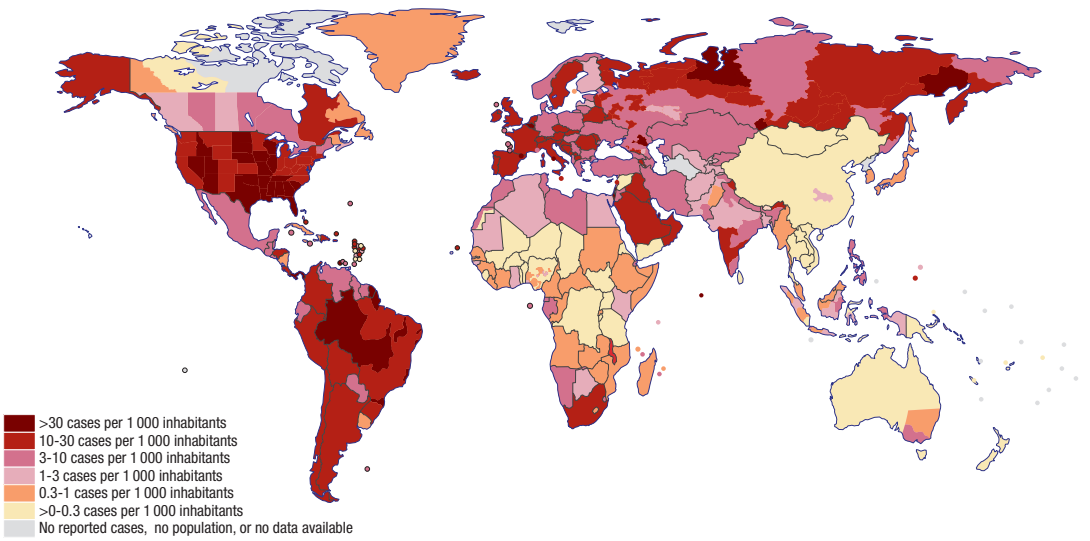
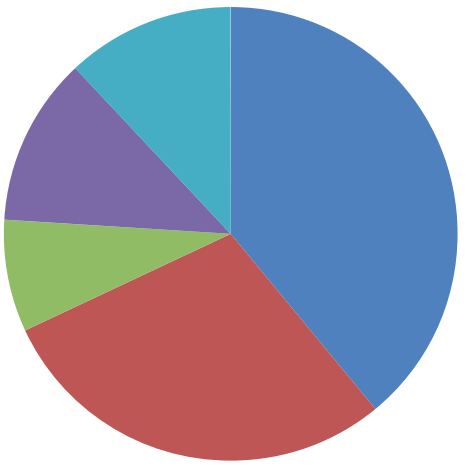


Figure 2.8.1g Number of infected COVID-19 people per capita as of 28 October 2020



Access to sanitation	Percentage
Safely managed sanitation (improved facilities that are not shares with other households and where excreta is safely disposed of)	39%
Basic sanitation (the use of improved a facility that is not shared with other households)	29%
Limited sanitation (improved facilities shared among multiple households)	8%
Unimproved sanitation (facilities do not effectively separate excreta from human contact)	12%
Open defecation	12%

Figure 2.8.1f Access to improved sanitation, 2018

ACTIVITIES

1 Study Figure 2.8.1a (page 77). Identify the regions of the world with the highest and lowest gross national income per capita.

2 Study Table 2.8.1a (page 77). Construct a column graph featuring the gross domestic income per capita of the world's 20 wealthiest countries. Shade Australia's column with a contrasting colour.

3 Study Figure 2.8.1b (page 77). With the aid of an atlas, identify those regions of the world that have the lowest life expectancy.

4 Study Figure 2.8.1c (page 77). Using data from the table write a sentence or two outlining the differences in life expectancy for the developed and less and least developed worlds.

5 Study Figures 2.8.1a (page 77) to 2.8.1g. Explain the link between the data presented in Figure 2.8.1d and the information provided in Figures 2.8.1b, 2.8.1c, 2.8.1d and 2.8.1e.

6 Study Figure 2.8.1e. With the aid of an atlas, identify those parts of the world that have an infant mortality rate greater than 5 per cent.

7 Study Figure 2.8.1f and then complete the following questions:
- a What percentage of the global population has access to safely managed sanitation?
- b What percentage of the global population has access to limited sanitation?
- c What percentage of the global population defecates in the open?

8 Study Figure 2.8.1g. Identify those regions of the world experiencing the highest incidence of COVID-19 in October 2020.

9 Write a report using data from the maps, tables and graphs in Unit 2.8.1 to outline and explain the relationship between gross domestic product per capita and factors such as life expectancy, infant mortality, access to improved sanitation and the incidence of COVID-19.

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2.8.2 ACCESS TO WATER

A clean supply of fresh water is vital for people's health. However, like many of the Earth's resources, it is unevenly distributed and stored. More than 97 per cent of the Earth's water is too salty to use for drinking or agricultural purposes. It is stored in the oceans, which cover 85 per cent of the Earth's surface. This means that only 2.5 per cent of the world's water is fresh. Of this, 68.9 per cent is stored as snow and glaciers, 30.8 per cent as groundwater and just 0.3 per cent is found in lakes and rivers.

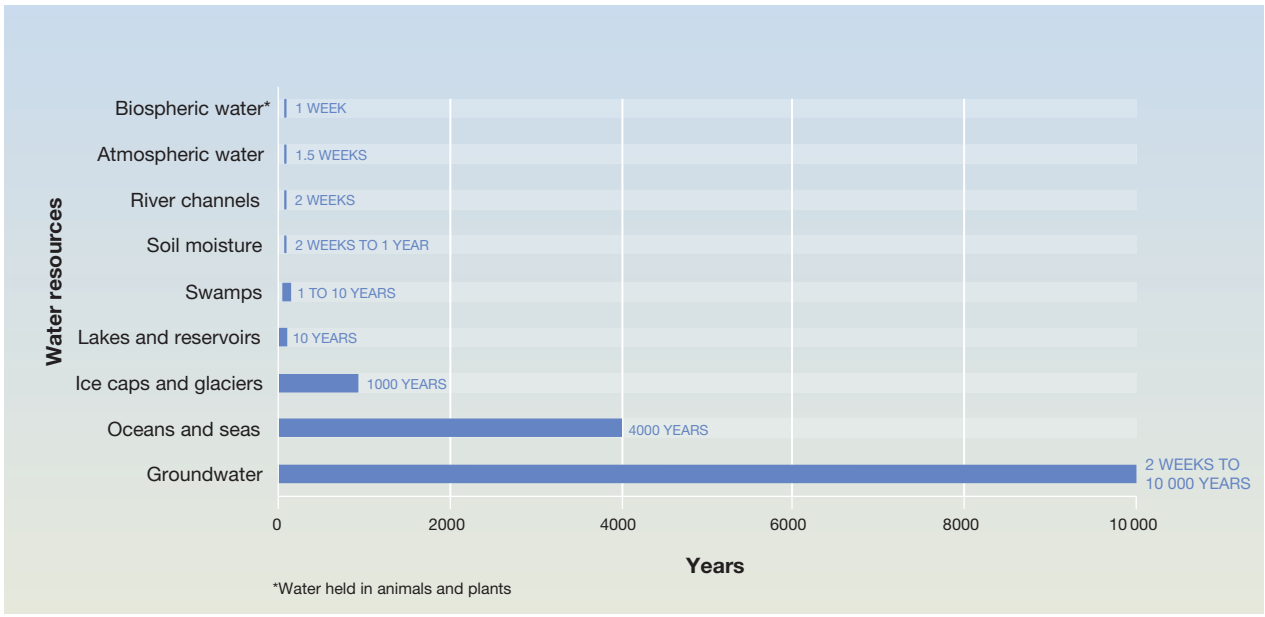

Figure 2.8.2a Estimated storage times of the world's water resources

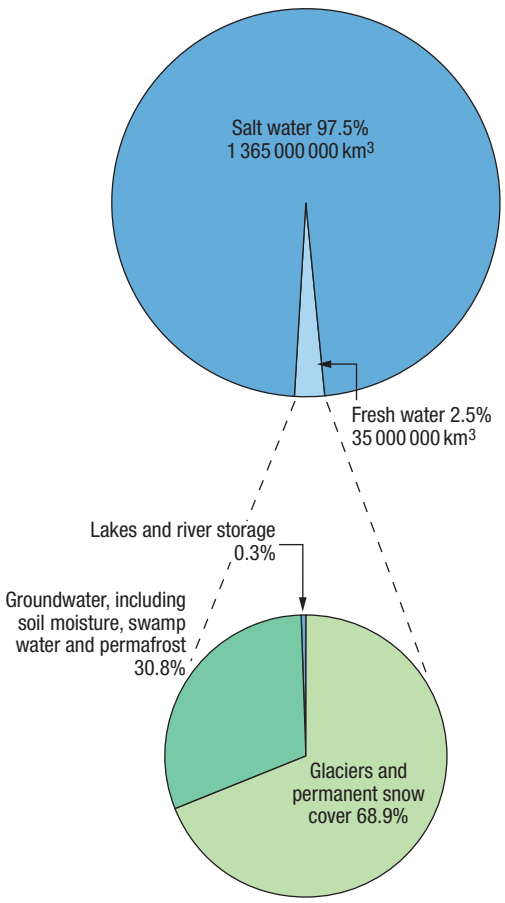

Figure 2.8.2b Total global salt water and fresh water estimates

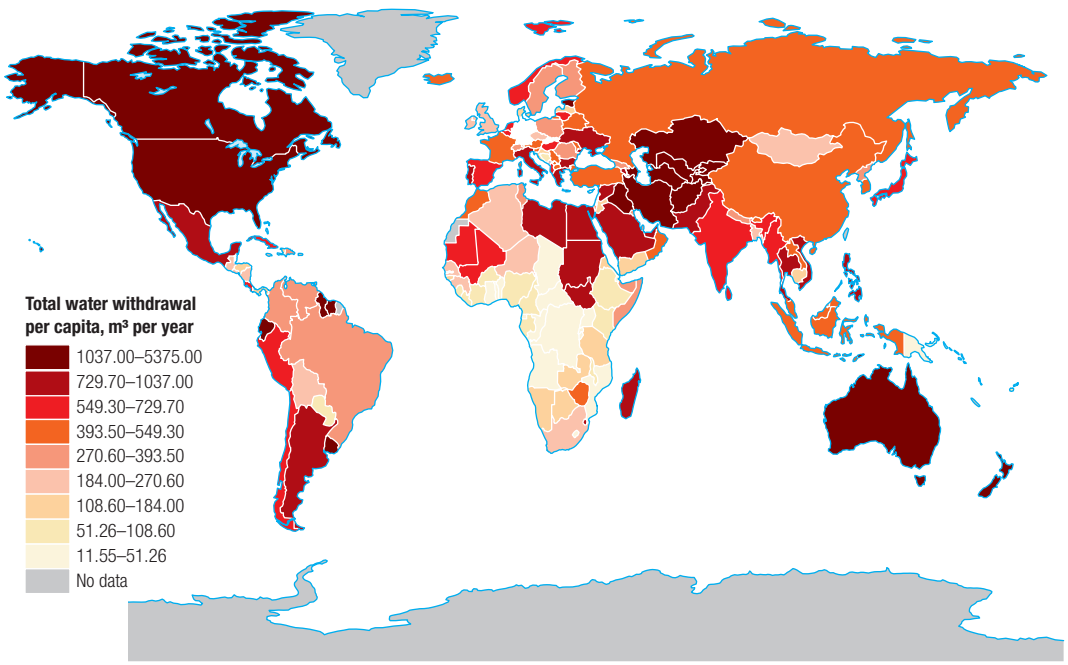

Figure 2.8.2c Total water use per year

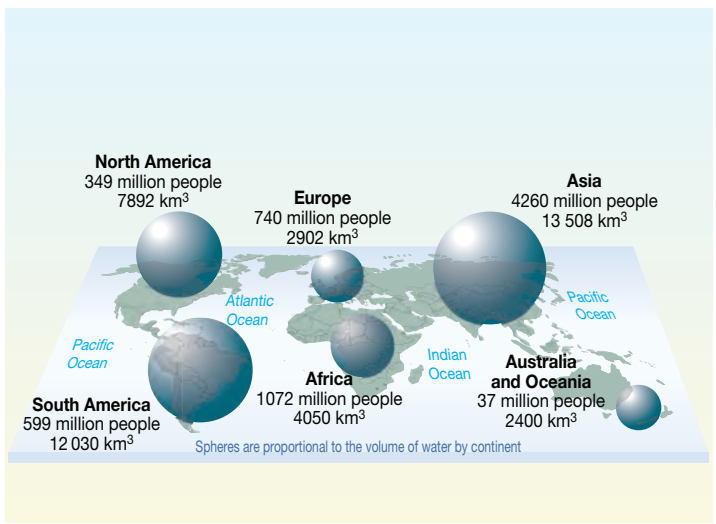

Figure 2.8.2d Water resources by continent, annual average volume

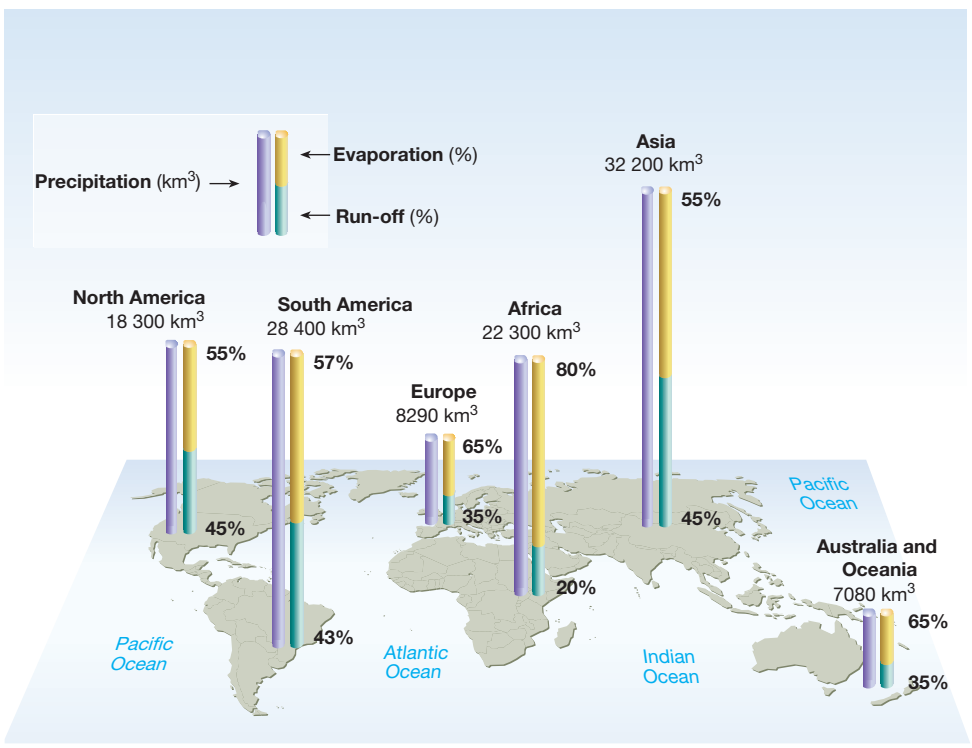

Figure 2.8.2e Precipitation, evaporation and run-off by region

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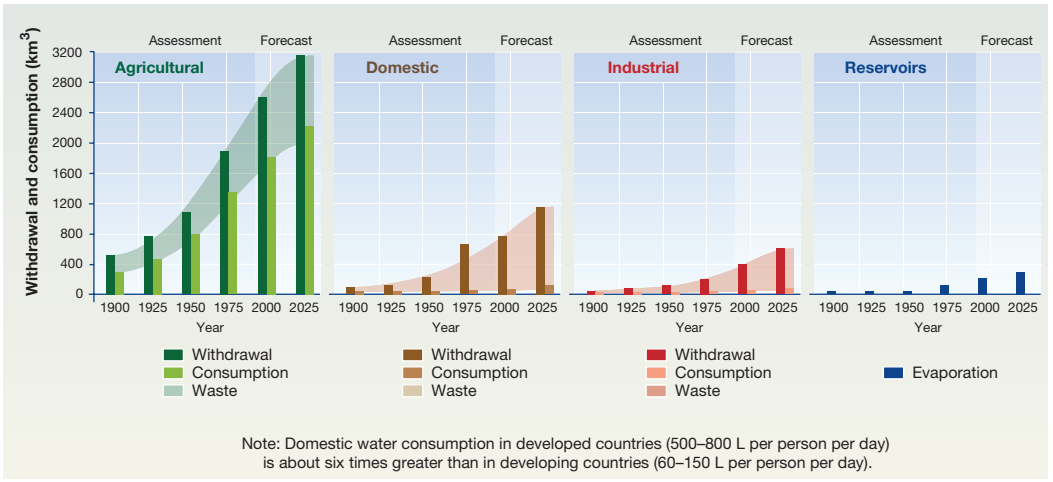

Figure 2.8.2f Global water use: withdrawal and consumption by sector, 1900–2025

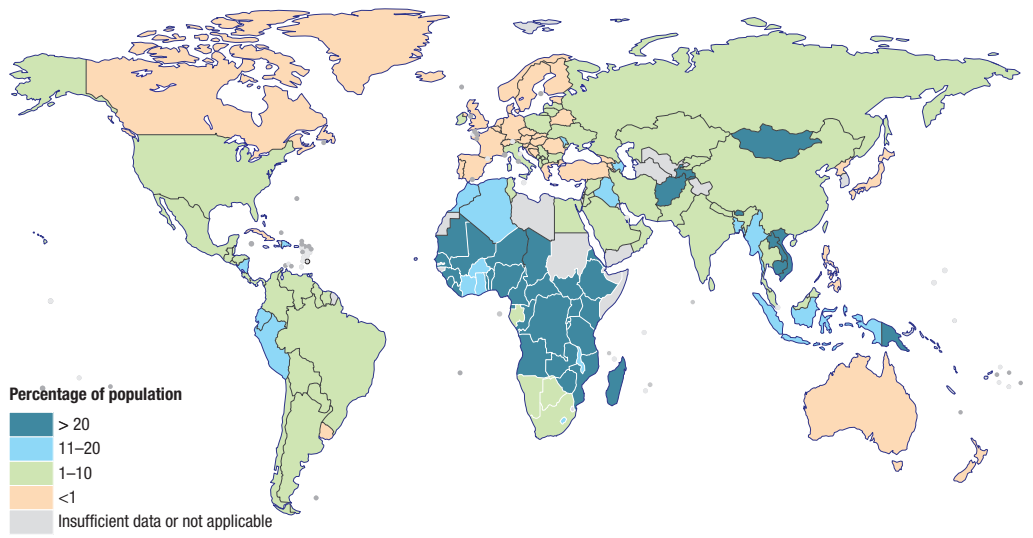

Figure 2.8.2g Percentage of population using an unimproved drinking water source

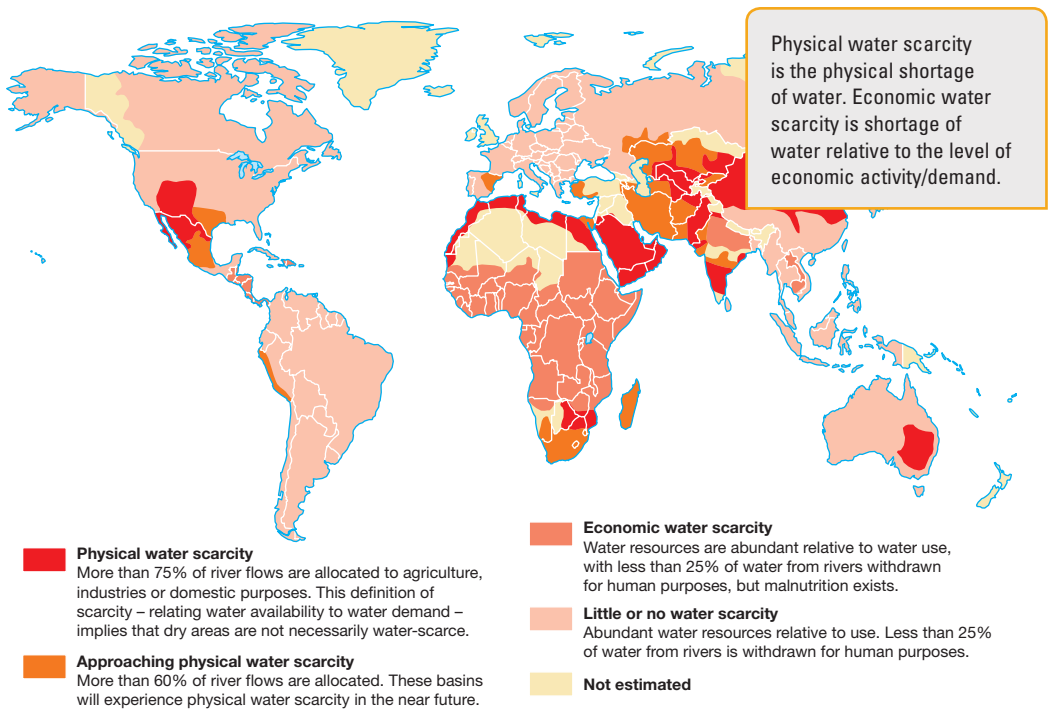

Figure 2.8.2h Projected water scarcity, 2025

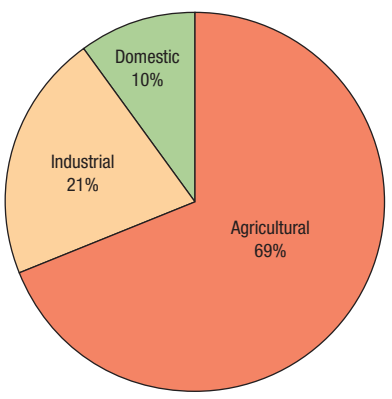

Figure 2.8.2i Global water use by sector

Figure 2.8.2j Refugee women wait to get water from a water-well as they live under hard conditions, Dafur, Sudan.

Over 1.2 billion (or 18 per cent) of the Earth's people do not have access to clean, safe water. Each year between 5 and 10 million people (mostly children) die from water-related illnesses. The most serious of these are hepatitis, typhoid, cholera, hookworm, malaria and trachoma. Each person needs 5 L of water a day to survive and a further 25 L per day to stay clean and healthy.

ACTIVITIES

1 Study Figure 2.8.2a (page 79). Using the data in the graph, write a report outlining the estimated time water is stored in various parts of the water cycle. What are the implications of this for the availability of water for human use?

2 Study Figure 2.8.2b (page 79) and then complete the following tasks:
- a Using the data in the graph showing the distribution of the world's fresh water, identify the volume of the world's fresh water stored in glaciers and permanent snow cover.
- b Undertake internet research to find out what permafrost is and in your own words provide a definition.

3 Study Figure 2.8.2c (page 79) and then, with the aid of an atlas, complete the following tasks:
- a Identify those parts of the world that have annual per capita water use greater than 1037 m^3 a year.
- b What is the annual per capita water use of China?
- c On what continent are the countries with the lowest annual per capita use of water located?

4 Using data from Figure 2.8.2d (page 79), calculate the annual average volume of water available for each 1 million people living on each continent. Use the data to construct a bar graph showing the average annual availability of water for each 1 million people. Give your graph an appropriate title.

5 Study Figure 2.8.2d (page 79) and then complete the following questions:
- a Which continental landmass has the largest annual average volume of water?
- b What is the average annual volume of water on the driest of the continental landmasses shown in the graph?
- c By how much does the average annual volume of water available in South America exceed that available in North America?

6 Study Figure 2.8.2e (page 79) and then complete the following questions:
- a Which region receives the greatest precipitation?
- b Which of the regions featured has the least precipitation?
- c Which region(s) has the highest percentage of run-off?
- d Which region has the greatest rate (%) of evaporation?
- e What are the implications of these data for agriculture in Africa?

7 Study Figure 2.8.2f and then complete the following tasks:
- a Rank the sectors according to the amount of water consumed in 2000.
- b How much water was withdrawn for agriculture in 2000?
- c What percentage of agricultural withdrawals was wasted in 2000?
- d By how much did domestic withdrawal of water increase between 1950 and 2000?
- e Which water use sector has the highest percentage of waste relative to consumption in 2025?

8 Study Figure 2.8.2g. With the aid of an atlas, identify the parts of the world where more than 20 per cent of the population rely on an unimproved drinking water source.

9 Study Figure 2.8.2h and then, with the aid of an atlas, complete the following tasks:
- a Which parts of the world are likely to experience economic water scarcity in 2025?
- b Which parts of the world are likely to experience physical water scarcity in 2025?
- c Undertake internet research. Write a report outlining the water crisis facing planet Earth.

10 Study Figure 2.8.2i. Name the sector that accounts for the greatest share of water use.

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SECTION 3 Australia

3.1 Australia

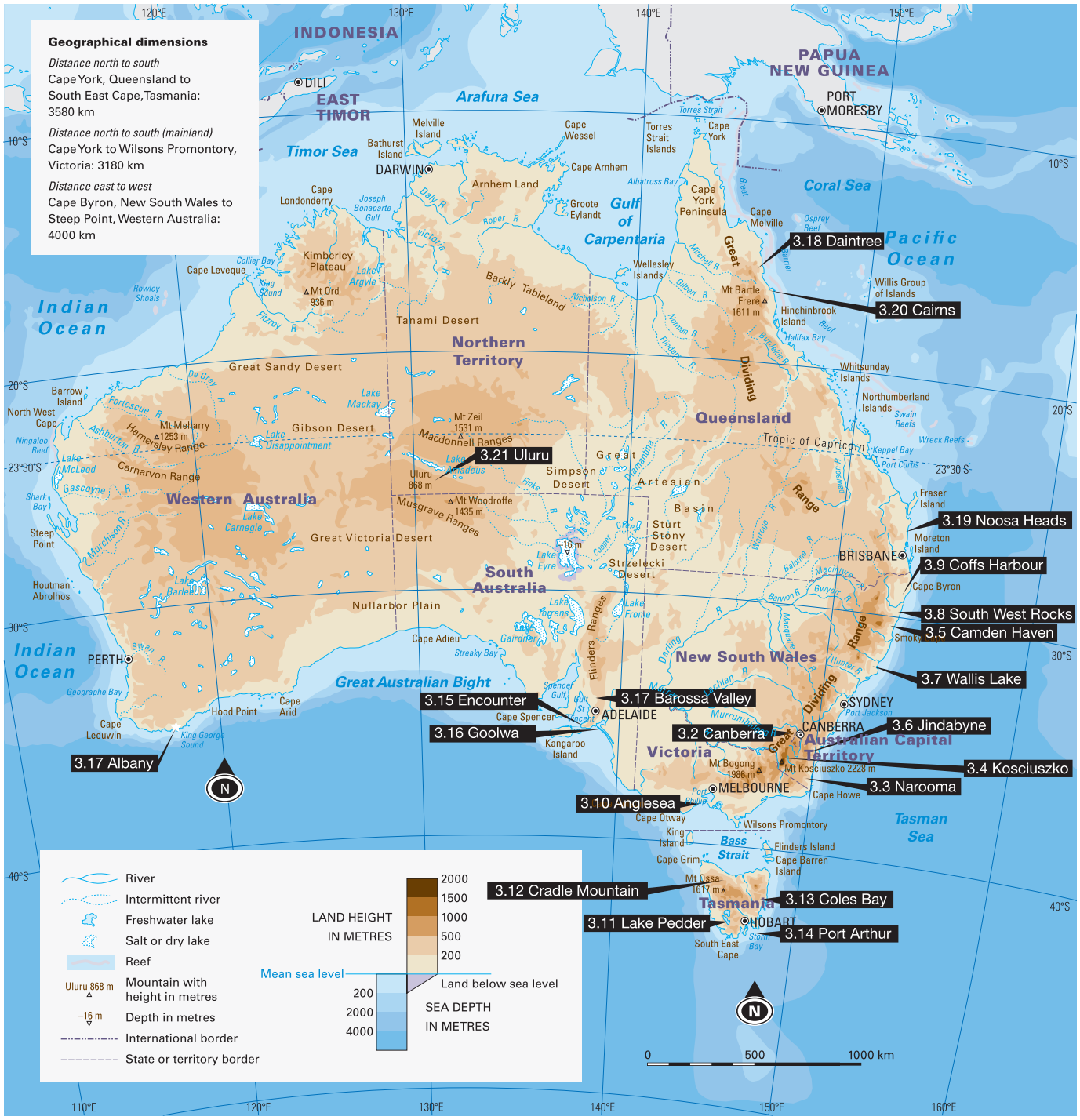

Figure 3.1a Map of Australia

ACTIVITIES

1 Name the strait separating:
- a mainland Australia from Tasmania
- b Cape York Peninsula from Papua New Guinea.

2 Name the oceans to the west and east of the continent.

3 Name the sea in which the Great Barrier Reef is located.

4 In which state or territory would you find the following landform feature?
- a Macdonnell Ranges
- b Musgrave Ranges
- c Flinders Ranges
- d Gibson Desert

5 Identify the highest peak in each state and territory.

6 Which is Australia's most southerly mainland capital city?

7 Which is Australia's most easterly capital city?

8 What is the direction of:
- a Adelaide from Melbourne
- b Hobart from Sydney?

9 What is the straight-line distance between:
- a Adelaide and Darwin
- b Perth and Brisbane?

10 Name the island located at:
- a lat. 39°52'S long. 143°45'E
- b lat. 34°45'S long. 137°00'E
- c lat. 25°30'S long. 153°00'E.

11 Name the landform feature located at:
- a lat. 17°20'S long. 145°45'E
- b lat. 25°21'S long. 131°02'E
- c lat. 28°15'S long. 138°08'E
- d lat. 36°27'S long. 148°16'E.

12 Locate the following places on the physical map of Australia.
- a Cape Byron: the mainland's most easterly point
- b Steep Point: the continent's most westerly point
- c Cape York Peninsula: the mainland's most northerly point
- d Wilsons Promontory: the mainland's most southerly point
- e South East Cape: Tasmania's most southerly point.

13 Name a river that drains the Arnhem Land Plateau in the Northern Territory.

14 Name the river that flows into Western Australia's Shark Bay.

15 Name the river that separates New South Wales from Victoria.

16 Name the gulf on which Adelaide is located.

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3.2 Canberra (ACT) topographic map extract

Canberra is Australia's capital city and, with a population of 431 000 people, is the country's largest inland urban centre and the eighth-largest overall. The site of Canberra was selected for the location of the nation's capital in 1908 as a compromise between rivals Sydney and Melbourne, Australia's two largest cities. It is unusual among Australian cities, being an entirely planned city. Following an international contest for the city's design, a blueprint by American architect Walter Burley Griffin was selected. Construction commenced in 1913.

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.2a and the map extract. Identify the features labelled 1 to 12.

4 Identify the feature of the biophysical environment located at:
- a GR 985985
- b GR 848834
- c GR 860790
- d GR 878951.

5 Identify the feature of the constructed environment located at:
- a GR 904983
- b GR 948918
- c GR 883918
- d GR 912974.

6 Give the grid reference of five recreational activities found on the map extract.

7 What river has been dammed to form Lake Burley Griffin?

8 What type of vegetation is found in AR 8489?

9 What type of land use is found at GR 893937?

10 Identify the feature of the built environment located 5.2 km to the south-west of the summit of Mount Ainslie (GR 964949).

11 What is the direction of Black Mountain (GR 908946) from Parliament House (AR 9390)?

12 What is the aspect of the slope in AR 9193?

13 What is the bearing of Parliament House from the Australian War Memorial (AR 9593)?

14 What is the length of the north–south runway at Fairbairn Airport?

15 What is the straight-line distance between Parliament House and the Australian War Memorial?

16 Estimate the distance by road from the showground (GR 956994) to Parliament House.

17 Calculate the time it would take to travel from the showground to Parliament House at an average speed of 60 km/h.

18 Estimate the density of buildings in AR 9880.

19 What is the height of the landform feature at GR 994033?

20 Estimate the height of the landform feature at GR 979034.

21 What is the difference in elevation between Black Mountain and Mount Ainslie?

22 What is the difference in elevation of Mount Majura (GR 984984) and Mount Arawang (GR 859844)?

23 What is the local relief in AR 9678?

24 Is Red Hill (AR 9288) visible from the summit of Mount Ainslie?

25 Is Majura (AR 9994) visible from the summit of Black Mountain?

26 Calculate the gradient of the slope between GR 965785 and GR 968795.

27 What evidence is there that Canberra is a planned city?

28 Undertake library research. When was Canberra founded? Outline the process involved in the selection of the site. Who was Walter Burley Griffin? What role did he play in the development of Canberra?

29 Working in groups, brainstorm the advantages and disadvantages of living in a planned city such as Canberra. Share your group's findings with the rest of the class.

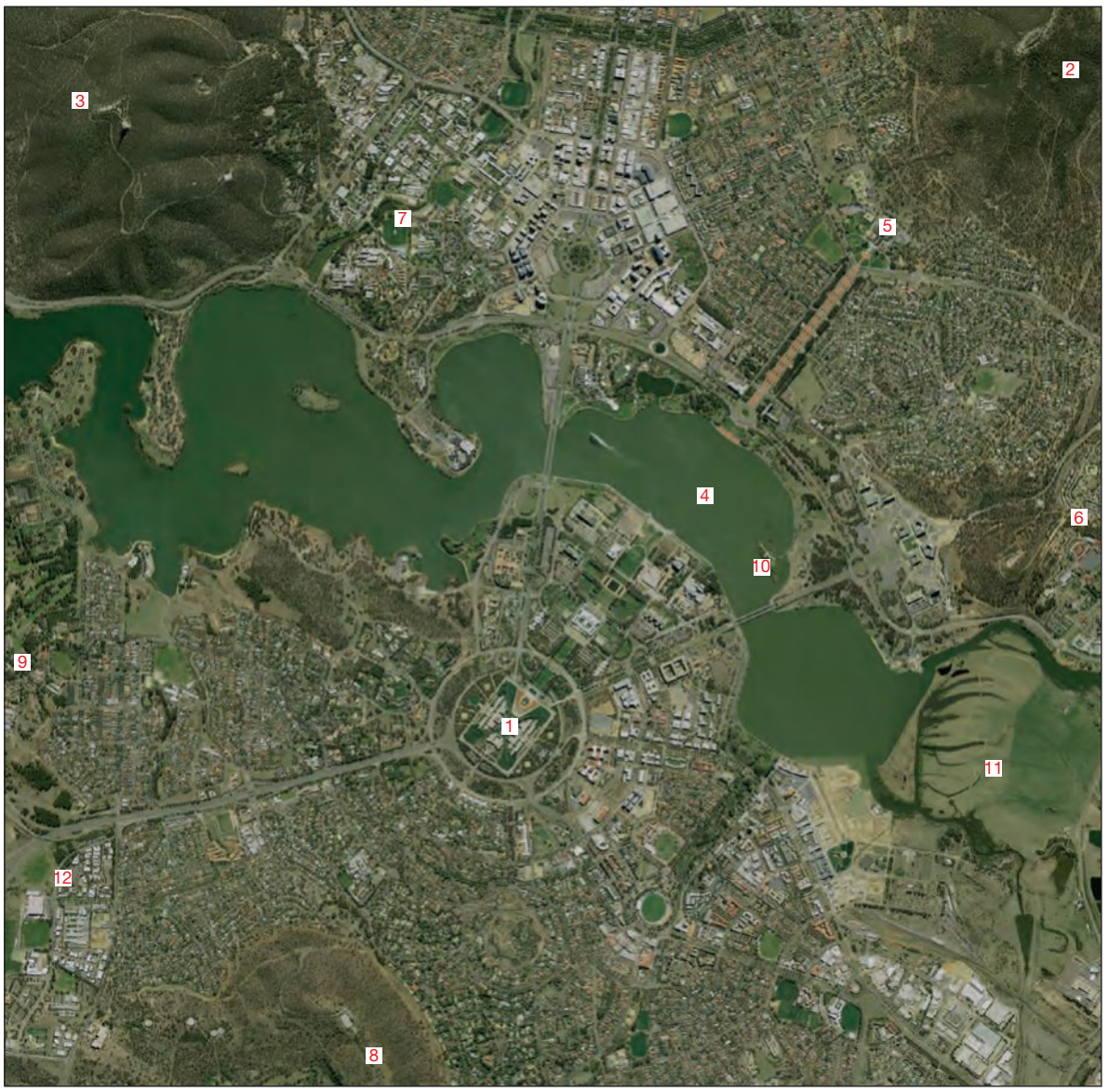
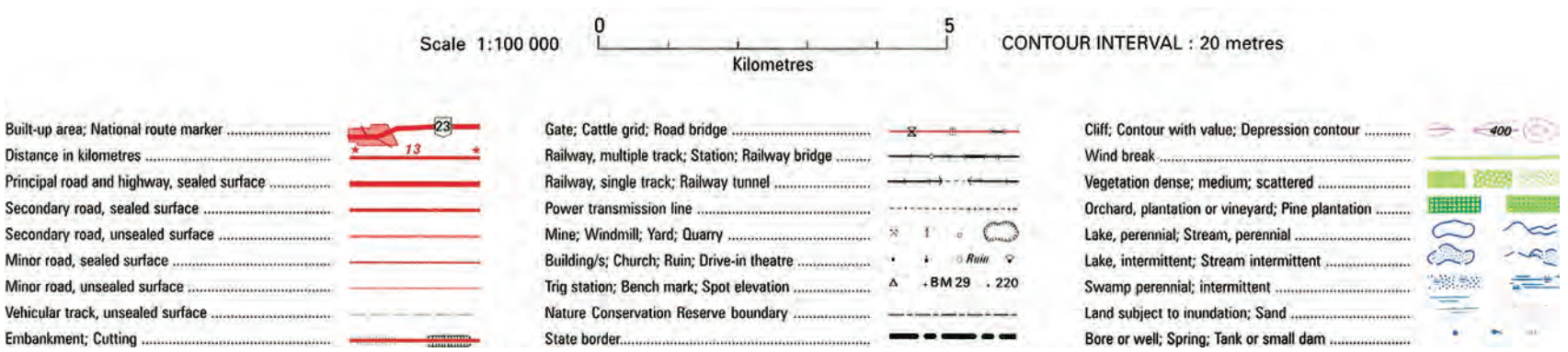
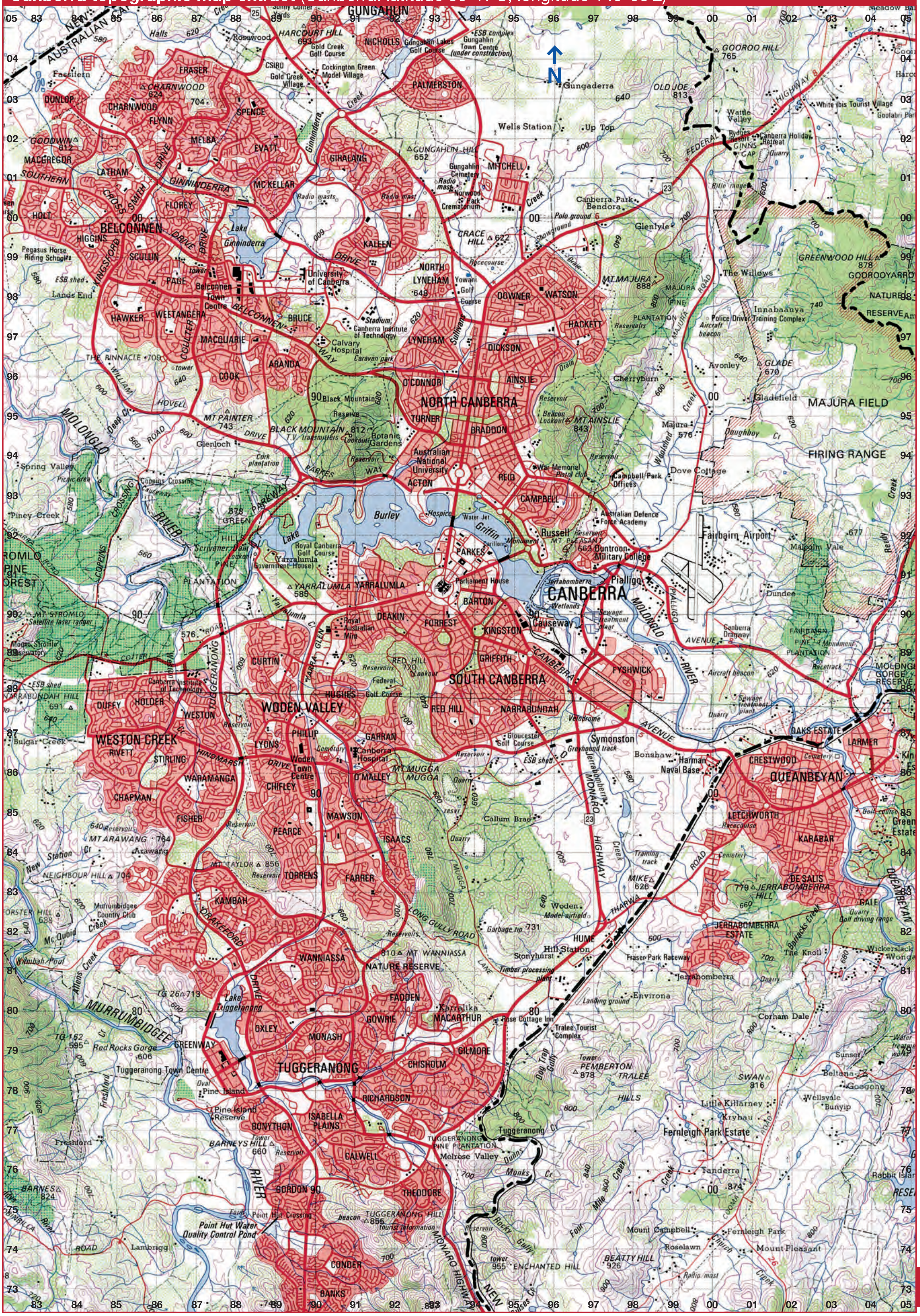


Figure 3.2a Aerial photograph of central Canberra



ISBN 978-1-009-07583-1

Canberra topographic map extract (Canberra: latitude 35°17′S, longitude 149°08′E)



ISBN 978-1-009-07583-1 Grant Kleeman

3.3 Narooma (NSW) topographic map extract

Figure 3.3a Oblique aerial photograph of Narooma, NSW, Australia

Figure 3.3b Firefighters at the Currowan fire

Narooma is a popular tourist destination on the far south coast of New South Wales. The name Narooma is believed to be derived from the Aboriginal word meaning 'clear blue waters'. The town has a population of just over 3300 people.

Black Summer Bushfires (2019–20)

One of the biggest blazes of the Australian Black Summer Bushfires was the Currowan fire on the South Coast of NSW. The fire started at Currowan (less than an hour by car to the north-east of Narooma) on 26 November 2019. Over the next 74 days, it blackened almost 500 000 hectares of forest and grassland, destroyed 312 homes and damaged another 173. Three people died, and countless animals were killed or displaced. The Currowan fire was one of the biggest in recorded Australian history.

The fire was ignited by a lightning strike somewhere in the rugged terrain of the Currowan State Forest. Fanned by a west-north-westerly, the fire spread rapidly.

A decade of dry conditions, and two years of intense drought, had sapped moisture from the land and greatly increased the amount of fuel available to burn. Trees, stressed by drought, had dropped large amounts of leaves.

A combination of strong winds, low humidity, dry soil and high temperatures pushed the Currowan fire from its point of ignition northwards to the Southern Highlands in less than six weeks. On the worst days, the fire advanced 12–15 kilometres. It also spread to the east and south-east as the wind direction changed.

A week after the fire had begun, it started to approach coastal towns. Evacuation centres opened in Ulladulla and Batemans Bay, at that time considered to be relatively safe.

The region's distinctive escarpment and its hilly terrain, combined with strong winds, made the fires behave unpredictably. Spot fires, often many kilometres ahead of the fire front, made the situation even more hazardous.

Those living in coastal communities prepared for ember attacks and watched the sky go black in the afternoon. Bushfire-generated storms added to the sense of doom.

The storms were generated when columns of heat rose with smoke, and once they rose more than 15–16 kilometres high, they formed a thunderhead that produced lightning storms. Once the system collapsed, it sent the wind in a 360-degree direction, making fires behave erratically on the ground and throwing spot fires kilometres ahead of the fire front.

As conditions worsened, authorities ordered the mass exodus of holidaymakers from the South Coast. The Princes Highway was soon clogged with traffic. The congestion lasted for hours.

After 74 days, rainfall finally extinguished the Currowan blaze.

Cultural burning

In the months after the Black Summer fires, attention turned to how the Australian environment could be managed better so that such catastrophic events are avoided in the futures, especially as the world's climate warms. Many fire experts argued that there is much we can learn from how Aboriginal and Torres Strait Islander peoples managed the land over the many thousands of years they have lived here.

They have used culturally prescribed land-management practices – including fire – to care for Country. This is called 'cultural burning', and the knowledge of how to practise it has been passed down from generation to generation, with the elders of the group instructing the young.

Cultural burning involves the use of 'cool' or low-intensity fire to reduce the risk of extreme fire events that result in the burning of whole trees and forest canopies. Protecting the canopy is an important aim of cultural burning because it supports many of the resources important to Aboriginal and Torres Strait Islander peoples – including insects, birds' nests and shade. The loss of the canopy fundamentally alters the surrounding ecosystem – sunlight breaks through and dries out the soil. Cultural burning also serves other purposes, such as keeping waterways clear and protecting sacred parts of the landscape.

ACTIVITIES

When completing these activities, refer to the legend on page 82.

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.3a. Name the features numbered 1–6 on the photograph.

4 In what direction was the camera facing when the photograph was taken?

5 Identify the feature of the biophysical environment located at:
- a GR 407877
- b GR 422899
- c GR 391885
- d GR 422885.

6 Identify the feature of the constructed environment located at:
- a GR 429880
- b GR 418880
- c GR 413890
- d GR 401914.

7 What is the area reference of Kianga Lake?

8 Name the type of biophysical feature found in AR 4286.

9 Name the type of land use found in AR 4188.

10 Name the type of vegetation found in AR 4191.

11 On what waterway is Narooma located? How might such a feature be formed?

12 What waterway flows into Kianga Lake at GR 413911?

13 What is the direction of Kianga Point (AR 8289) from Lavender Point (AR 4088)?

14 In what direction is Kianga Creek flowing in AR 3891?

15 What is the bearing of Shell Point (AR 4087) from Bar Rock Lookout (AR 4288)?

16 What is the bearing of the lighthouse/beacon (GR 424889) from Kianga Point (AR 4289)?

17 What is the approximate length of Bar Beach (AR 4289)?

18 What is the general aspect of the slope on which the park has been developed in AR 4189?

19 What is the approximate area of Kianga (AR 4190)?

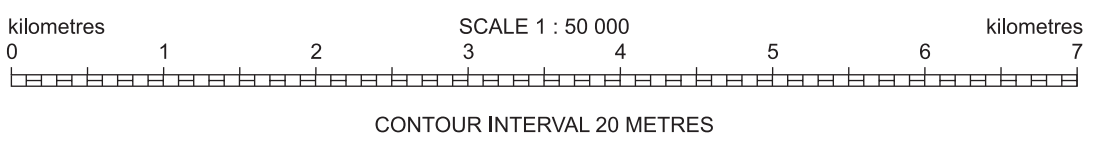
20 What is the density of buildings in AR 4087?

21 What is the height of the hill at GR 403919?

22 What is the elevation of the surface of the small lake at GR 432864?

23 Explain why the Currowan fire developed into such a devastating bushfire.

24 Explain what 'cultural burning' is. How does it reduce the likelihood of extreme fire events?



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Grant Kleeman

Narooma topographic map extract (Narooma: latitude 36°13’S, longitude 150°07'E)

ISBN 978-1-009-07583-1

Grant Kleeman

3.4 Kosciuszko (NSW) topographic map extract

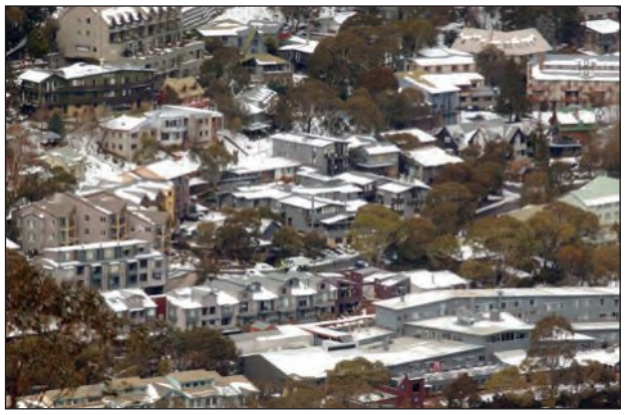
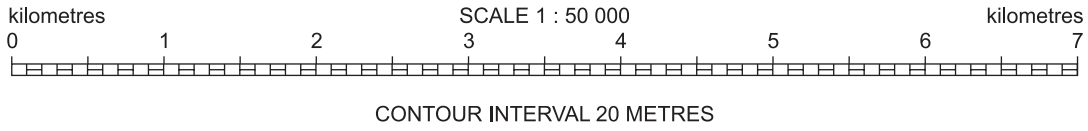


Figure 3.4a Oblique aerial photograph of Thredbo, New South Wales

Thredbo is a village and ski resort in the Snowy Mountains of New South Wales. It is about 500 km south of Sydney. Thredbo has the longest ski runs in Australia, and this attracts around 700 000 winter visitors annually. In summer, Thredbo is a hiking and summer sport destination. Mountain bike riding is an increasingly popular recreational activity. Work on developing the resort commenced in 1957.

Thredbo is the traditional name for this place, and is written on maps as early as 1840. It has been seasonally occupied by at least four main communities of Aboriginal people for thousands of years. Archaeological evidence goes back at least 8700 years.



ACTIVITIES

When completing these activities refer to the legend on page 82.

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 253668
- b GR 157692
- c GR 275687
- d GR 250715.

4 Identify the feature of the constructed environment located at:
- a GR 214712
- b GR 280710
- c GR 148652
- d GR 196648.

5 What type of land use is found in AR 1659?

6 What is the grid reference of the following landform features?
- a Mount Twynam
- b Mount Kosciuszko
- c Lake Otapatamba
- d Mount Perisher

7 Name the tributary that joins the Snowy River at GR 158645.

8 What is the direction of Blue Lake (AR 1770) from the summit of Mount Kosciuszko (AR 1364)?

9 In which direction does the Snowy River flow in AR 1968?

10 What is the feature of the physical environment located 1 km to the south of Mount Kosciuszko?

11 What is the aspect of the slope in AR 2263?

12 What is the bearing of Mount Clarke (AR 1567) from Mount Kosciuszko?

13 What is the straight-line distance between the summit of Mount Kosciuszko and Mount Townsend (GR 1268)?

14 What is the length of the walk from GR 151605 to the summit of Mount Kosciuszko via the walking trail and road?

15 Estimate the area of Blue Lake.

16 What is the height of Mount Kosciuszko?

17 Estimate the height of the following landform features:
- a Mount Clarke (AR 1567)
- b Mount Perisher (AR 2469)
- c Porcupine Rocks (GR 252670).

18 What is the difference in elevation between Mount Kosciuszko and Mount Townsend?

19 Can Mount Clarke (AR 1567) be seen from the summit of Mount Guthrie (AR 1967)?

20 Calculate the average gradient of Lubra Creek from its source at GR 272677 to where it enters the Thredbo River (GR 271655).

21 Construct the cross-section from Duncan geodetic station (GR 257676) to the peak at GR 255635.

22 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 21.

23 Undertake library research. Investigate how alpine lakes, such as Blue Lake, are formed.

24 Working in groups, identify possible sources of environmental damage in the fragile alpine ecosystem of the Snowy Mountains area. Share the points raised in your group's discussion with the rest of your class. Brainstorm ways in which the impact of people could be minimised.

25 Use Tables 3.4a and 3.4b to construct the climate graphs for Thredbo Village and Crackenback Station. These two stations have a horizontal separation of just 2.2 km. Account for the difference in climate experienced.

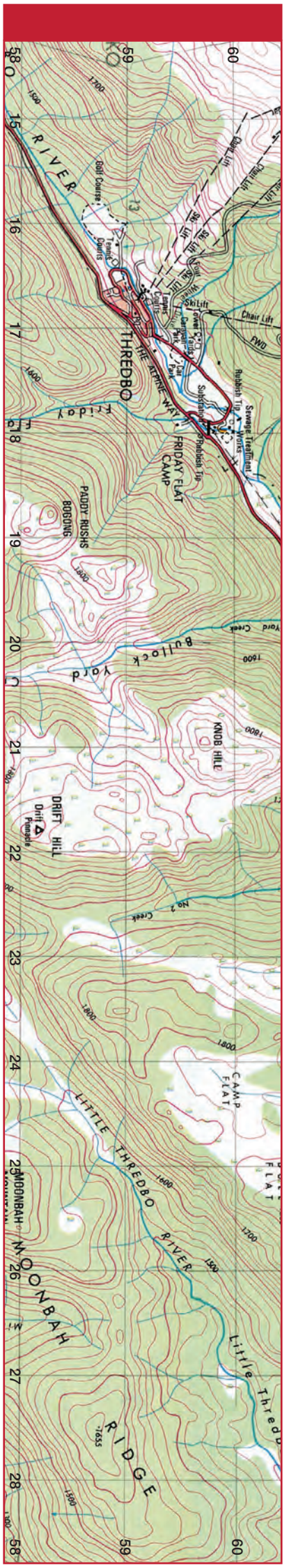


Table 3.4a Climate data for Thredbo (Village), elevation 1380 m, latitude 36°51′S, longitude 148°30′E

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean min. temp. (°C)	6.5	6.7	4.3	1.7	–0.5	–2.9	–3.9	–2.4	–0.8	1.3	3.2	5.1	2.0
Mean max. temp. (°C)	20.7	20.6	18.0	13.7	10.0	6.3	5.1	6.2	9.5	13.0	15.7	18.8	14.0
Mean rainfall (mm)	115.6	84.2	113.4	119.3	172.4	160.1	161.3	185.6	207.7	207.4	158.6	119.1	1804.6

Table 3.4b Climate data for Thredbo (Crackenback Station), elevation 1957 m, latitude 36°49′S, longitude 148°29′E

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean min. temp. (°C)	6.0	7.1	5.2	1.7	–1.6	–3.6	–5.5	–5.0	–3.5	–0.5	1.5	4.7	–0.4
Mean max. temp. (°C)	15.4	16.4	13.5	9.3	4.6	2.0	0.1	0.4	2.8	7.2	10.3	14.0	6.9
Mean rainfall (mm)	103.0	91.9	124.1	118.3	141.2	85.8	130.2	134.0	150.8	168.3	162.4	111.1	1521.0

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Grant Kleeman

Kosciuszko topographic map extract (Thredbo: latitude 36°51′S, longitude 148°30′E)

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Grant Kleeman

3.5 Camden Haven (NSW) topographic map extract

Camden Haven is located 30 km south of Port Macquarie. The area's principal settlement (Laurieton) is located where the Camden Haven River enters the Tasman Sea.

North Brother Mountain dominates the landscape. Another landform of note is the delta of Camden Haven River at the point at which it enters Watson Taylors Lake.

The Birpai (also known as Birrbay) people have lived in the area for more than 40 000 years.

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 855991
- b GR 685877
- c GR 847087
- d GR 785940.

4 Identify the feature of the constructed environment located at:
- a GR 709021
- b GR 827082
- c GR 843043
- d GR 842052.

5 What creek flows into the sea at GR 865092?

6 What type of vegetation is found at AR 8408?

7 What type of vegetation is found in AR 7486?

8 What type of land use is found in AR 7608?

9 Name the type of biophysical feature found in GR 835985.

10 Identify the feature of the biophysical environment located 14 km to the north-east of South Brother Mountain (AR 6887).

11 What is the direction of Kew (AR 7399) from Lake Cathie township (AR 8609)?

12 In what direction does Herons Creek flow in AR 7503?

13 Is the mouth of the Camden Haven River visible from the summit of Middle Brother Mountain (GR 695924)?

14 What is the settlement pattern found in AR 7499?

15 What is the aspect of the slope in AR 7996?

16 What is the bearing of South Brother Mountain (GR 685877) from North Brother Mountain (GR 790971)?

17 Estimate the straight-line distance between Diamond Head trig station (GR 811899) and Camden Head trig station (GR 848984).

18 Estimate the distance by road from Kew (GR 738999) to the bridge at GR 714905.

19 Calculate the time it would take to travel from Kew (GR 738999) to the bridge at GR 714903 at an average speed of 60 km/h.

20 Estimate the area of Queens Lake.

21 What is the density of buildings in AR 7599?

22 Estimate the height of the landform feature at GR 774028.

23 What is the difference in elevation of North Brother Mountain (GR 790971) and South Brother Mountain (GR 685877)?

24 Estimate the local relief experienced on a traverse from GR 736951 to GR 790971.

25 Estimate the local relief in AR 8189.

26 Calculate the gradient of the slope between GR 790971 and GR 790954.

27 Undertake research. Identify the type of delta formed by the Camden Haven River. Explain how deltas such as this develop.

28 The section of coast shown on the map extract is dominated by depositional landform features. What evidence is there to support this view?

29 Write a report describing how landform has affected the area's drainage pattern and its settlement and communications patterns.

30 What types of functions would be provided by a settlement such as Kew? How may these be different from those offered by Laurieton (GR 805980)?

You be the judge

A group of developers wishes to convert Gogleys Lagoon into a canal estate and resort complex. The canal estate will have 300 building sites with water frontages. The resort will include a 110-room hotel, a marina and a retail complex housing shops and restaurants. When completed, the resort will create 160 permanent jobs. Local environment groups have objected to the development on the grounds that it will destroy the environmentally sensitive lagoon ecosystem. The pro-development council has approved the development. Those opposed to the development have gone to the Land and Environment Court in an effort to have the development stopped. You are the judge of the Land and Environment Court. Will you allow the development to go ahead?

Figure 3.5a A sample of community views

ACTIVITIES

Read each of the statements made by members of the Laurieton community and then complete the following tasks:

1 List the statements that are in favour of building the resort and its facilities. Make a separate list of the statements that are not in favour of the development going ahead.

2 Which set of views do you agree with?

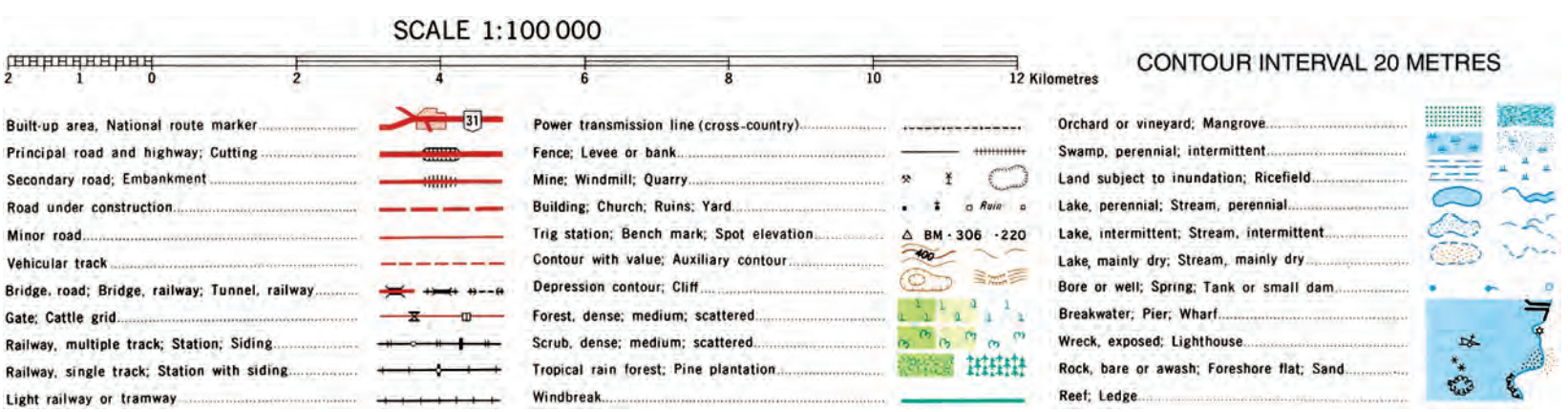
3 In small groups of four or five students, discuss the different views about the proposed development. Study the map extract and evaluate the suitability of the site. Reach agreement on what you think should happen. Be prepared to defend your group's point of view when you report back to the class.

4 Examine both sides. Have the people on each side of the discussion in Activity 3 present the case for the other side, using exact arguments.

5 Discuss in class the statement: 'The resort should go ahead'.

6 At the end of the debate, conduct a secret ballot to determine whether the class will recommend that the resort should go ahead.

7 Write an exposition outlining the arguments you would use to justify your point of view on the issue.



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Grant Kleeman

Camden Haven topographic map extract (Laurieton: latitude 31°65′S, longitude 152°80′E)

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Grant Kleeman

3.6 Jindabyne (NSW) topographic map extract

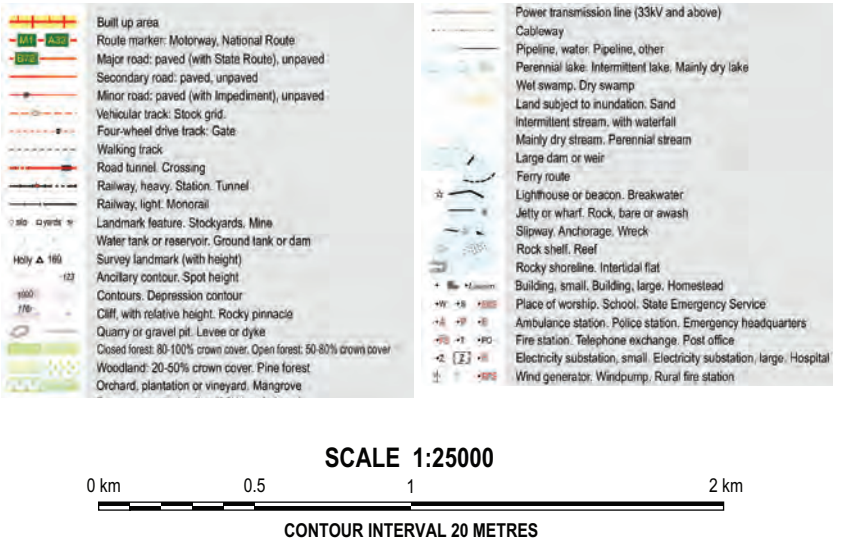
Jindabyne (population 2 600) is located on the shores of Lake Jindabyne just to the east of the Snowy Mountains. The town is a popular year-round holiday destination, especially in winter. It is close to some of Australia's ski resorts found within the Kosciuszko National Park. These include Thredbo, Perisher and Charlotte Pass.

Originally located on land now submerged under Lake Jindabyne, the township was relocated to its present location in the 1960s in conjunction with the construction of the Jindabyne Dam on the Snowy River.

Figure 3.6a Lake Jindabyne with Jindabyne township in the foreground

Figure 3.6b Oblique aerial photograph of Jindabyne

Figure 3.6c Oblique aerial photograph of Jindabyne dam



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- **a** GR 446696
- **b** GR 458677
- **c** GR 448714
- **d** GR 435693.

4 Identify the feature of the constructed environment located at:
- **a** GR 464665
- **b** GR 432693
- **c** GR 454674
- **d** GR 448685.

5 What is the area reference of:
- **a** Jindabyne Dam
- **b** Jindabyne Airport?

6 Name the type of land use found in AR 4566.

7 Name the type of vegetation found in AR 4765.

8 Identify the recreational facilities found in AR 4467.

9 What creek flows into Lake Jindabyne at GR 432692?

10 Study Figures 3.6a, 3.6b and 3.6c. In what direction was the camera facing when each photograph was taken?

11 In what direction is the Snowy River flowing in AR 4665?

12 In what direction is Mill Creek flowing in AR 4767?

13 What is the bearing of the survey marker (GR 470684) from the survey marker on Lions Island (AR 4469)?

14 What is the bearing of the Jindabyne Mini Hydro Power Station (AR 4666) from the survey marker at GR 470684?

15 What is the length of the NW–SE runway at Jindabyne Airport?

16 What is the length of the Jindabyne Dam wall?

17 What is the aspect of the slope in AR 4668?

18 What is the area of Jindabyne township?

19 What is the density of buildings in AR 4565?

20 What is the difference in elevation of survey markers in AR 4469 and AR 4766?

21 What is the elevation of the surface of Lake Jindabyne?

22 Construct the cross-section from point A to point B. Use a vertical scale of 1 cm = 20 m.

23 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 22.

24 What is the gradient of the slope between points A and C?

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Jindabyne topographic map extract (Jindabyne: latitude 36°25'S, longitude 148°37'E)

ISBN 978-1-009-07583-1

Grant Kleeman

3.7 Wallis Lake (NSW) topographic map extract

Wallis Lake, together with the adjacent Myall Lake system, developed behind a sand-based barrier system. The twin towns of Forster and Tuncurry have developed at the mouth of the Coolongolook River. The waterways surrounding Wallis Lake are well known for oyster production.

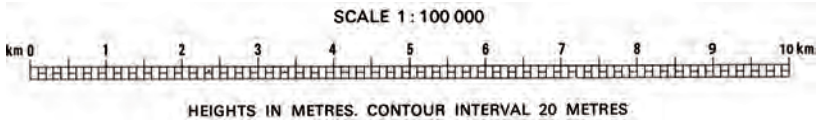

Figure 3.7a Oblique aerial photograph of Forster-Tuncurry

Figure 3.7b Satellite photograph of the Wallis and Myall Lake complex, Google Earth, Data SIO, NOAA, US Navy, NGA, GEBCO, © 2016 Google, Image © 2016 CNES / Astrium, Image © 2016 DigitalGlobe

ACTIVITIES

When completing these activities, refer to the legend on page 82.

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.7b and the map extract. Identify the features labelled 1 to 8.

4 Identify the feature of the biophysical environment located at:
- a GR 564146
- b GR 557193
- c GR 558186
- d GR 534244.

5 Identify the feature of the constructed environment located at:
- a GR 537397
- b GR 588353
- c GR 510368
- d GR 531160.

6 Which two rivers meet at GR 430380?

7 What type of vegetation dominates in AR 5124?

8 What type of land use is found in AR 5214?

9 What type of road links Seal Rocks (AR 5610) to the main road at Bungwhal (AR 4716)?

10 Name the biophysical feature centred on GR 547156.

11 What is the direction of Seal Rocks (AR 5610) from Forster (AR 5538)?

12 In which direction is the Wallingat River flowing in AR 4232?

13 Identify the feature of the biophysical environment located 9.8 km to the north-west of Seal Rocks lighthouse (AR 5610).

14 What is the aspect of the slope in AR 5524?

15 What is the bearing of Cape Hawke Lookout (AR 5835) from Forster light-house (AR 5339)?

16 What is the length of the bridge linking Forster (AR 5538) to Tuncurry?

17 Estimate the distance by road from GR 536393 to Elizabeth Beach (GR 556226).

18 Calculate the time it would take to travel from GR 536393 to Elizabeth Beach (GR 556226) at an average speed of 60 km/h.

19 Estimate the area of Wallis Island's Nature Reserve.

20 Study Figure 3.7a. In what direction was the camera pointing when the photograph was taken?

21 What is the height of the landform feature at GR 445263?

22 What is the difference in elevation of Booti Hill (AR 5524) and Yaric (AR 5519)?

23 Estimate the local relief experienced on a traverse from GR 461300 to GR 480336.

24 Estimate the local relief in AR 5519.

25 Calculate the gradient of the slope between Yaric (GR 556193) and GR 562200.

26 Identify the settlement pattern in AR 5620.

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Wallis Lake topographic map extract (Forster: latitude 32°10′S, longitude 152°30′E)

ISBN 978-1-009-07583-1

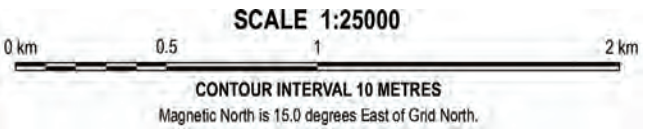
Grant Kleeman

3.8 South West Rocks (NSW) topographic map extract

Figure 3.8a Satellite photograph of South West Rocks, Google Earth, Data SIO, NOAA, US Navy, NGA, GEBCO, © 2016 Google, Image © 2016 CNES / Astrium, Image © 2016 DigitalGlobe

South West Rocks is located on the Mid North Coast of NSW, near the mouth of the Macleay River.

The region's spectacular beaches make the town a popular summer holiday destination.



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.8a and the map extract. Identify the features numbered 1–8.

4 Identify the feature of the biophysical environment located at:
- a GR 086803
- b GR 060817
- c GR 083789
- d GR 069796.

5 Identify the feature of the constructed environment located at:
- a GR 045822
- b GR 048802
- c GR 056804
- d GR 046817.

6 What is the area reference of Little Smoky?

7 Name the type of vegetation found at GR 052802.

8 What tributary joins the Macleay River in AR 0181?

9 What creek flows into Trial Bay in AR 0383?

10 What is the direction of Big Smoky (AR 0679) from South West Rocks?

11 In what direction is Spencers Creek flowing in AR 0280?

12 What is the bearing of Big Smoky (AR 0679) from the summit of Little Smoky (AR 0781)?

13 What is the straight-line distance between the summit of Big Smoky (AR 0679) and the summit of Little Smoky (AR 0781)?

14 What is the aspect of the slope in AR 0782?

15 What is the area of Saltwater Lake?

16 What is the density of buildings in AR 0379?

17 What is the height of Little Smoky (AR 0781)?

18 What is the difference in elevation of Little Smoky (AR 0781) and Big Smoky (AR 0679)?

19 What is the elevation of the surface of the small lake at GR 076806?

20 Estimate the local relief experienced on a traverse from the summit of Big Smoky (AR 0679) to the summit of the small hill at GR 051791.

21 Construct the cross-section from GR 051791 to the summit of Big Smoky. Use a vertical scale of 1 cm = 50 m.

22 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 21.

23 What is the gradient of the slope between the summit of Big Smoky and the shoreline at GR 083796?

24 Describe the site of South West Rocks.

ISBN 978-1-009-07583-1

South West Rocks topographic map extract (South West Rocks: latitude 30°88′S, longitude 153°04′E)

ISBN 978-1-009-07583-1

3.9 Coffs Harbour (NSW) topographic map extract

Figure 3.9a Oblique aerial photograph of Coffs Harbour, Google Earth, Data SIO, NOAA, US Navy, NGA, GEBCO, © 2016 Google, Image © 2016 CNES / Astrium, Image © 2016 DigitalGlobe

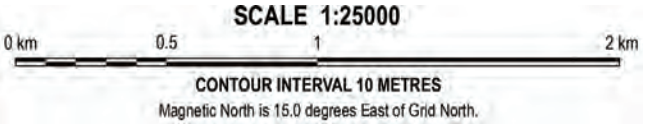
Coffs Harbour is located on the Mid North Coast of New South Wales about 540 km to the north of Sydney. With a population of over 70 000 it is one of the largest urban centres in the North Coast region.

Coffs Harbour's economy once depended on bananas. The growing of blueberries, tourism and fishing are now the most important industries. It is also a popular destination for retirees and those seeking a more relaxed lifestyle.

Coastal resorts and commercial centres surround the area, which is dominated by mountains, covered in forest and banana plantations.

Coffs Harbour is the only place in New South Wales where the Great Dividing Range meets the Pacific Ocean.

Figure 3.9b Satellite photograph of Coffs Harbour, Google Earth, Data SIO, NOAA, US Navy, NGA, GEBCO, © 2016 Google, Image © 2016 CNES / Astrium, Image © 2016 DigitalGlobe



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 142513
- b GR 142503
- c GR 138485
- d GR 123455.

4 Identify the feature of the constructed environment located at:
- a GR 127498
- b GR 112452
- c GR 099499
- d GR 116485.

5 What is the area reference of the Coffs Harbour Jetty?

6 Study Figure 3.9a and the map extract. Identify the features numbered 1–5.

7 Study Figure 3.9a. In what direction was the camera pointing when the photograph was taken?

8 Study Figure 3.9b and the map extract. Identify the features numbered 1–5.

9 Name the type of biophysical feature found in AR 1447.

10 Name the type of land use centred on GR 100450.

11 Name the type of vegetation found in AR 1151.

12 On what waterway is Coffs Harbour located?

13 What is the direction of Little Muttonbird Island from Muttonbird Island?

14 In what direction is Coffs Creek flowing in AR 1248?

15 What is the distance by road at GR 094451 to the railway overpass at GR 128488?

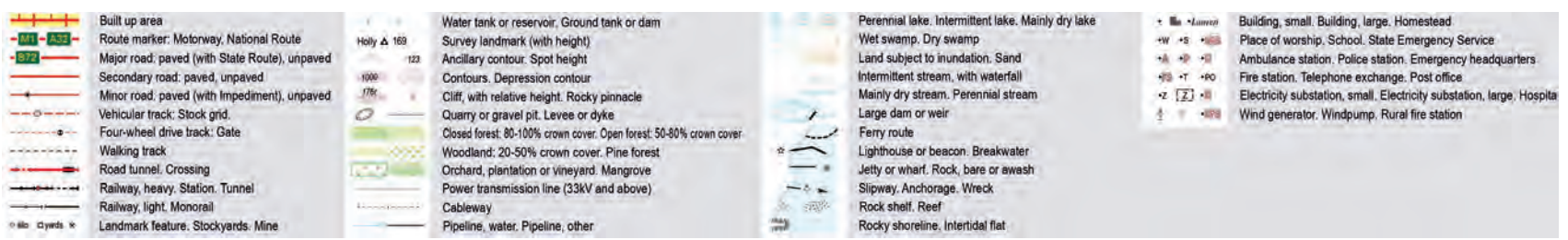
16 What is the length of the Coffs Harbour Airport runway?

17 What is the length of the Corambirra Point breakwater?

18 What is the aspect of the slope in AR 1112?

19 What is the area of the Coffs Harbour?

20 What is the elevation of Muttonbird Island (AR 1447)?



ISBN 978-1-009-07583-1

Coffs Harbour topographic map extract (Coffs Harbour: latitude 30°18′S, longitude 153°8′E)

ISBN 978-1-009-07583-1

Grant Kleeman

3.10 Anglesea (VIC) topographic map extract

Anglesea is a coastal community located on the Great Ocean Road in Victoria. The American-owned Alcoa corporation operated a power station and open-cut coalmine on the outskirts of the town until late 2015. The town is a popular summer holiday destination for people living in Melbourne and regional Victoria.

Figure 3.10b Satellite photograph of the area covered by the Anglesea topographic map extract, Google Earth, Data SIO, NOAA, US Navy, NGA, GEBCO, © 2016 Google, Image © 2016 CNES / Astrium, Image © 2016 DigitalGlobe

Video 3.10a
Aerial footage of Spit Point lighthouse (**00:20**)

Figure 3.10a Oblique aerial photograph of Anglesea, Victoria

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.10a and the map extract. In what direction was the camera pointing when the photograph was taken?

4 Study Figure 3.10b and the map extract. Identify the features numbered 1–6.

5 Identify the feature of the biophysical environment located at:
- **a** GR 470434
- **b** GR 543428
- **c** GR 518448
- **d** GR 462434.

6 Identify the feature of the constructed environment located at:
- **a** GR 474383
- **b** GR 455492
- **c** GR 556463
- **d** GR 500508.

7 What is the area reference of Eagle Nest Reef?

8 Name the type of land use found in AR 5346.

9 Name the type of vegetation found in AR 4842.

10 On what waterway is Anglesea located?

11 What is the direction of Point Roadknight (AR 5442) from the Point Light Station (AR 4738)?

12 In what general direction is Painkalac Creek flowing in AR 4639?

13 Name the drainage pattern evident on the Anglesea topographic map extract.

14 What is the bearing of Point Light Station (AR 4738) from Point Roadknight (GR 5442)?

15 What is the straight-line distance between the summit of Mount Ingoldsby (AR 5144) and Point Light Station (AR 4738)?

16 What is the distance by road from the intersection at GR 471386 to the intersection at GR 535438?

17 What is the aspect of the slope in AR 4942?

18 What is the area of the built-up area in Aireys Inlet and Fairhaven?

19 What is the height of the hill at:
- **a** GR 483443?
- **b** GR 467467?

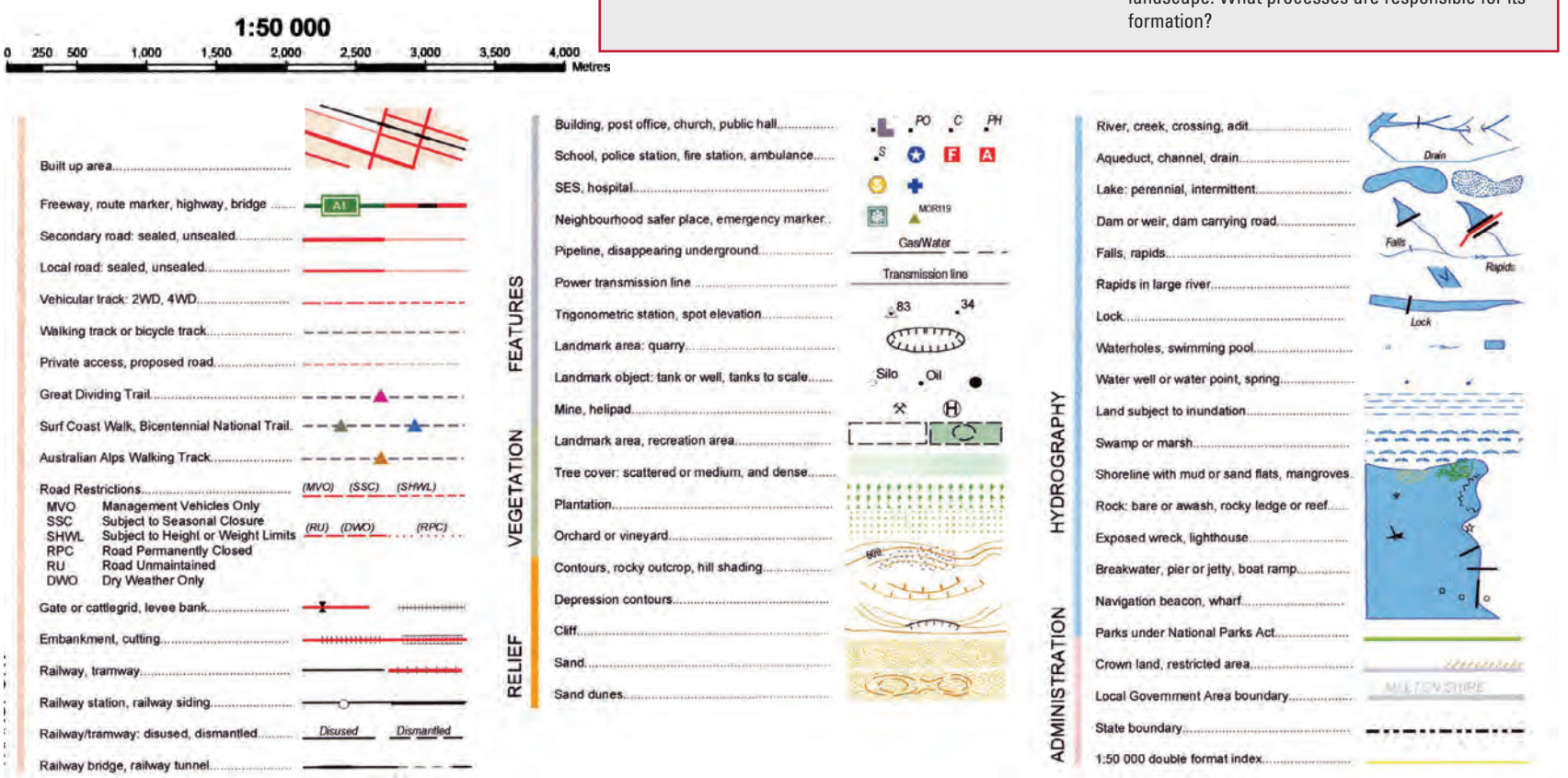
20 What is the elevation of the marsh/swamp in AR 4646?

21 Estimate the local relief experienced on a traverse from the spot height in AR 4745 to the summit of the hill at GR 467468.

22 What is the gradient of the slope between the spot height in AR 4942 and the shoreline at GR 497420?

23 Identify the likely recreational activities available in the area covered by the map extract.

24 Study Video 3.10a and describe Anglesea's coastal landscape. What processes are responsible for its formation?



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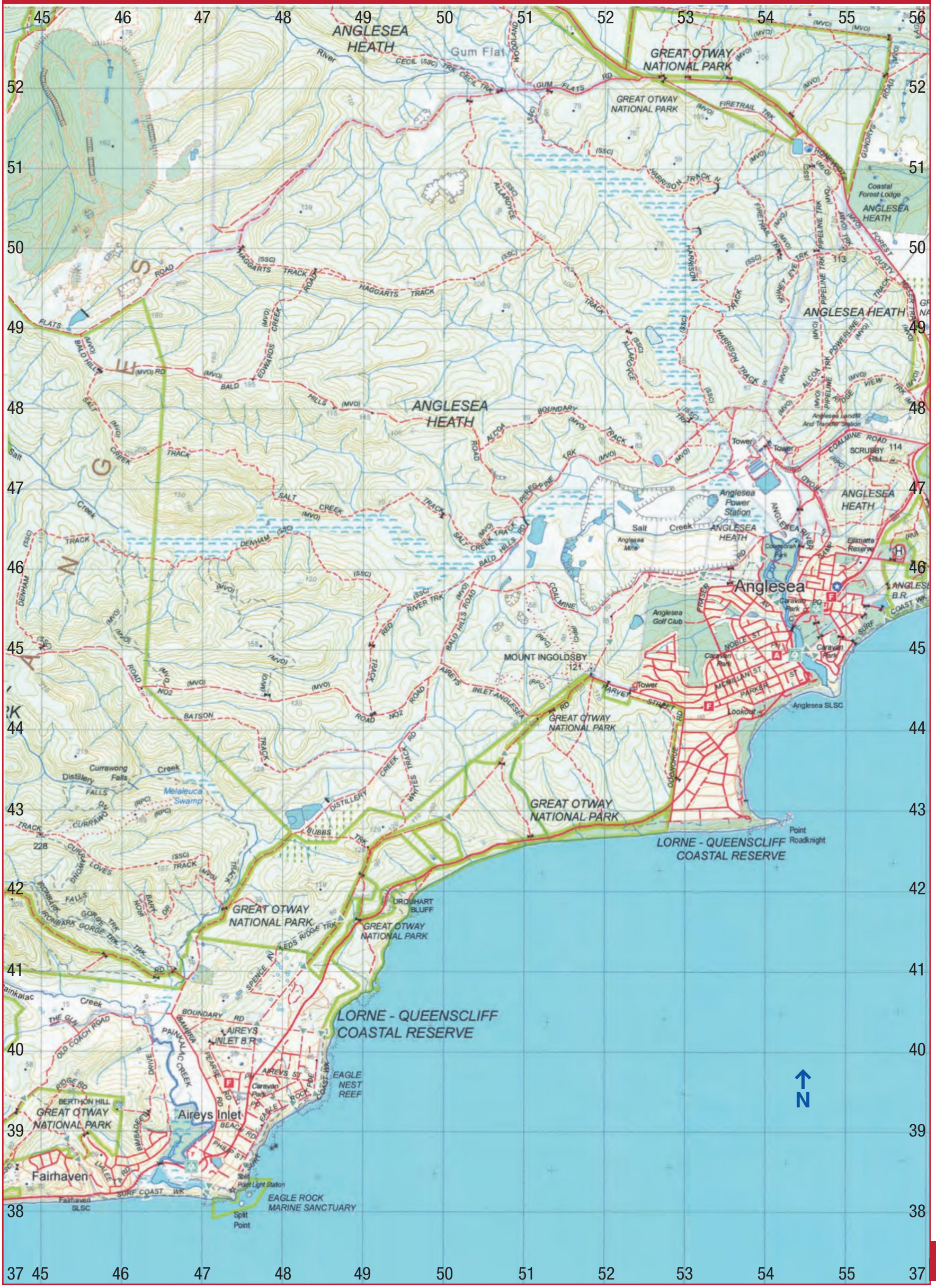
Anglesea topographic map extract (Anglesea: latitude 38˚41′S, longitude 144˚18′E)



ISBN 978-1-009-07583-1

Grant Kleeman

3.11 Lake Pedder (TAS) topographic map extract

Lake Pedder, once a glacial outwash lake, is now a dam formed by the 1972 damming of the Serpentine and Huon rivers by the Tasmanian Hydron Electric Commission.

The building of the dam, and especially the flooding of the original lake with its spectacular white sand beach, resulted in protests across Australia.

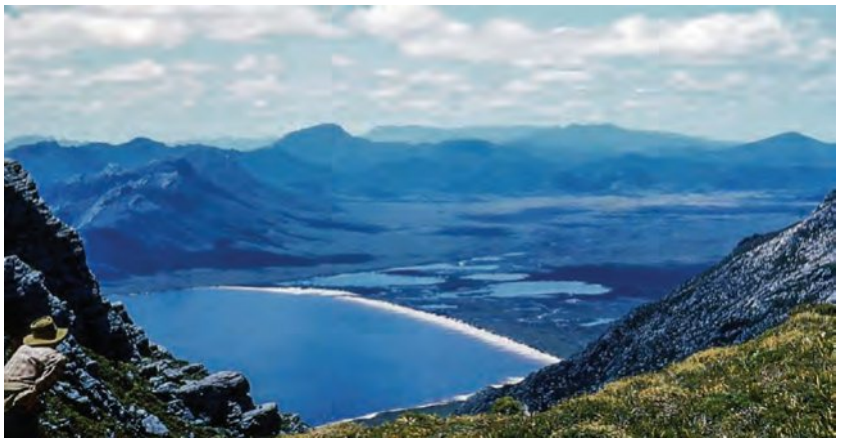


Figure 3.11a Spectacular Lake Pedder before its inundation

Figure 3.11b The waters of the 'new' Lake Pedder have inundated the Lake Pedder shown in Figure 3.11a. Google Earth, Image © CNES / Astrium, © 2016 Google.

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 325568
- b GR 313394
- c GR 290496
- d GR 333552
- e GR 252432.

4 Identify the feature of the constructed environment located at:
- a GR 277558
- b GR 207627
- c GR 279586
- d GR 373545.

5 Study Figure 3.11a. Construct a photo sketch and label the prominent features of the physical environment. In which direction was the camera facing when the photograph was taken?

6 Name the river into which the waters of Lake Pedder once flowed.

7 What type of vegetation is found in AR 2662?

8 What type of vegetation dominates the flood plain of the Serpentine River?

9 What type of vegetation is found in AR 4046?

10 What is the biophysical feature located in AR 2343?

11 In what direction does Maria Creek flow in AR 3948?

12 What is the direction of Mount Solitary (AR 3843) from Mount Helder (AR 3051)?

13 What is the aspect of the slope in AR 3046?

14 What is the bearing of Mount Helder (GR 305510) from the summit of Mount Solitary (GR 388435)?

15 Estimate the distance by road from Strathgordon (GR 225644) to the Wedge River Picnic Area (GR 373545).

16 Calculate the time it would take to ride a bike from Strathgordon (GR 225644) to the Wedge River Picnic Area (GR 373545) at an average speed of 10 km/h.

17 What is the area of Lake Pedder?

18 What is the height of the landform feature at GR 244604?

19 Estimate the height of Mount Solitary (AR 3843).

20 Estimate the height of the peak at GR 371504.

21 Estimate the height of the peak at GR 310470.

22 What is the difference in elevation of Mount Cawthorne (GR 290496) and Stillwater Hill (GR 282548)?

23 What is the local relief in AR 3256?

24 Calculate the gradient of the slope between the summit of Mount Solitary (GR 388435) and GR 388417.

25 Construct a cross-section from GR 228465 to Mount Cawthorne (GR 290496). Use a vertical scale of 1 cm = 200 m.

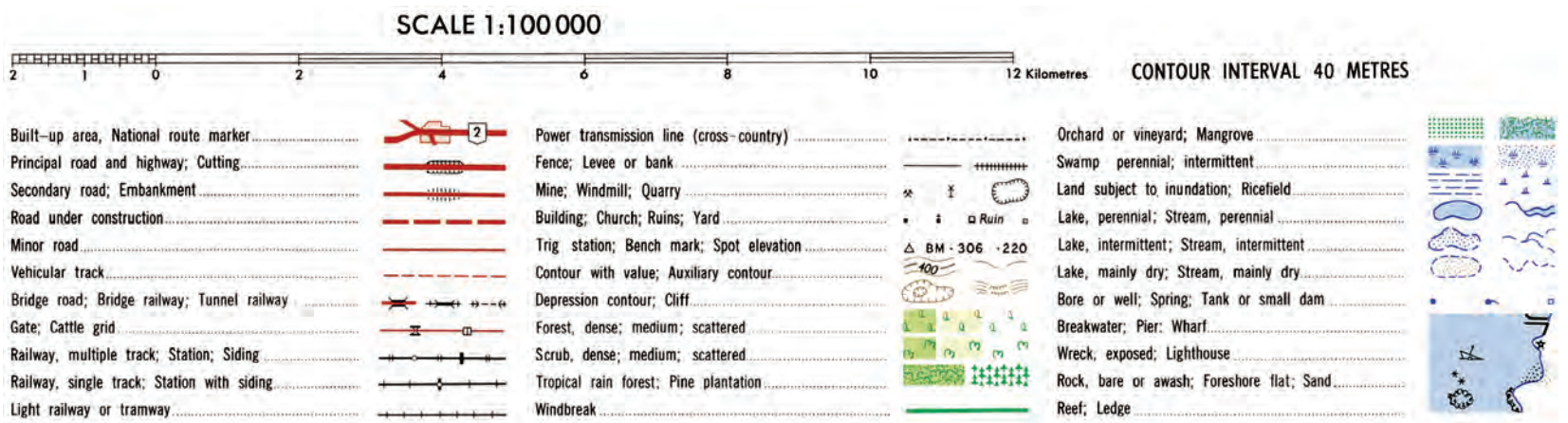
26 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 25.

27 Construct a cross-section from GR 388400 to GR 388460. Use a vertical scale of 1 cm = 150 m.

28 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 27.

29 What evidence is there that glaciation (development, movement and decline of glaciers) played a role in shaping the landscape in the south-west quadrant of the map extract?

30 The flooding of Lake Pedder was the source of a bitter debate between conservationists and those supporting an expansion of Tasmania's capacity to produce hydro-electricity. In recent years, conservationists have argued that the reservoir should be drained and the lake restored. Working in groups, compile a list of the arguments for and against such a proposal. Conduct a class debate. Topic: 'The Lake Pedder reservoir should be drained and the original lake restored'. Write an exposition outlining your view on the issue.



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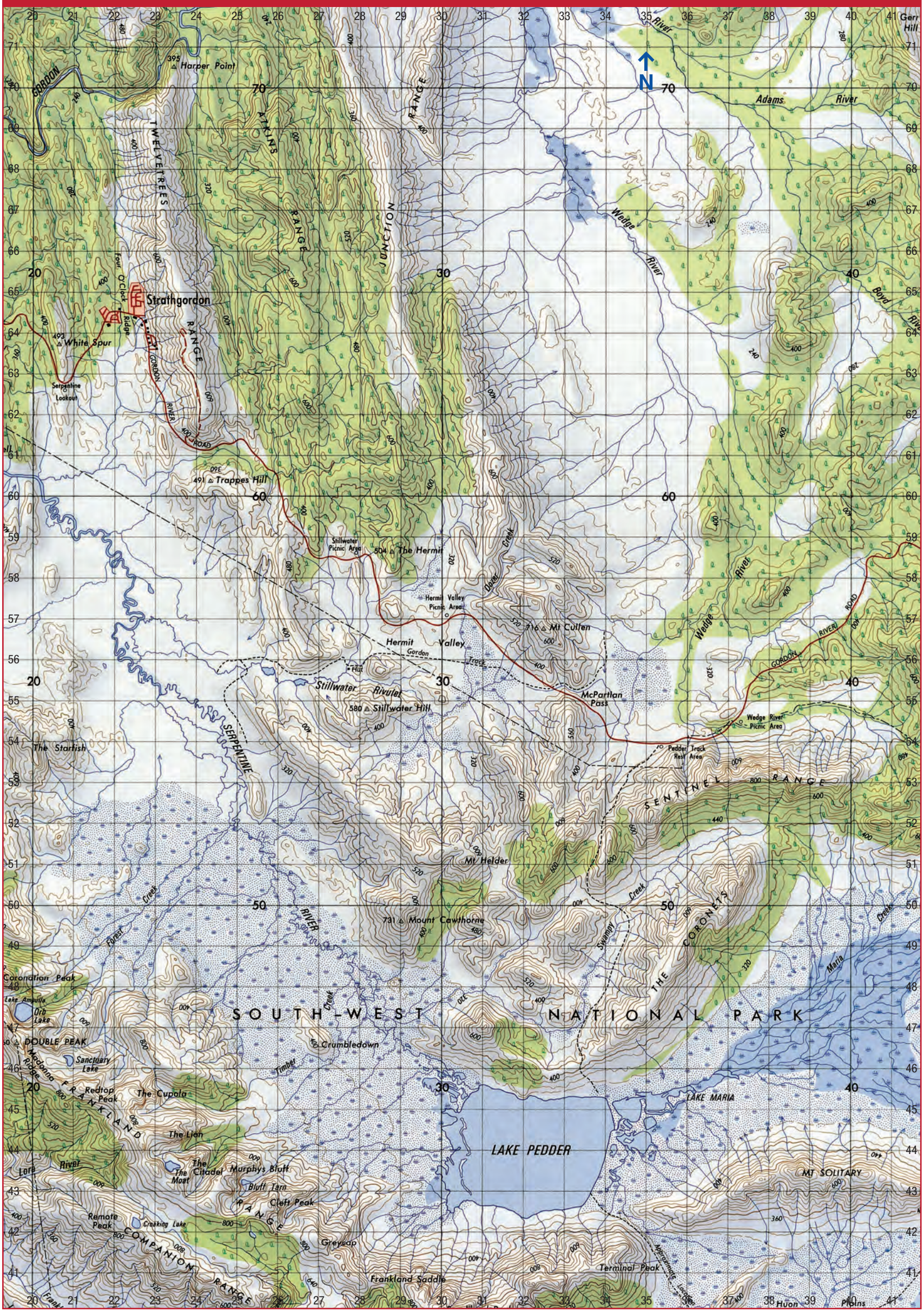
Lake Pedder topographic map extract before inundation (Strathgordon: latitude 42°46´S, longitude 146°03´E)



ISBN 978-1-009-07583-1

Grant Kleeman

3.12 Cradle Mountain (TAS) topographic map extract

Cradle Mountain is found in Tasmania's Cradle Mountain–Lake St Clair National Park. Rising to 1545 m above sea level, it has evidence of Indigenous occupation going back more than 10 000 years. Today it is one of the principal tourist attractions in the state. Cradle Mountain is composed of dolerite columns of volcanic origin.

Figure 3.12a View of Cradle Mountain across Dove Lake

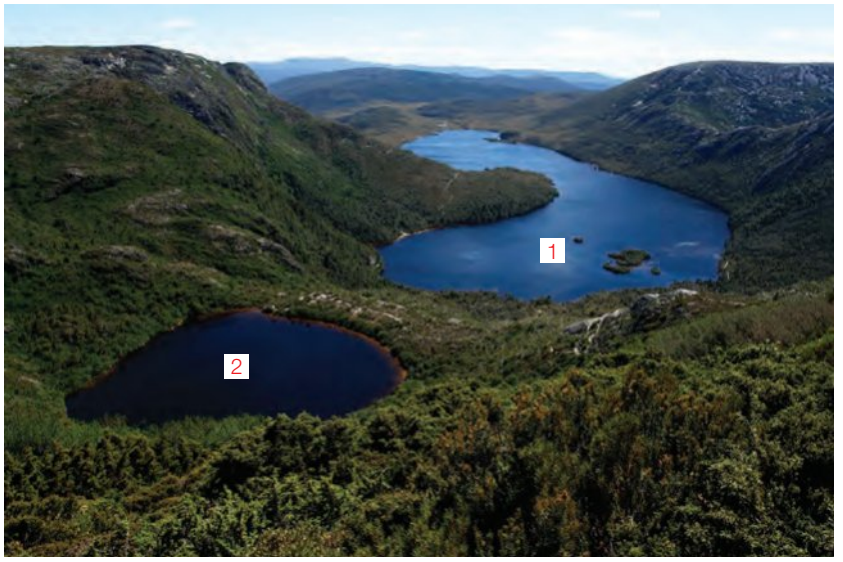


Figure 3.12b View from the slopes of Cradle Mountain

Figure 3.12c View of Cradle Mountain across Dove Lake

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 103849
- b GR 116886
- c GR 135879
- d GR 110873.

4 Identify the feature of the constructed environment located at:
- a GR 116902
- b GR 125885
- c GR 108875
- d GR 111895.

5 What is the grid reference of the Scout Hut in the north-west quadrant?

6 What type of landform is found at AR 1284?

7 What is the type of vegetation found in:
- a AR 1088
- b AR 1189?

8 What type of recreational activity dominates in the area covered by the Cradle Mountain topographic map extract?

9 What is the direction of flow of Ronny Creek in AR 1089?

10 What is the direction of Crater Lake from Dove Lake?

11 What is the direction of Suttons Tran from Lake Wilks?

12 What is the aspect of the slope in AR 1388?

13 What is the straight-line distance between the summit of Cradle Mountain and Mount Campbell?

14 What is the bearing of Little Horn (AR 1285) from Cradle Mountain (AR 1184)?

15 Estimate the area of Dove Lake.

16 What is the difference in elevation between Cradle Mountain (AR 1184) and Little Horn (AR 1285)?

17 What is the elevation of:
- a Lake Lilla
- b Dove Lake?

18 What is the gradient of the slope from the summit of Little Horn and Glacier Rock (AR 1288)?

19 What geomorphological processes are responsible for the landscape and landform features found on the Cradle Mountain topographic map extract?

20 Study Figure 3.12a and the map extract. Identify the features numbered 1–4.

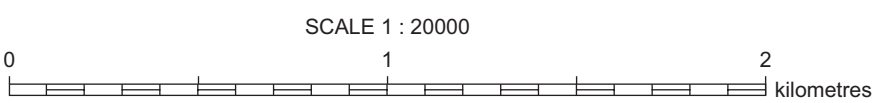
21 In what direction was the camera pointing when the photograph in Figure 3.12a was taken?

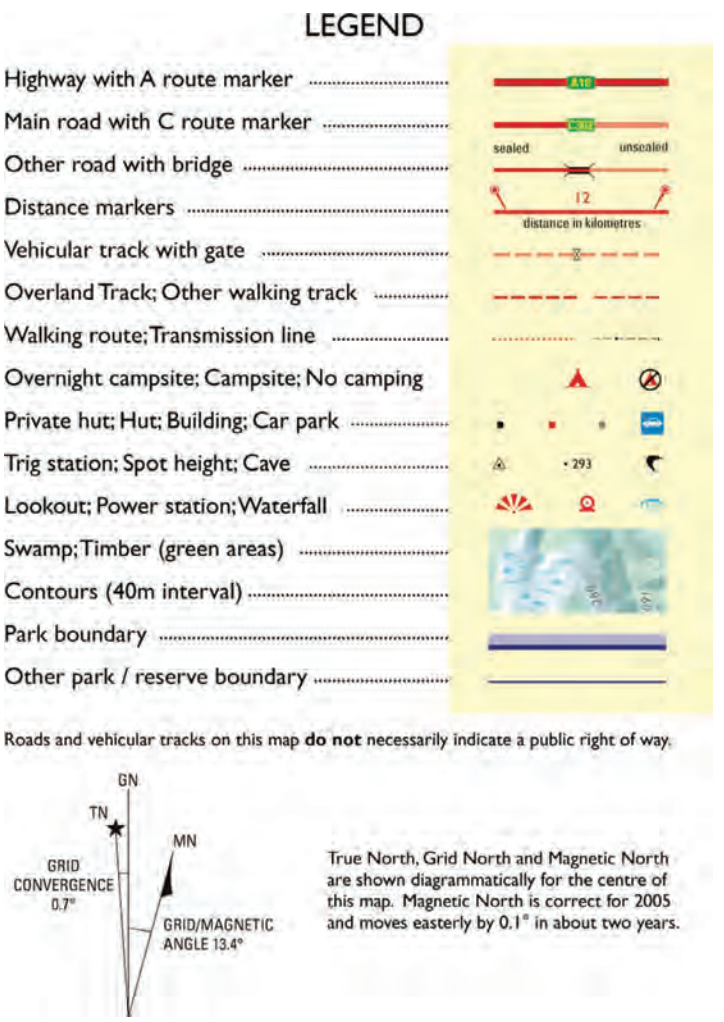
22 Study Figure 3.12b and the map extract. Identify the features numbered 1–2.

23 In what direction was the camera pointing when the photograph in Figure 3.12b was taken?

24 Study Figure 3.12c and the map extract. What is the grid reference of the boatshed?

25 Construct a photo sketch of Figure 3.12c. Label the features of the biophysical environment.





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Cradle Mountain topographic map extract (Cradle Mountain: latitude 41°65′S, longitude 145°94′E)

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ISBN 978-1-009-07583-1

Grant Kleeman

3.13 Coles Bay (TAS) topographic map extract

Figure 3.13a Wineglass Bay viewed from The Hazards

Figure 3.13b Wineglass Bay and The Hazards

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.13a and the map extract. In which direction was the camera facing when the photograph was taken?

4 Study Figure 3.13b. Construct a photo sketch highlighting the features of the biophysical environment. In which direction was the camera facing when this photograph was taken?

5 Study Figure 3.13c and the map extract. Identify the features numbered 1–6.

6 Identify the feature of the biophysical environment located at:
- a GR 049356
- b GR 073323
- c GR 073314
- d GR 065296
- e GR 076254.

7 Identify the feature of the constructed environment located at:
- a GR 079371
- b GR 047373
- c GR 064369
- d GR 075343
- e GR 065332.

8 What is the area reference of Mount Amos?

9 Name the type of biophysical feature found in AR 0825.

10 Name the type of vegetation found in AR 0629.

11 What river flows into Parsons Cove at GR 062333?

12 What is the direction of Mount Baudin (AR 0832) from Coles Bay (AR 0635)?

13 In what direction is Callitris Creek flowing in AR 0824?

14 What is the bearing of Mount Mayson (GR 060316) from Mount Dove (AR 0732)?

15 What is the bearing of Mount Graham (AR 0825) from Mount Amos (AR 0732)?

16 What is the straight-line distance between the summit of Mount Mayson (AR 0531) and the summit of Mount Graham (AR 0825)?

17 What is the length of Tawnah Creek (SW map quadrant)?

18 What is the aspect of the slope in:
- a AR 0731
- b AR 0532
- c AR 0832
- d AR 1029?

19 What is the height of the dammed water body in AR 0736?

20 What is the difference in elevation of Mount Amos (AR 0732) and Mount Dove (AR 0732)?

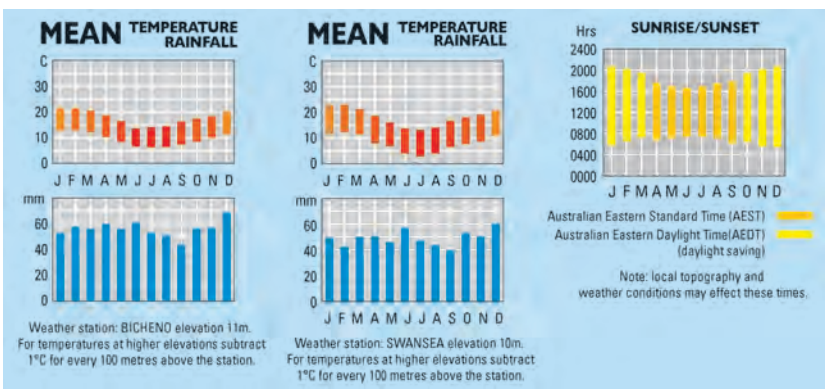
21 Construct the cross-section from the shoreline at GR 085316 to the summit of Mount Dove in AR 0732. Use a vertical scale of 1 cm = 50 m.

22 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 21.

23 What is the gradient of the slope in the cross-section you constructed in Activity 21?

24 What is the gradient of Loony Creek in the SW quadrant of the topographic map extract?

25 Working in groups, brainstorm the recreational activities visitor to The Hazards and Freycinet Peninsula.



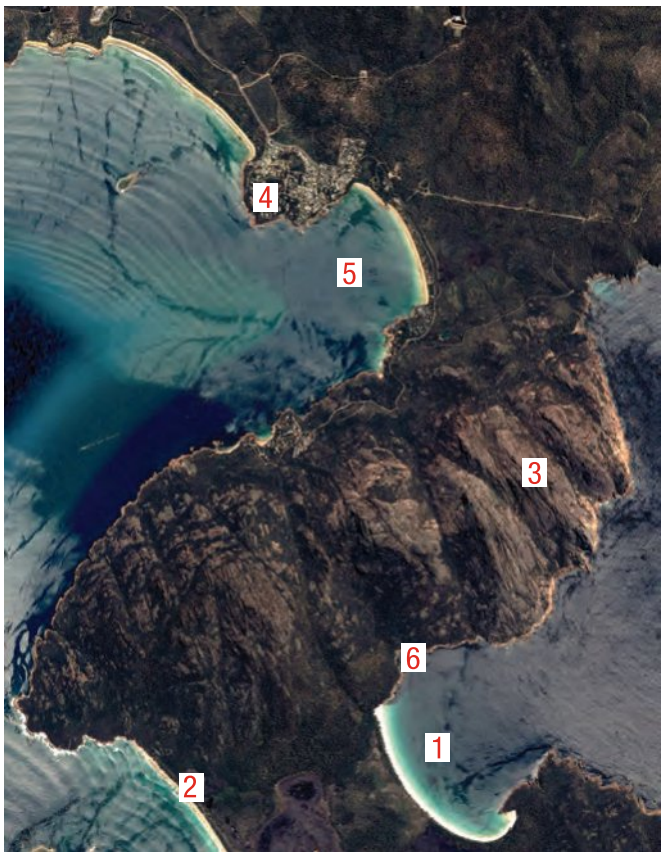


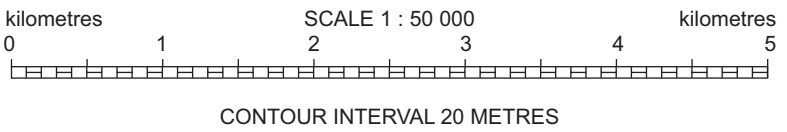
Figure 3.13c Satellite photograph of Freycinet National Park, Google Earth, Image © 2016 TerraMetrics, © 2016 Google, Data SIO, NOAA, US Navy, NGA, GEBCO, Images © 2016 CNES / Astrium

Freycinet National Park is located on the east coast of Tasmania, 125 km northeast of Hobart. It occupies a large area of the Freycinet Peninsula. Bordering the national park is the small settlement of **Coles Bay**.

The standout features of Freycinet National Park include Wineglass Bay (rated by travel companies as one of the world's ten best beaches), the red and pink granite formations, and a series of jagged granite peaks known as 'The Hazards'.

Significant Aboriginal sites have been found in this area, including stone artefacts, rock shelters and shell middens.

Whaling, tin, coal, and farming are all industries that touched Freycinet before it became a national park.



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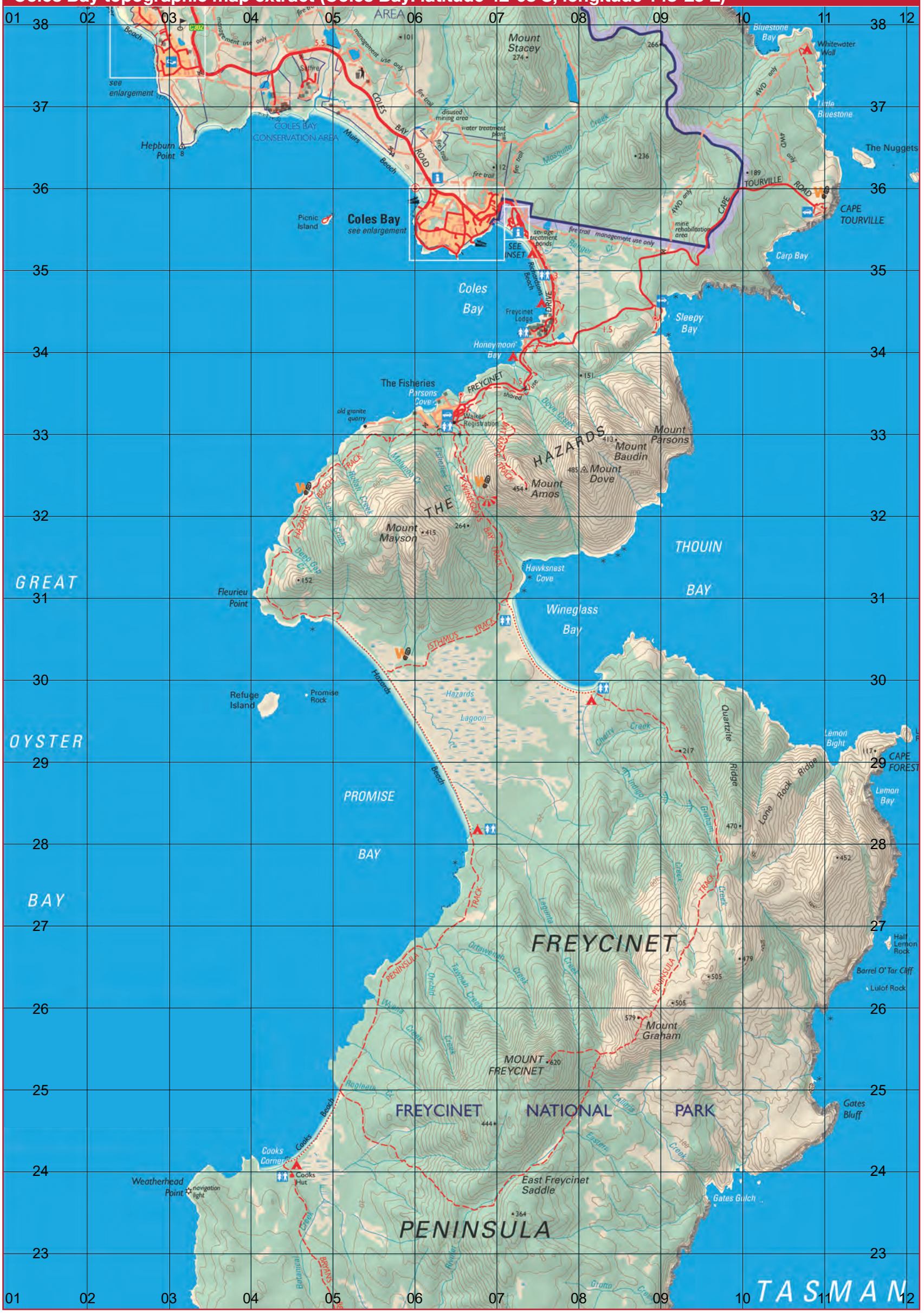
Coles Bay topographic map extract (Coles Bay: latitude 42°08'S, longitude 148°23'E)



Base image by TASMAP (www.tasmap.tas.gov.au) © State of Tasmania

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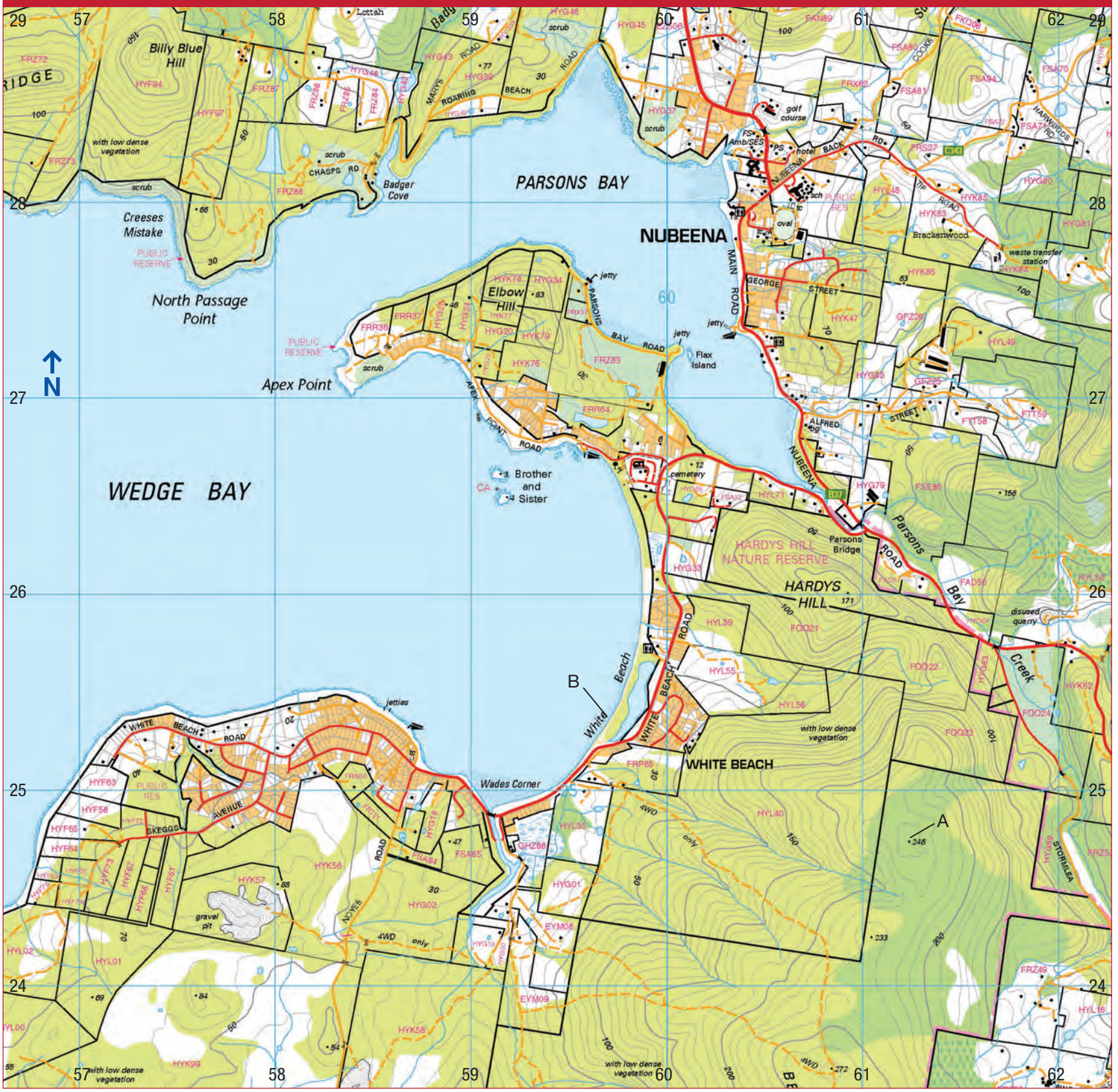
Grant Kleeman

3.14 Port Arthur (TAS) topographic map extract

Wedge Bay topographic map extract (Nubeena: latitude 43°10′S, longitude 147°75′E)



SCALE 1:25000

0 km 0.5 1 2 km

CONTOUR INTERVAL 10 METRES

Magnetic North is 15.0 degrees East of Grid North.

Built-up area with commercial buildings
Roads maintained for continuous public use: Highway; Major arterial road; Minor arterial or Collector road; Local road; Touring route numbers
Roads of restricted use or access: Other road with bridge; Vehicular track with gate
Walking track or horse trail; Railway line
Transmission line with pylon positions
Building; Police station; Fire station; School
Post Office; Picnic area; Public toilets
Caravan park; Camping ground; Refuse disposal
Landmark feature; Mine; Feature of historic or special interest
Area feature; Sports Ground; Cemetery

Trig station beacon; Spot elevation; Excavation
Contour with value; Depression contour
Rock scree; Broken rocky surface
Dense forest; Medium forest
Low dense vegetation; Distinctive grass
Scrub, heath or sedge; Submerged trees
Orchard, Timber plantation
Windbreak
Indefinite shoreline or floodbank; Levee
Tidal rocks or ledge; Offshore rock, bare or awash
Navigation light or lighthouse; Exposed wreck
Sand; Tidal reef
Saline coastal flat; Tidal flats
Jetty; Launching ramp

Swamp: perennial, intermittent
Wet area; Subject to flooding
Watercourse: waterfall, rapids
Local Government Area name
Local Government Area boundary
Other administrative boundaries
Reserve boundary; Vinculum or joining symbol
Property boundary; Land parcel boundary and identifier
Locality boundary with locality name

BOUNDARIES: Cadastral and administrative boundaries shown on this map are NOT authoritative and are shown as at . Boundaries of Crown Land (including Reserves) extend to low water mark. The land parcel identifier, e.g. ABC12 can be used to gain title, property and survey references.

INFORMATION: Title and Survey information can be obtained from the Land Data Registration Branch, DPIPWE. Topographical information is available from Geodata Services Branch, DPIPWE and property details from Service Tasmania. Land information may be accessed also at www.thelist.tas.gov.au

ISBN 978-1-009-07583-1

Port Arthur topographic map extract (Port Arthur: latitude 43°18′S, longitude 147°84′E)

ACTIVITIES

1. What is the scale of the map extracts?
2. What is the contour interval used on the map extracts?
3. Identify the feature of the biophysical environment located on the Port Arthur map extract at:
   a. GR 705223
   b. GR 662218.
4. Identify the feature of the constructed environment located on the Wedge Bay map extract:
   a. GR 603274
   b. GR 587253.
5. Name the types of vegetation found in AR 6621 on the Port Arthur map extract.
6. What river flows into Mason Cove (AR 6922) on the Port Arthur map extract?
7. In what direction is Parsons Bay creek flowing in AR 6125 on the Wedge Bay map extract?
8. What is the aspect of the slope in AR 6024 on the Wedge Bay map extract?
9. What is the density of buildings in AR 6923 on the Port Arthur extract?
10. What is the height of Billy Blue Hill in AR 5728 on the Wedge Bay map extract?
11. What is the height of Mount Tonga in AR 6724 on the Port Arthur map extract?
12. Construct the cross-section from the spot height at GR 611243 (Point A) to the shoreline of Wedge Bay at GR 596253 (Point B). Use a vertical scale of 1 cm = 50 m.
13. Calculate the vertical exaggeration of the cross-section that you constructed in Activity 12.
14. What is the gradient of the slope in the cross-section that you constructed in Activity 12?
15. Use Google Earth to explore the area covered by the Port Arthur map extract. What features of the biophysical and constructed environments can you identify?

Port Arthur is a small town and former convict settlement on the Tasman Peninsula, Tasmania. Port Arthur is one of Australia's most significant heritage areas and an open-air museum. **Nubeena**, on Wedge Bay, is a small, scenic village near the Port Arthur Historic Site.

Figure 3.14a Port Arthur Historic Site, Google Earth © 2021 Google

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Grant Kleeman

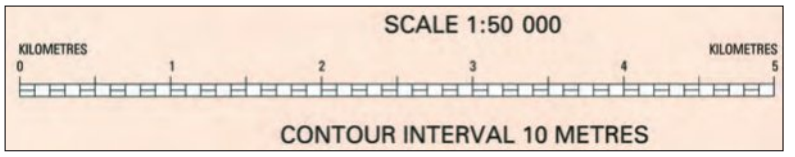
3.15 Encounter (SA) topographic map extract

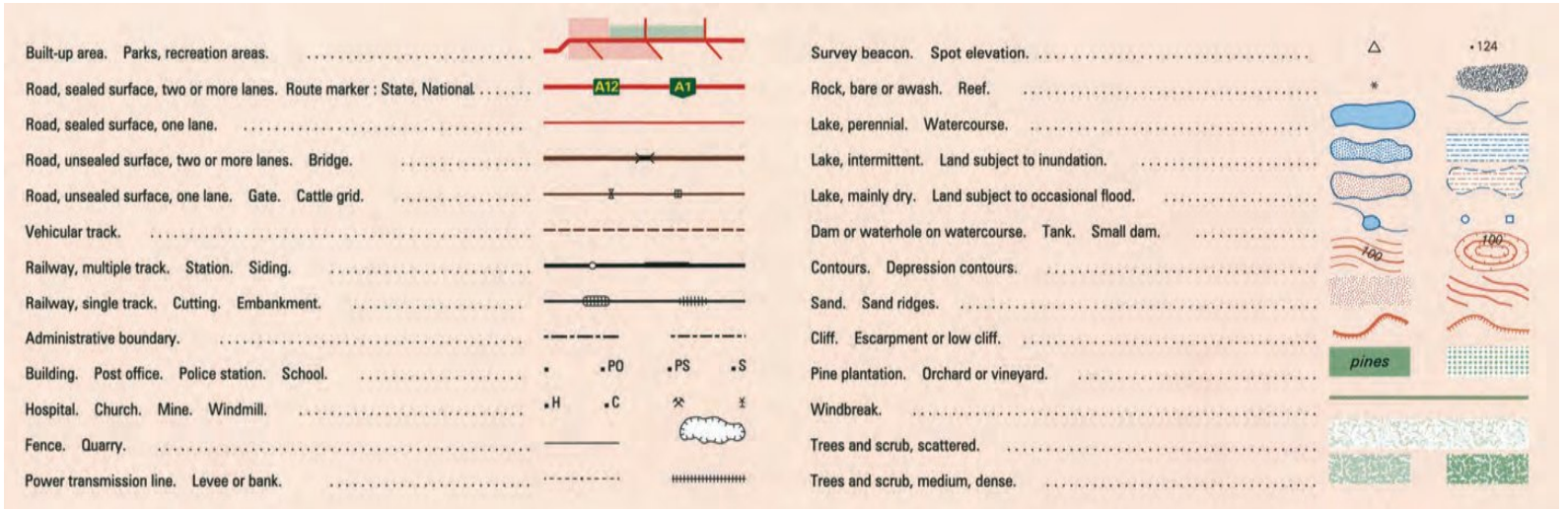
Victor Harbor is located on the southern coastline of South Australia, about 80 km south Adelaide. Victor Harbor is not a port but rather a quiet community, with the economy basing on farming, fishing and services, especially tourism. Victor Harbor is famous for its numerous festivals and celebrations, including a three-day Schoolies Week festival and its annual Art Show.

The Ramindjeri people call this area Wirramulla, and Kaiki (Granite Island) has great spiritual significance.

Figure 3.15a Oblique aerial photograph of Victor Harbor

Figure 3.15b Victor Harbor's famous horse-drawn tram. This is one of the town's principal tourist attractions.





ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 808648
- b GR 865604
- c GR 829587
- d GR 905654.

4 Identify the feature of Encounter Bay environment located at:
- a GR 849624
- b GR 858619
- c GR 855653
- d GR 833617.

5 What is the area reference of Wright Island?

6 Name the type of biophysical feature found in AR 8668.

7 Name the nature of the land cover found in AR 8263 to the east of the golf course.

8 Name the 3.15a of land use found in AR 8263.

9 Name the type of residential estate found in AR 8261.

10 What river flows into Victor Harbor at GR 853640?

11 What is the direction of Crozier Hill (AR 8064) from the Brown Hill (AR 8668)?

12 In what direction is the Inman River flowing in AR 8064?

13 Name the river that enters the sea at GR 836620.

14 What is the bearing of Brown Hill (AR 8668) from Grozier Hill (GR 808648)?

15 What is the bearing of Rosetta Head (AR 8258) from Seal Island (AR 8660)?

16 What is the straight-line distance between the summit of Rosetta Head (AR 8258) and the summit of Grozier Hill (AR 8064)?

17 What is the length of the causeway linking Granite Island to the mainland?

18 Estimate the area of Granite Island.

19 What is the height of the cemetery at GR 905683?

20 What is the difference in elevation of Grozier Hill (AR 8064) and Brown Hill (AR 8668)?

21 What is the elevation of the lake at GR 854658?

22 Study Figure 3.15a. State the direction in which the camera was facing when the photograph was taken.

23 Identify the features numbered 1–5 on Figure 3.15a.

24 Using grid and area references identify evidence on the map extract that indicate that Victor Harbor is a popular tourist destination.

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Encounter topographic map extract (Encounter: latitude 35° 32'S, longitude 138° 37'E)

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Grant Kleeman

3.16 Goolwa (SA) topographic map extract

Figure 3.16a The mouth of the River Murray

Murray Mouth is the point at which the River Murray enters the Southern Ocean. The exact location of Murray Mouth has changed over time. Historical records show that the channel out has migrated along the sand dunes over time. At times of greater river flow and rough seas, the sand dunes are eroded to create a new channel leaving the old one to silt and disappear. The current mouth of the Murray River can be found about 10 km south-east of the town of Goolwa.

The Murray is Australia's longest river at 2 508 km and its tributaries include five of the next six longest rivers of Australia (the Murrumbidgee, Darling, Lachlan, Warrego and Paroo Rivers). Together the catchments of the river systems together form the Murray–Darling Basin.

Figure 3.16b Oblique aerial photograph of the Murray Mouth

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.16a and identify the features numbers 1–10.

4 Identify the feature of the biophysical environment located at:
- a GR 135692
- b GR 051656
- c GR 140650
- d GR 094625.

5 Identify the feature of the constructed environment located at:
- a GR 995687
- b GR 987672
- c GR 106686
- d GR 004676.

6 What is the area reference of Murray Mouth?

7 Name the type of biophysical feature found in AR 1360.

8 Name the type of vegetation found in AR 0268.

9 On what waterway is the Mundoo Barrage located?

10 Why is settlement absent in AR 1465?

11 What tributary enters Holmes Creek in AR 1165?

12 What is the bearing of the shacks in AR 0962 from those in AR 1262?

13 What is the length of the Goolwa Barrage?

14 What is the density of building in AR 1068?

15 Study Figure 3.16a and the topographic map extract (ARs 0067 and 0167). What changes does the photograph highlight in terms of the nature of urban development in this part of Hindmarsh Island?

16 Study Figure 3.16b. In what direction was the camera facing when the photograph was taken?

17 Describe the nature of the topography evident on the Goolwa Topographic Map Extract.

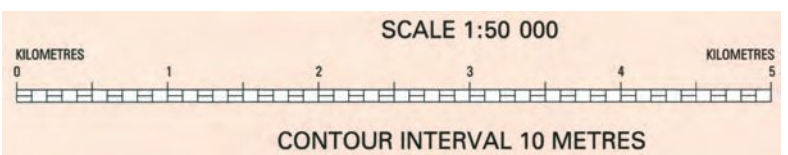
18 Describe the settlement pattern evident on Hindmarsh Island.

19 Investigate the formation of barrier coastal features such as the Sir Richard Peninsula and Younghusband. Write a report outlining your findings.

20 Speculate on why barrages have been built across channels in the area covered by the map extract.

21 Investigate the controversy surrounding the construction of the Hindmarsh Island Bridge.

22 Outline the types of recreational activities that might be available to those living in or visiting the area shown on the map extract.



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Goolwa topographic map extract (latitude 35° 33'S, longitude 138° 52'E)

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Grant Kleeman

3.17 Albany (WA) topographic map extract

Albany is a port city 418 km southeast of Perth, the capital of Western Australia. Albany is the oldest permanently settled town in Western Australia, predating Perth and Fremantle by over two years. With a population of 38 300, the city is the state's sixth-largest population centre.

Albany played an important role in Australia's military history. Ships carrying the Australian Imperial Force and the New Zealand Expeditionary Force (later known collectively as Anzacs) gathered at Albany in late October 1914 prior to their departure for the battlefields of World War I. The first detachment departed in convoy on 1 November 1914, with a second detachment departing in late December 1914. Albany was the last place in Australia that many of these Anzacs would ever see.

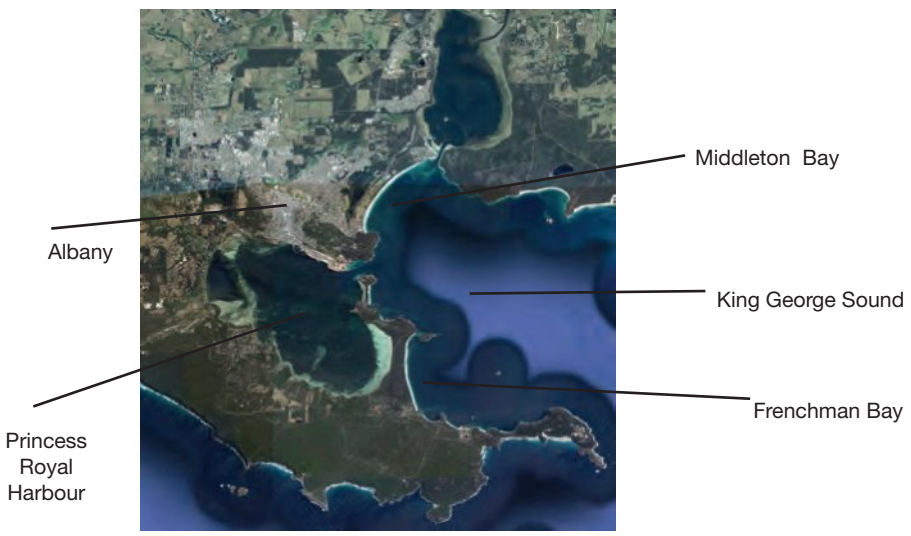
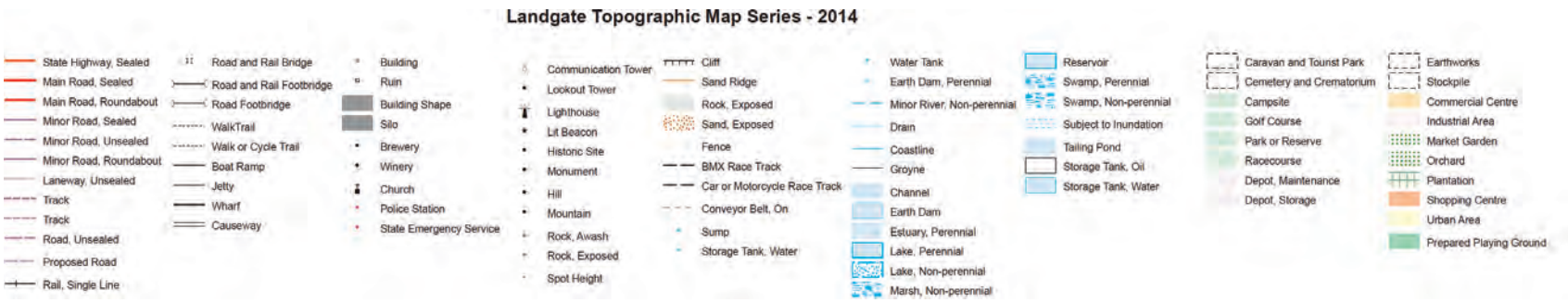


Figure 3.17a The location of Albany relative to the surrounding geography of southern Western Australia, Google Earth, Image © 2016 CNES / Astrium © 2016 Google, Data SIO, NOAA, US Navy, NGA, GEBCO

Figure 3.17b Satellite photograph of Albany, Western Australia, Google Earth, Image © Terrametrics, Image © 2016 CNES / Astrium © 2016 Google, Data SIO, NOAA, US Navy, NGA, GEBCO



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.17a. Describe the location of Albany. Suggest why this site was selected for the development of a port.

4 Study Figure 3.17b and the map extract. Locate the following features on the satellite photograph: Albany's port facilities, Mount Clarence, Mount Adelaide, golf course, Lake Seppings and Ataturk Entrance. After whom was Ataturk Entrance named?

5 Identify the feature of the biophysical environment located at:
- a GR 586628
- b GR 605623
- c GR 604642
- d GR 603614.

6 Identify the feature of the constructed environment located at:
- a GR 584634
- b GR 606633
- c GR 607617
- d GR 574625.

7 What is the area reference of Quarantine Hill?

8 Name the type of biophysical feature found in AR 6060.

9 Name the types of land use found in AR 5865.

10 What waterway is located in AR 5865?

11 What is the direction of Quarantine Hill (AR 6059) from Mount Clarence (AR 5862)?

12 In what direction is Yakamia Creek flowing in AR 5865?

13 What is the bearing of Mount Adelaide (AR 6062) from Mount Clarence (AR 5862)?

14 What is the straight-line distance between the summit of Mount Clarence (AR 5862) and the summit of Quarantine Hill (AR 6059)?

15 What is the width of the Ataturk Entrance at its narrowest point?

16 What is the aspect of the slope in AR 5862?

17 What is the area of Lake Sappings?

18 What is the height of Quarantine Hill (AR 6059)?

19 What is the difference in elevation of Mount Clarence and Mount Adelaide?

20 Construct the cross-section from the spot height at GR 606608 to the summit of Mount Adelaide (AR 6062). Use a vertical scale of 1 cm = 20 m.

21 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 20.

22 What is the gradient of the slope between the summit of Mount Clarence and the waterfront of Hanover Bay (GR 580623)?

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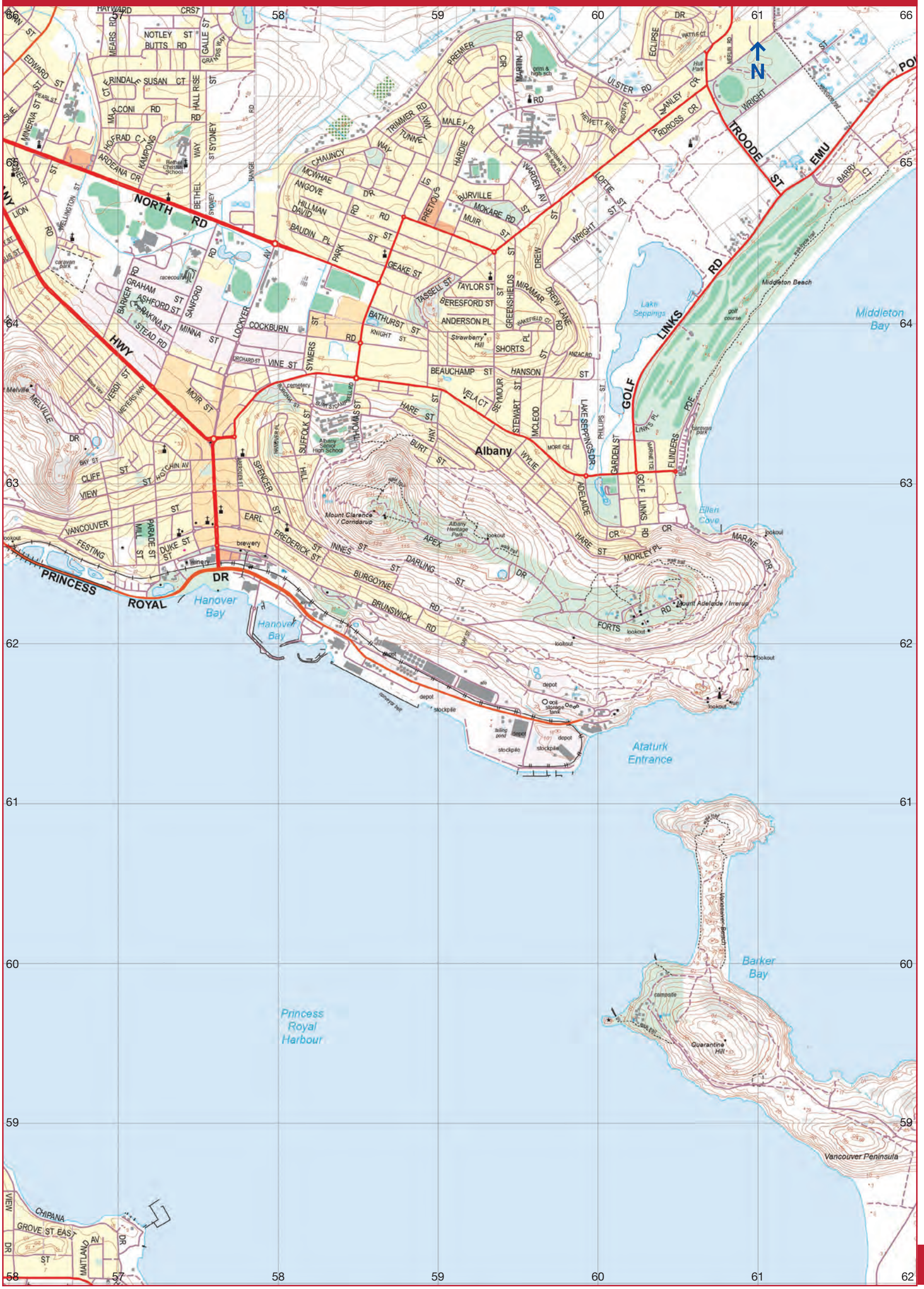
Albany topographic map extract (Albany: latitude 35°02′S, longitude 117°88′E)



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Grant Kleeman

3.18 Daintree (QLD) topographic map extract

The **Daintree** National Park, a World Heritage site, is located in North Queensland – 79 km north of Cairns and 24 km from Port Douglas. There are two sections in Daintree National Park. Mossman Gorge is a valley where the Mossman River cascades over granite boulders. Cape Tribulation has long sandy beaches leading to rainforest mountains.

The Daintree Rainforest is believed to be one of the three oldest rainforests in the world. The traditional owners of this forest are the Eastern Kuku Yalanji people.

Figure 3.18a Oblique aerial photograph of Port Douglas, Queensland

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 384035
- b GR 384998
- c GR 244942
- d GR 281797.

4 Identify the feature of the constructed environment located at:
- a GR 358769
- b GR 205027
- c GR 359746
- d GR 264790.

5 What river flows into the sea in:
- a AR 3498
- b AR 3084?

6 What type of vegetation is found in:
- a AR 2495
- b AR 3197?

7 What type of land cover is found in AR 3475?

8 What is the biophysical feature found in AR 3997?

9 What is the direction of Snapper Island (AR 3997) from Dayman Point (GR 311876)?

10 In which direction is the Mossman River flowing in AR 2302?

11 Estimate the width of the Daintree River in AR 3399.

12 What is the bearing of Black Rock Reef (AR 3803) from Dayman Point (GR 311876)?

13 What is the bearing of The Bluff (AR 2175) from Mt Somerset (AR 2583)?

14 Estimate the distance by road from Mossman (GR 264790) to Dayman Point (GR 311875).

15 Calculate the time it would take to travel from Mossman (GR 264790) to Dayman Point (GR 311875) at an average speed of 60 km/h.

16 What is the settlement pattern in ARs 3090, 3091 and 3092?

17 What is the difference in elevation of Mount Somerset (AR 2583) and Mt Beaufort (AR 2879)?

18 Construct the vegetation transect from GR 190010 to GR 374010.

19 Construct a precis map showing the pattern of vegetation on the map extract.

20 Describe the nature of the coastline in the area between Port Douglas and Cooya Beach.

21 Study Figure 3.18a and complete the following tasks:
- a What type of photograph is featured?
- b In what direction was the camera facing when the photograph was taken?
- c Construct an annotated photo sketch of Port Douglas.

22 What evidence is there that the Daintree River has changed its course?

23 Working in groups, brainstorm the attractions of the physical environment that make the Daintree area popular with ecotourists.

24 Use Table 3.18a to construct a climate graph for Port Douglas. Then complete the following tasks:
- a Which are the hottest months?
- b Which is the coolest month?
- c What is the average annual range of mean daily maximum temperatures?
- d Which is the wettest month?
- e Which is the driest month?
- f Describe the seasonal distribution of rainfall.
- g Construct a column graph showing the annual distribution of rain days.

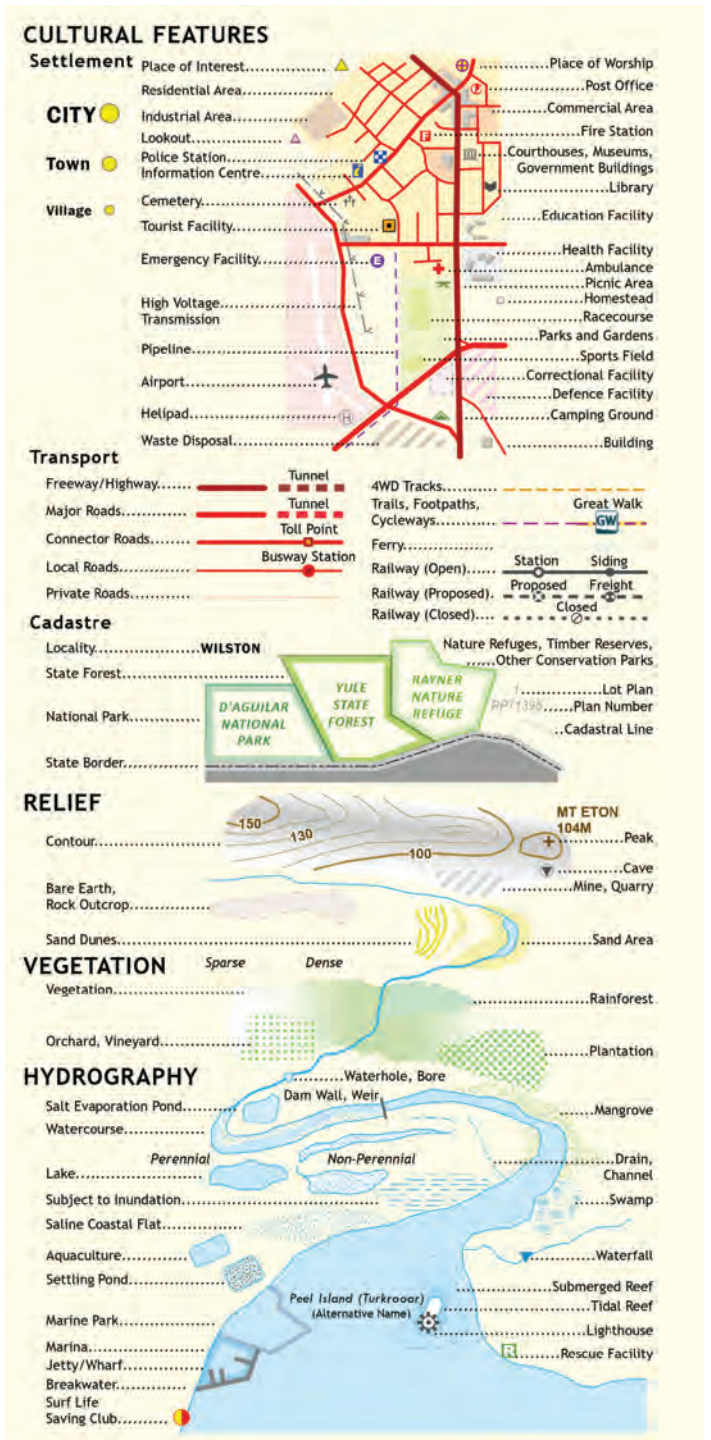
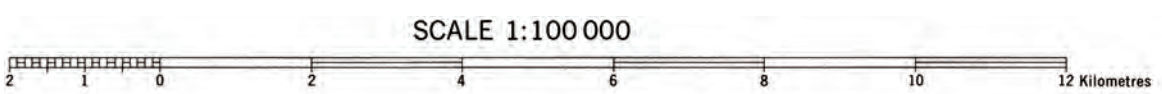


Table 3.18a Climate data for Port Douglas: elevation 4 m, latitude 16°48′S, longitude 145°47′E

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean min. temp. (°C)	23.7	23.5	22.8	21.5	19.5	17.7	16.8	17.1	18.6	20.8	22.3	23.3	20.6
Mean max. temp. (°C)	30.3	30.1	29.5	28.3	26.7	25.1	24.6	25.3	26.7	28.3	29.5	30.3	27.9
Mean rainfall (mm)	396	421	428	205	72	48	26	24	32	47	105	204	2008
Mean number of raindays	15.7	15.8	16.4	13.5	9.9	7.1	5.4	5.2	5.2	6.1	8.7	11.5	120.4



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Grant Kleeman

Daintree topographic map extract (Port Douglas: latitude 16° 48'S, longitude 145° 47'E)

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Grant Kleeman

3.19 Noosa (QLD) topographic map extract

Noosa is a resort town on Queensland's Sunshine Coast. It is famous for its beaches, surf and fashionable cafes and boutiques.

Noosa is also a world biosphere site, with a very high diversity of species in the natural vegetations and broad range of habitats. The Noosa River has received an 'A' grade from the Environmental Protection Agency.

Hypothetical: you be the judge

An Indonesian-owned transnational corporation has submitted a development application for a large resort complex in the area between the Noosa River and Lake Cooroibah. When completed, the complex will house a 400-room, five-star hotel and convention centre, a casino, a Greg Norman–designed 18-hole golf course, 1000 apartments and 300 detached dwellings lining the Noosa River. The resort will be linked to Noosa by a new four-lane bridge.

The land is currently undeveloped. It is covered by coastal eucalypt forest and mangrove wetlands. Some of the area is subject to inundation following periods of above-average rainfall. The local Aboriginal community says that the area contains a number of sacred sites.

The development application has divided the Noosa community. The pro-development council is keen for the resort to go ahead. A number of councillors stand to benefit financially from the additional economic activity that the resort's construction will generate. Local conservationists are outraged by the proposal. Others fear that the lifestyle that attracted them to the area will be spoilt by the influx of 2000 additional residents and up to 2000 additional tourists.

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 3.19a. Name the features numbered 1–8.

4 Identify the feature of the biophysical environment located at:
- a GR 119824
- b GR 073800
- c GR 105813
- d GR 116805.

5 Identify the feature of the constructed environment located at:
- a GR 080820
- b GR 042806
- c GR 029757
- d GR 017735.

6 What river flows into Lake Cooroibah in AR 0283?

7 What type of vegetation is found in AR 0283?

8 What type of land use is found in GR 0679?

9 Name the recreational land use found in:
- a AR 1081
- b AR 0181 and 0180.

10 What is the direction of Lake Weyba from Doonella Lake?

11 In which direction is the Noosa River flowing in AR 0383?

12 Identify the feature of the biophysical environment located 3.7 km to the north-east of Keuser Island (GR 073800).

13 What is the bearing of Noosa Hill (AR 1081) from the fire station in AR 0480?

14 What is the distance by road between the roundabout at GR 034752 and the roundabout at GR 063712?

15 Estimate the length of the airstrip in AR 0677.

16 What is the area of Lake Weyba?

17 Estimate the height of the landform feature at GR 099749.

18 Estimate the height of the landform feature in AR 0684.

19 Construct the vegetation transect from GR 020830 to GR 070840.

20 What indications are there that much of the land around Noosa Heads is low lying?

21 Study the map extract and the oblique aerial photograph of Noosa Heads (Figure 3.19a). Write a report describing the effects of human activity on the estuary of the Noosa River.

22 Working in groups, compile a list of the benefits of the type of human intervention described in Activity 21.

23 List the possible environmental costs associated with this type of intervention. Share the findings of your group's discussions with the rest of the class. Take a vote to see whether such environmental impacts are justified.

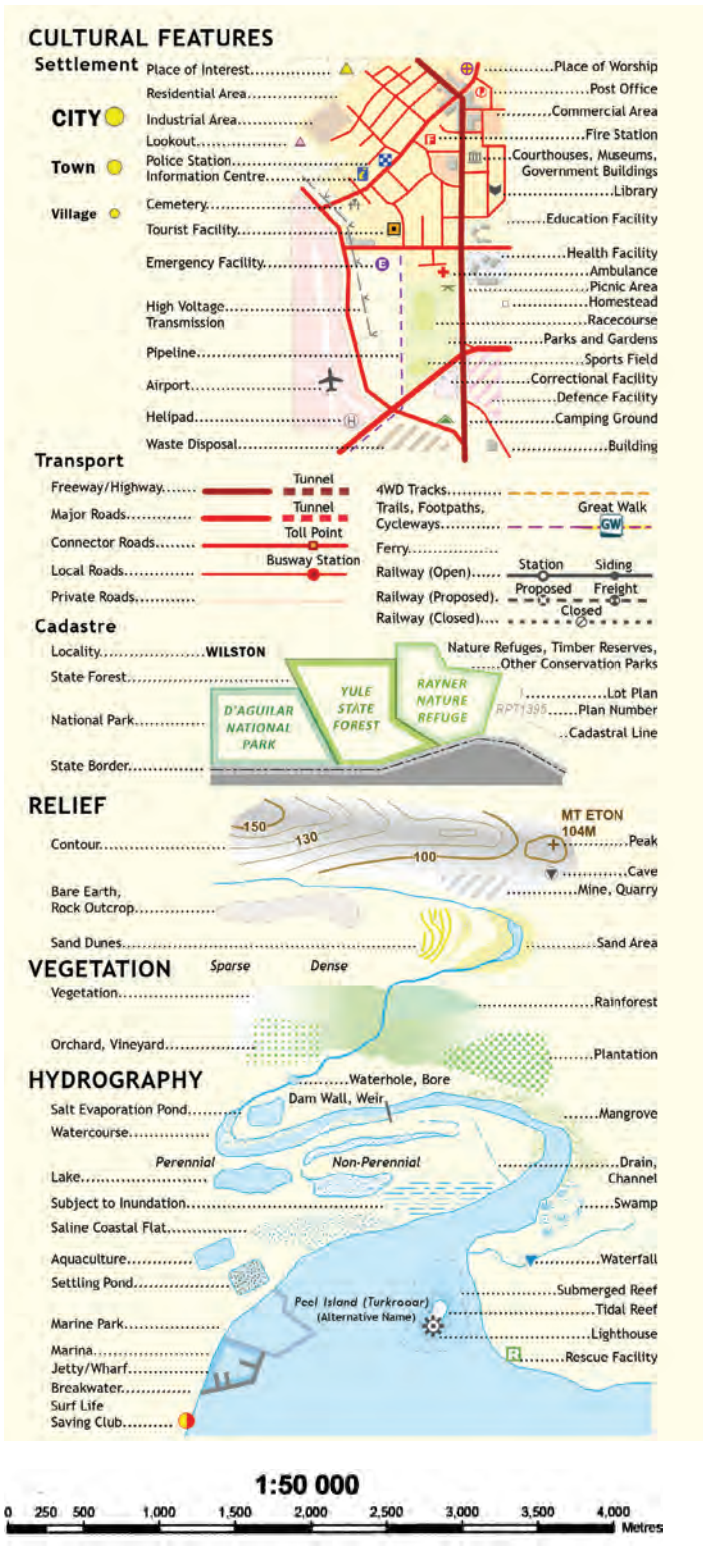
24 Describe the nature of the coastal environment between Peregian Beach (AR 1073) and the beaches of Laguna Bay (AR 0783).

25 Study Figure 3.19a. In what direction was the camera facing when the photograph was taken?

26 Study Video 3.19a and complete the following tasks:
- a In what direction was the drone moving when the footage was taken?
- b Identify the following features: Noosa Hill, Noosa Inlet, Noosa River and Noosa Heads.
- c Identify the coastal process responsible for the formation of the landscape shown in the footage.

Figure 3.19a Google Earth image of Noosa Heads © 2021 Google

Video 3.19a Aerial footage of Noosa Heads (**00:22**)



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Noosa topographic map extract (latitude 26° 23'S, longitude 153° 06'E)

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Grant Kleeman

3.20 Cairns (QLD) topographic map extract

Cairns is a major coastal city in Far North Queensland. The town developed into a railhead and major port for exporting sugar cane, gold and other metals, minerals and agricultural products from surrounding coastal areas and the Atherton Tableland region. Today tourism is the city's major industry. It is a gateway to the spectacular Great Barrier Reef.

Change over time

Topographic maps provide a snapshot of the biophysical, managed and constructed environments of a place at a particular point in time. This topographic map of Cairns was published in 1989. Since then Cairns has experienced rapid urban growth. To view the extent of growth it is often best to compare maps with aerial imagery such as that shown in Figure 3.20a.

Figure 3.20a Satellite photograph of Cairns, Google Earth © 2021 Google

Video 3.20a
Aerial footage of Palm Cove (**00:27**)

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- **a** GR 553383
- **b** GR 599503
- **c** GR 608448
- **d** GR 568270.

4 Identify the feature of the constructed environment located at:
- **a** GR 558362
- **b** GR 690211
- **c** GR 671226
- **d** GR 583466.

5 Study Figure 3.20a and the map extract, and complete the following tasks:
- **a** Identify the features numbered 1–8.
- **b** Describe the site of Cairns.
- **c** What restricts the expansion of Cairns to the south-east and west?
- **d** Describe the relationship between vegetation and topography.
- **e** How do we know that there are crops in various stages of the growth cycle in the agricultural areas surrounding Cairns?

6 What river flows into the sea at AR 6834?

7 What type of vegetation is found in AR 7222?

8 What type of land use is found in AR 6139?

9 Name the biophysical feature found in AR 6142.

10 What is the direction of Yorkeys Knob (AR 6341) from Palm Cove (AR 5847)?

11 In which direction is the Barron River flowing in AR 6134?

12 What is the aspect of the slope in AR 6127?

13 What is the bearing of Taylor Point (GR 608448) from Yorkeys Point (GR 637418)?

14 What is the straight-line distance between Haycock Island (GR 608496) and the summit of Earl Hill (GR 613426)?

15 What is the length of the main runway at Cairns Airport (GR 666328)?

16 Estimate the distance by road from Cairns Airport (GR 666328) to Palm Cove (GR 583478).

17 Calculate the time it would take to travel from Cairns Airport (GR 666328) to Palm Cove (GR 583478) at an average speed of 60 km/h.

18 Estimate the area of Admiralty Island.

19 What is the height of the landform feature at GR 748281?

20 What is the difference in elevation of Earl Hill (GR 613426) and Red Peak (GR 581365)?

21 Estimate the local relief in AR 6142.

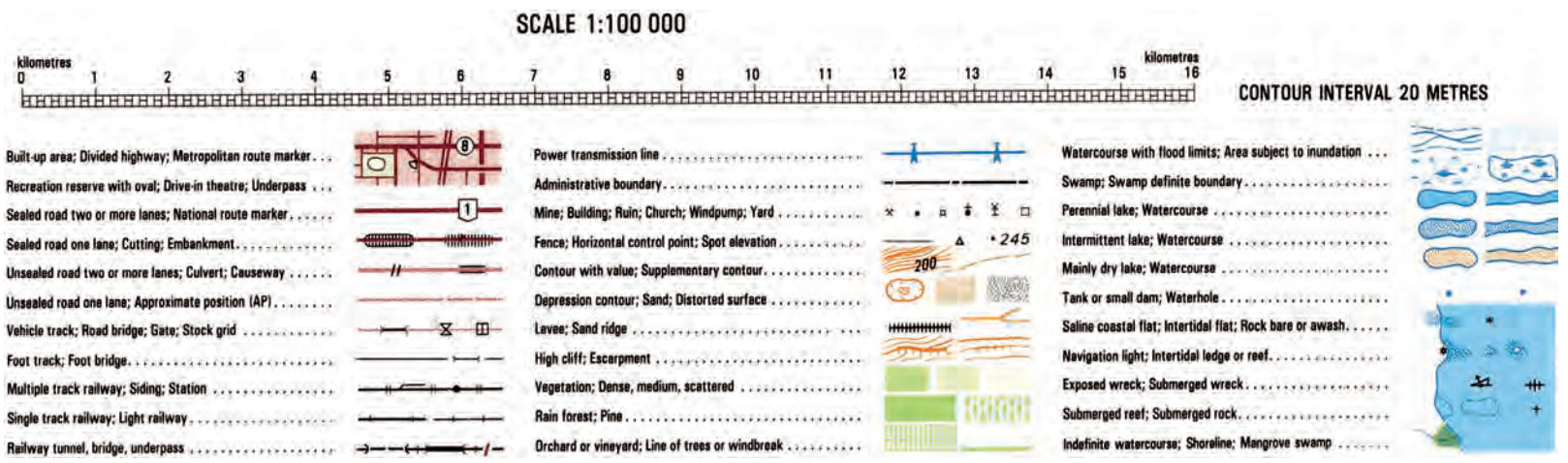
22 Calculate the gradient of the slope between the spot height at GR 748281 and the building at GR 745267.

23 What is the type of settlement pattern found in AR 6828?

24 What is the gauge of the railway passing through the Barron Gorge?

25 Study Video 3.20a (AR 5847) then complete the following activities:
- **a** State the direction in which the drone is moving.
- **b** Describe the nature of the landscape revealed by the drone footage.
- **c** Name the mountain range seen in the background.
- **d** Outline the evidence suggesting that the area receives relatively large amounts of rainfall.
- **e** Outline why tourists would find this a popular holiday destination.
- **f** Speculate on the fate of the area shown as the sea level rises.

26 Construct a precis map showing the relationship between landform, settlement and transport infrastructure in the area shown on the topographic map extract. Use the Google Earth image to highlight the spread of urban development since 1989.



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Grant Kleeman

Cairns topographic map extract (Cairns: latitude 16°55′S, longitude 145°46′E)

ISBN 978-1-009-07583-1

Grant Kleeman

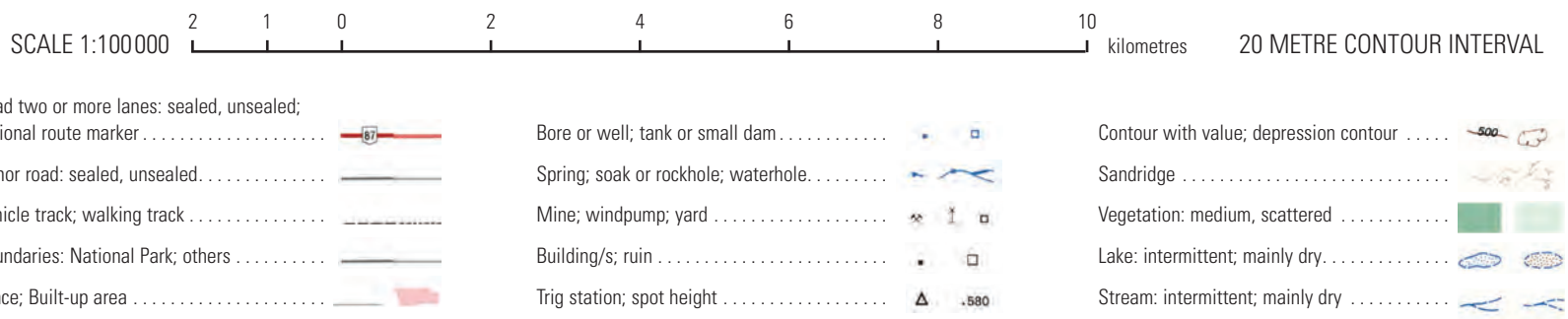
3.21 Uluṟu (NT) topographic map extract

Figure 3.21a Kata Tjuṯa (the Olgas)

Figure 3.21b Uluṟu

Figure 3.21c Kata Tjuṯa (the Olgas) from above, Google Earth, Image © 2016 CNES / Astrium, © 2016 Google

Figure 3.21d Uluṟu from above, Google Earth, © 2016 Google, Image © 2016 DigitalGlobe



Note: Since the Uluṟu topographic map extract was produced, the Yulara Tourist Village has been renamed Ayers Rock Resort and the Yulara Aerodrome has been renamed Ayers Rock Airport.

ACTIVITIES

1 What is the scale of the main map extracts?

2 What is the contour interval used on the map extract?

3 What is the Aboriginal name for the Olgas?

4 Identify the feature of the biophysical environment located at:
   a GR 750002 b GR 039957.

5 Identify the feature of the constructed environment located at:
   a GR 032935 b GR 005077
   c GR 755014 d GR 989029.

6 What type of vegetation cover is found in the area covered by the map extract?

7 What type of land use is centred on GR 000070?

8 What is the direction of Voyages Sails in the Desert hotel (AR 0007) from Uluṟu (Ayers Rock, AR 0495)?

9 Identify the feature of the built environment located 10 km to the north of the Entrance station (AR 9802).

10 What is the aspect of the slope in AR 0595?

11 What is the bearing of the summit of Uluṟu (GR 045952) from the Sunset Viewing Area at GR 008972?

12 What is the length of the runway at Ayers Rock Airport (AR 9813)?

13 What is the straight-line distance between the summit of Uluṟu (GR 045952) and the Voyages Ayers Rock Resort (GR 004073)?

14 Estimate the distance by road from Ayers Rock Airport (GR 988124) to the intersection at GR 039941.

15 Calculate the time it would take to travel from Ayers Rock Airport (GR 988124) to the Voyages Sails in the Desert hotel (GR 004070) at an average speed of 60 km/h.

16 Estimate the area of Uluṟu.

17 Estimate the density of buildings in AR 0794.

18 What is the height of Uluṟu?

19 What is the height of Mount Olga (GR 750002)?

20 What is the difference in elevation of Uluṟu and Mount Olga?

21 What is the local relief in AR 0495?

22 Calculate the gradient of the slope between GR 750002 and GR 736999.

23 Study the inset map of Uluṟu and complete the following tasks:
   a Construct the cross-section from point A to point B.
   b Construct the cross-section from point C to point D.

24 Calculate the vertical exaggeration of the cross-sections you drew in Activity 23.

25 Name the drainage pattern evident in the area occupied by Kata Tjuṯa.

26 Study Figures 3.21a and 3.21b. Construct a photo sketch of at least one of these photographs.

27 Undertake internet research to investigate the geological history of Uluṟu and Kata Tjuṯa.

28 Study Figures 3.21c and 3.21d. What do these aerial photographs tell us about the structure of Kata Tjuṯa and Uluṟu?

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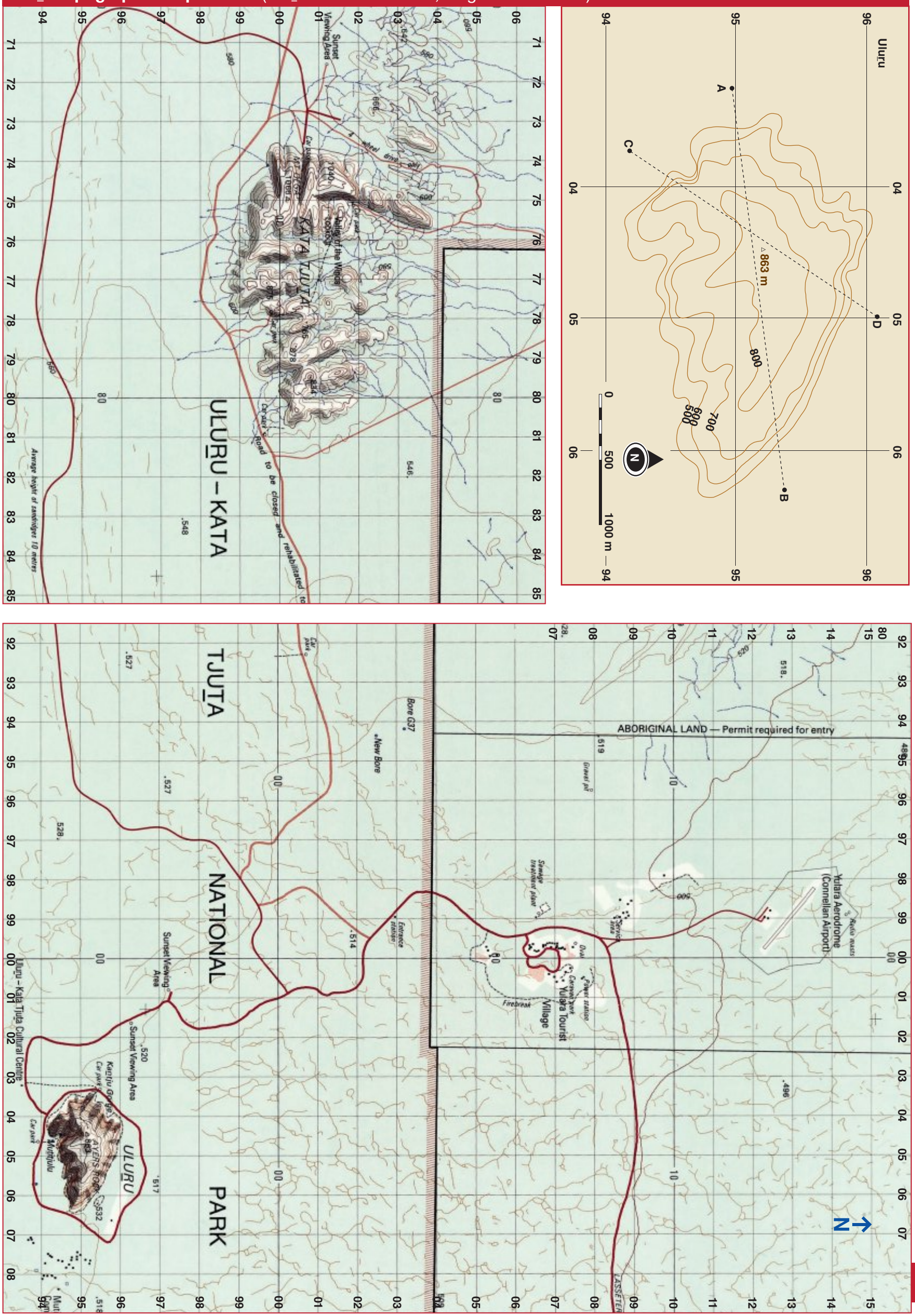
Uluṟu topographic map extract (Uluṟu: latitude 25°21′S, longitude 131°05′E)



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3.22 Gallipoli (Turkey) topographic map extract

The Gallipoli campaign

When World War I broke out in August 1914, the Ottoman Empire (Turkey) remained neutral. At first it was unwilling to side with either the Central Powers (Germany and Austro-Hungary) or the Allies (Britain, France and Russia). Within months, however, Turkey sided with Germany. Britain and France officially declared war on the Ottoman Empire in November 1914.

With the war in Europe at a stalemate, the British sought to open a new front in the east from which to attack Germany. To achieve this strategic objective they decided to send a naval force through the heavily defended Dardanelles (the waterway connecting the Aegean Sea to the Sea of Marmara) to capture Constantinople (now Istanbul, the Turkish capital).

A fleet of 16 British and French battleships and cruisers moved into the Dardanelles early on 18 March 1915. The French battleship *Bouvet* hit a mine and sank within minutes, resulting in the loss of nearly 600 lives. Two British battleships were also destroyed and three other vessels were crippled. By the end of the day the fleet had abandoned its attempt to break through the Turkish defences. Turkey had defeated the world's greatest naval power.

The British and French commanders were convinced that they could not force their way through the Dardanelles without first silencing Turkey's land-based guns.

Planning for the invasion of the Gallipoli Peninsula started immediately. An army of British, Australian, New Zealand, Indian and French soldiers was assembled in Egypt and on the Greek islands close to the peninsula. British troops were to make the main landing at Cape Helles, at the tip of the peninsula. Shortly before the British landing, troops from the Australian and New Zealand Army Corps (ANZAC) were to land to the north at Gaba Tepe.

At dawn on 25 April 1915 the first Anzac troops landed at North Beach (the location of the existing Anzac Memorial and Dawn Service site) and at Anzac Cove, just south of the nearby headland, Ari Burnu. The aim was to capture the strategically important Sari Bair Range and then advance inland to Mal Tepe to cut off the movement of Turkish reinforcements to Cape Helles.

Turkish resistance was light at first, but as the day progressed Turkish defences were strengthened. The Allies' objectives for the day were never achieved. Turkish forces pushed the exhausted Anzac troops back to their beachhead (a footing gained on hostile shores by an army). Field commanders called for the immediate withdrawal of the troops, but were instead ordered by their superiors to dig in and wait for further orders. For the following four months Allied forces remained dug in at their beachhead. All their attempts to break out were cut off by the Turkish forces, whose defensive positions occupied the higher ground.

In August 1915, one final attempt was made to break the stalemate. Thousands of additional British troops landed at Suvla Bay, to the north of the Anzac positions. At the same time, Anzac troops mounted an attack from the Anzac beachhead and an assault on Turkish positions at Lone Pine (see Figure 3.22j, page 125). It became known as the 'August Offensive'. While the offensive increased the area occupied by Allied forces, it failed to break the stalemate.

Supplies of weapons, ammunition, fresh food and drinking water were all in short supply. Casualties on both sides were very heavy. Many deaths were caused by disease. At times the proportion of the Allied forces who were sick reached almost 50 per cent. A common illness was dysentery (an infection of the intestines resulting in severe diarrhoea), and the smell of rotting bodies hung over the battlefield.

By November 1915 the British and French governments concluded that the Gallipoli campaign should end. The evacuation commenced in December. It was completed in early January 1916, by which time more than 83 000 men had been evacuated from the beachhead.

From a strategic and operational point of view, the Gallipoli landings were a failure. The Gallipoli campaign cost Australia 26 111 casualties, including 8709 deaths. The campaign would, however, be a defining event in Australian history. It helped to shape a national identity and was the birth of the Anzac tradition.

Figure 3.22a Anzac Cove viewed from Hell Spit, 1915. Ari Burnu can be seen in the background. Watson's Pier is towards the top of the photograph.

Figure 3.22b Anzac Cove, 1915. This is a hand-coloured photograph.

Figure 3.22c Anzac Cove, 2016. Ari Burnu can be seen in the background.

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Figure 3.22d North Beach, the principal Anzac landing place, viewed from Ari Burnu. The Sphinx can be seen in the background. The rail line was used to move supplies to and from Anzac Cove.

Figure 3.22e North Beach viewed from Ari Burnu, 2000

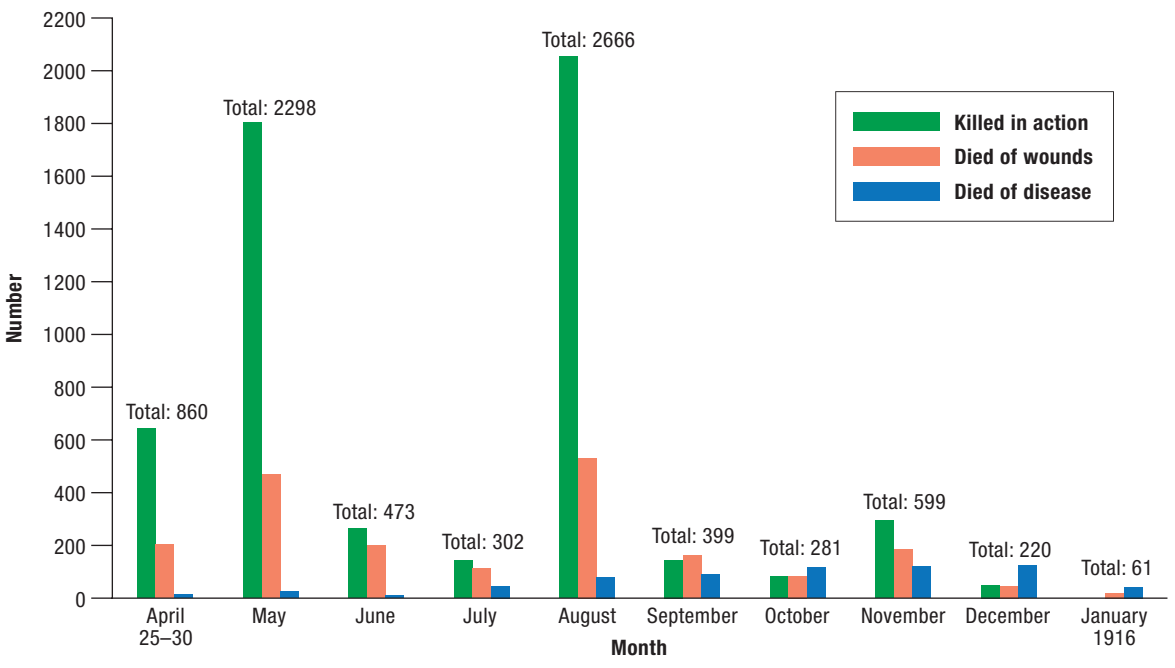

Figure 3.22f Australians killed at Gallipoli, 25 April 1915 to 8 January 1916

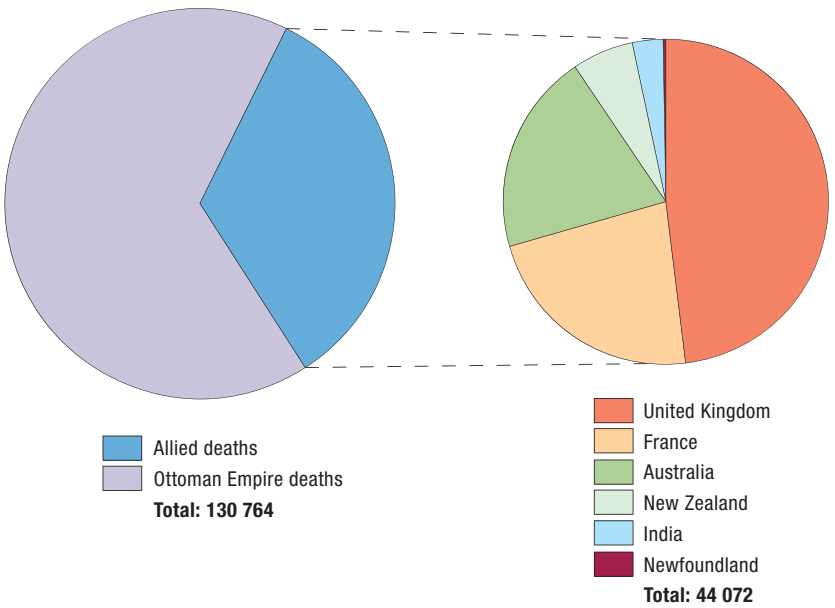

Figure 3.22g Gallipoli casualties

Topography

Overlooking Anzac Cove is a steep, sloping natural amphitheatre (a level area of land surrounded by a semi-circular rising slope) and escarpment. Immediately beyond Ari Burnu point, at the northern end of Anzac Cove, lies North Beach. Further north lies Ocean Beach, which sweeps away to the north in a great semi-circle towards the lowlands of Suvla Bay.

Along this coastline, steep and sparsely vegetated spurs run down to the sea from a range of high hills. Immediately behind North Beach is the distinctive landform feature known as 'The Sphinx' (Yuksek Tepe). This is a weathered pinnacle from which the ground falls steeply away into deep, narrow gullies.

You may notice that several of the maps in this section include names used by Australian soldiers during World War I. If you look at a current map of Gallipoli, you will see that the land is now in local use, with names in the Turkish language.

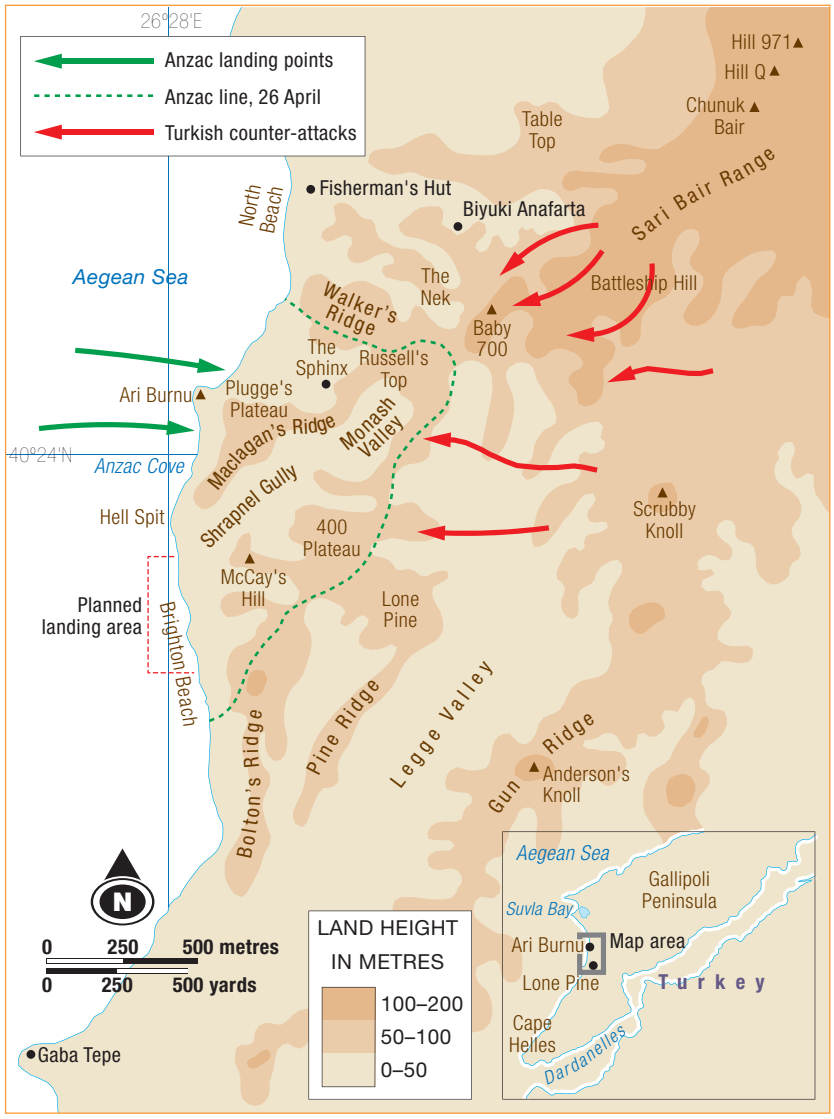

Figure 3.22h Territory occupied by Anzac troops on 25–26 April 1915

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The Maclaurin Map

Maps play an important part in war strategy. The map shown in Figure 3.22i was used by Colonel Henry Maclaurin, commander of the 1st Brigade, at the Anzac Cove landing. Maclaurin was born in Sydney in 1878, and worked as a barrister before enlisting in the AIF (Australian Imperial Force). He was killed at Gallipoli on 27 April 1915 by a Turkish sniper. Before the landing, Maclaurin marked on the map the position of the Turkish defences and coloured in the contours Because the map was drawn in 1914, the scale used Imperial rather than metric measurements - 1:40000 ft..

Gallipoli topographic map extract (Gallipoli: latitude 40°24′N, longitude 26°27′E)

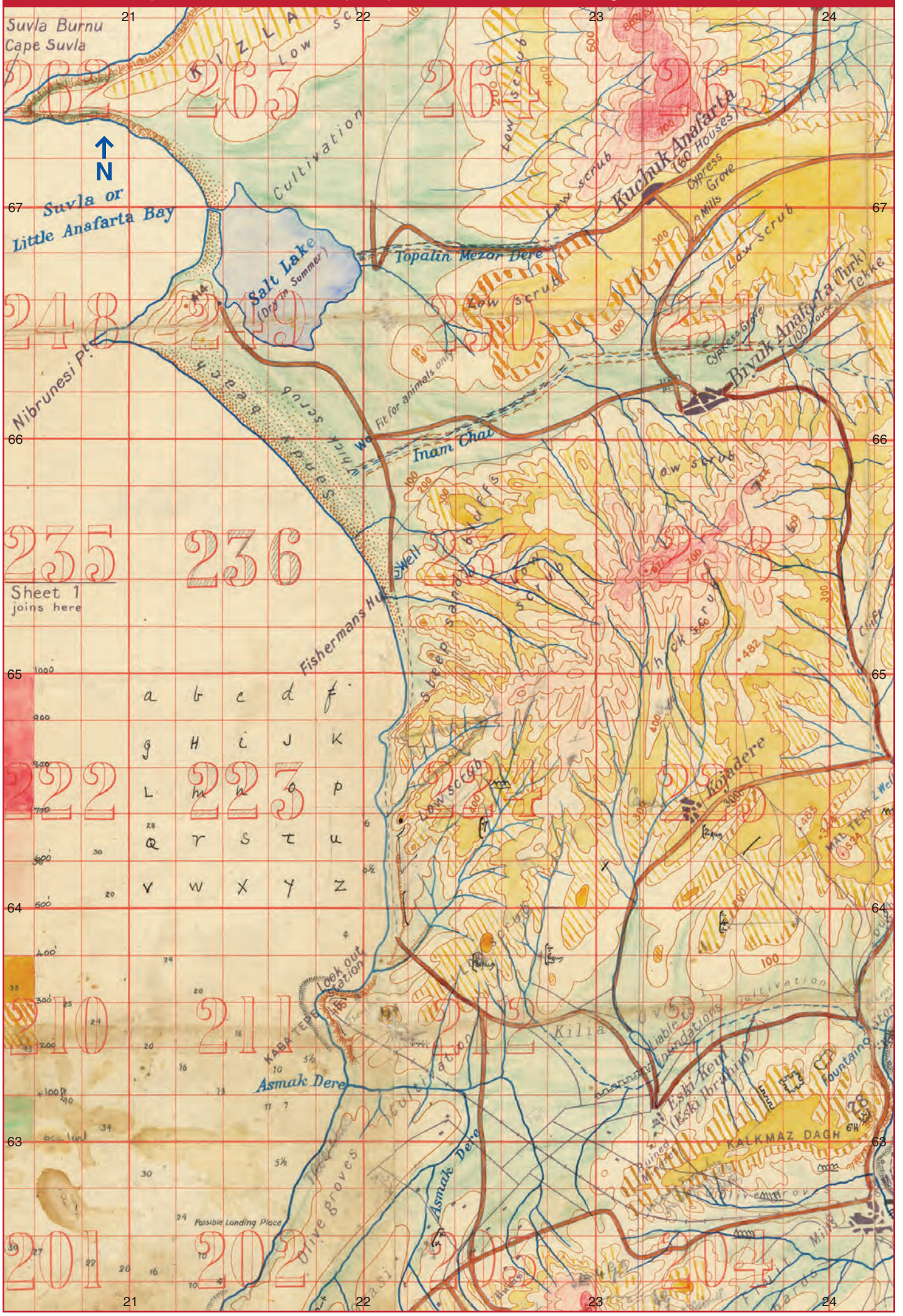

Figure 3.22i An extract from the Maclaurin Map

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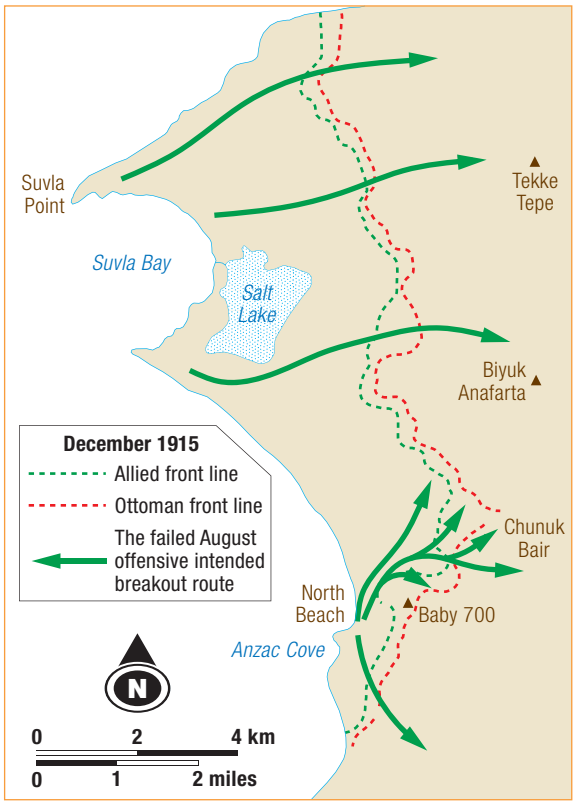

Figure 3.22j The front line at Gallipoli, August–December 1915

Turkish map of Anzac encampment, 2016

The map shown in Figure 3.22k was drawn for the Turkish Mapping Directorate after the evacuation of the Allies from Gallipoli in December 1915 and January 1916. Place names were printed in Ottoman Turkish, with English translations added later.

Above Ari Burnu you can see the piers built on North Beach. At the end of the first pier (called Williams Pier by the Anzacs) the ship called *The Milo* can be seen. This ship was grounded to act as a breakwater. Leading from the piers are tramways, which were used to move supplies from the piers to Anzac Cove. The map shows four grounded boats at Anzac Cove. One of these, a steel lifeboat from HMT *Ascot*, was removed from Anzac Cove in 1921 and is now on display in the Australian War Memorial in Canberra.

Figure 3.22k Turkish map of the Anzac encampment at Gallipoli, 1916

Figure 3.22l Oblique aerial photograph of Ari Burnu Cemetery with Anzac Cove in the background

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1 Anzac Cove
2 North Beach
3 Anzac memorial and dawn service site
4 Ari Burnu
5 The Sphinx
6 Ari Burnu Cemetery
7 Shell Green Cemetery
8 Beach Cemetery
9 Shrapnel Gully Cemetery
10 Lone Pine memorial
11 Hell Spit
12 Shrapnel Gully
13 Plugge's Plateau
14 Walker's Ridge
15 Maclagan's Ridge

Figure 3.22m Satellite photograph of Gallipoli, Google Earth © 2021 Google

ACTIVITIES

1 Read the text 'The Gallipoli campaign' (page 122) and study Figures 3.22h and 3.22i (pages 123 and 124) and then complete the following tasks:
- **a** Locate the following landform features on Figure 3.22i. State the grid reference of each feature:
  - **i** Gaba [Kaba] Tepe
  - **ii** North Beach
  - **iii** Ari Burnu
  - **iv** Anzac Cove
  - **v** Suvla Bay
  - **vi** Baby 700
  - **vii** Nibrunesi Point
  - **viii** Salt Lake.
- **b** Locate the following features of the constructed environment on Figure 3.22h:
  - **i** Fisherman's Hut
  - **ii** Biyuk Anafarta.

2 Study the photographs of Anzac Cove (Figures 3.22a to 3.22c, page 122) and then complete the following tasks:
- **a** Describe the topography of Anzac Cove.
- **b** In groups, discuss the advantages and disadvantages of Anzac Cove as a landing place.
- **c** Write a paragraph explaining why Anzac Cove proved to be such a difficult site from which to mount major military operations.
- **d** Describe the activities taking place in Figures 3.22a and 3.22b.

3 Study Figures 3.22h and 3.22i (pages 123 and 124) and then answer the following questions:
- **a** What is the direction of Baby 700 from Anzac Cove?
- **b** What is the direction of Nibrunesi Point from Anzac Cove?
- **c** What is the general aspect of the slope in AR 2267?
- **d** What is the elevation of Kojadere (AR 2364)?
- **e** What is the difference in elevation between Anzac Cove and the summit of Baby 700?

4 Study Figures 3.22d and 3.22e (page 123) and then complete the following tasks:
- **a** State the direction in which the camera was facing when these photographs were taken.
- **b** Working in groups, discuss the advantages and disadvantages of North Beach as a landing place.
- **c** As a group, decide which of the locations (Anzac Cove or North Beach) was the better location for a large-scale landing of troops and military.

5 Study Figures 3.22f and 3.22g (page 123) and then answer the following questions:
- **a** In which month of the campaign was the largest number of Australians killed?
- **b** Why did the number of troops killed in action peak in the month identified in part a?
- **c** Which was the second-most costly month in terms of the numbers killed in action and those who died from their wounds?
- **d** In what month did the number of deaths from disease peak?
- **e** What proportion of troops killed were from the Ottoman Empire (Turkey)?
- **f** Which Allied country had the greatest number of troops killed during the Gallipoli Campaign?
- **g** What proportion of total Allied deaths was Australian?
- **h** How many New Zealand troops were killed at Gallipoli?

6 Study Figure 3.22h (page 123) and then complete the following tasks:
- **a** Estimate the area of land occupied by Anzac forces on 25–26 April 1915.
- **b** Name the planned site of the Gallipoli landing. Describe its location relative to Anzac Cove.

7 Study Figure 3.22i (page 124) and then complete the following tasks:
- **a** Construct a precis map featuring the topography of the area covered by the map.
- **b** Describe the nature of the topography in the area around Anzac Cove and North Beach.
- **c** Working in groups, discuss how this topography hindered attempts by Anzac troops to achieve the campaign's military objectives.
- **d** Suggest why the topography south of Gaba Tepe meant that the campaign's planners selected that area as the most suitable for a landing site.

8 Study Figure 3.22m and then complete the following tasks:
- **a** Write a paragraph describing the landscape of Anzac Cove and the surrounding area.
- **b** Based on your observations, explain why North Beach, rather than Anzac Cove, was selected for the annual Anzac Dawn Service.

9 Study Figure 3.22m. Locate the following locations, each of which holds an important place in the history of the Gallipoli Campaign. Try locating them on Figure 3.22j (page 125).
- **a** Plugge's Plateau
- **b** The Sphinx
- **c** Walker's Ridge
- **d** Ari Burnu
- **e** Shrapnel Gully
- **f** Maclagan's Ridge.

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SECTION 4 New Zealand

4.1 New Zealand

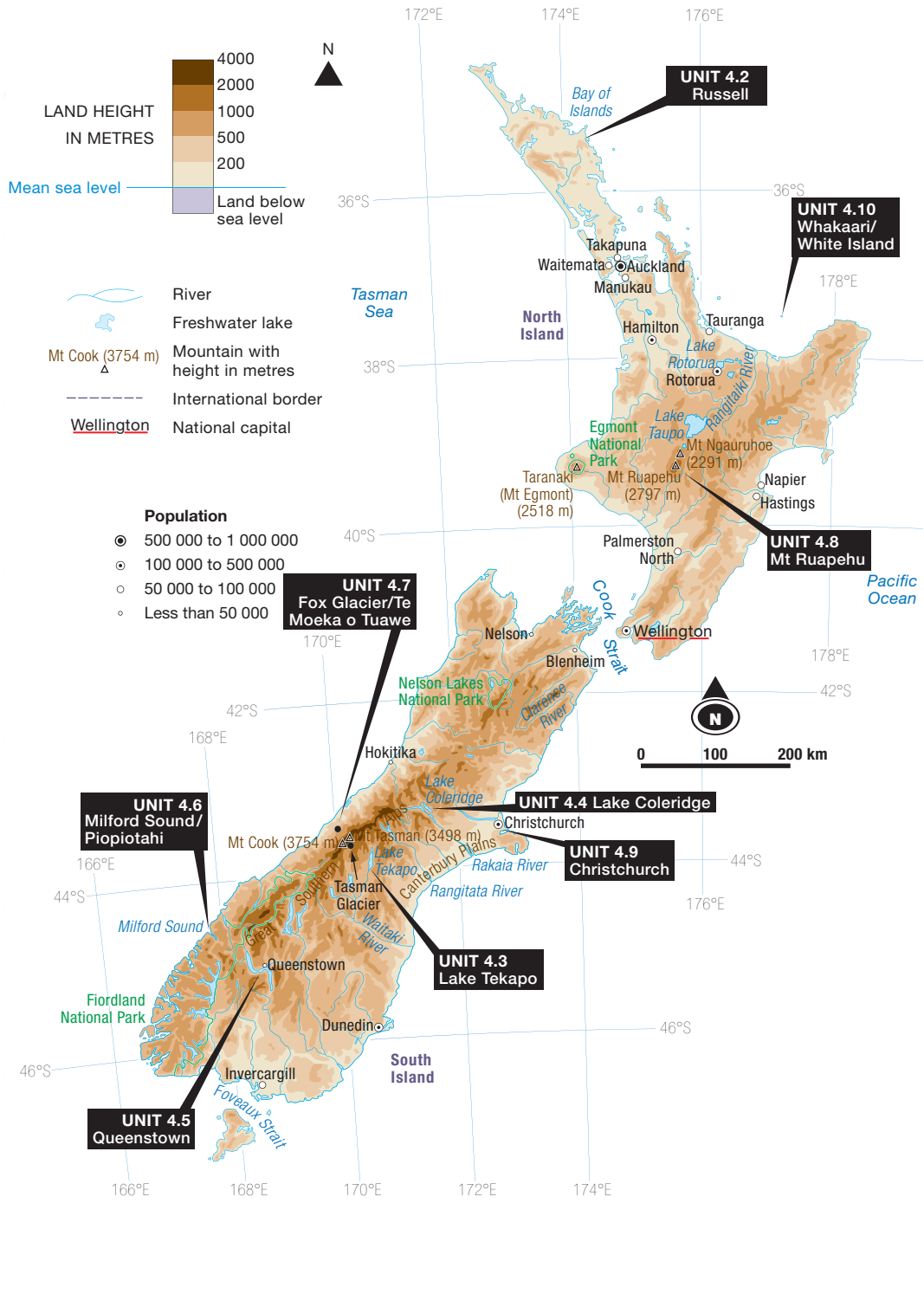

Figure 4.1b Russell, North Island, New Zealand

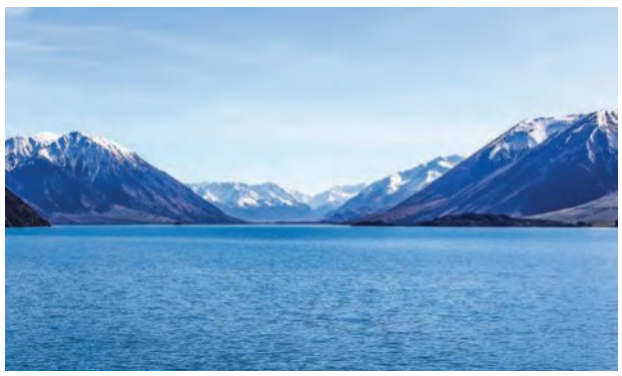

Figure 4.1c Lake Coleridge

Figure 4.1d Lake Tekapo

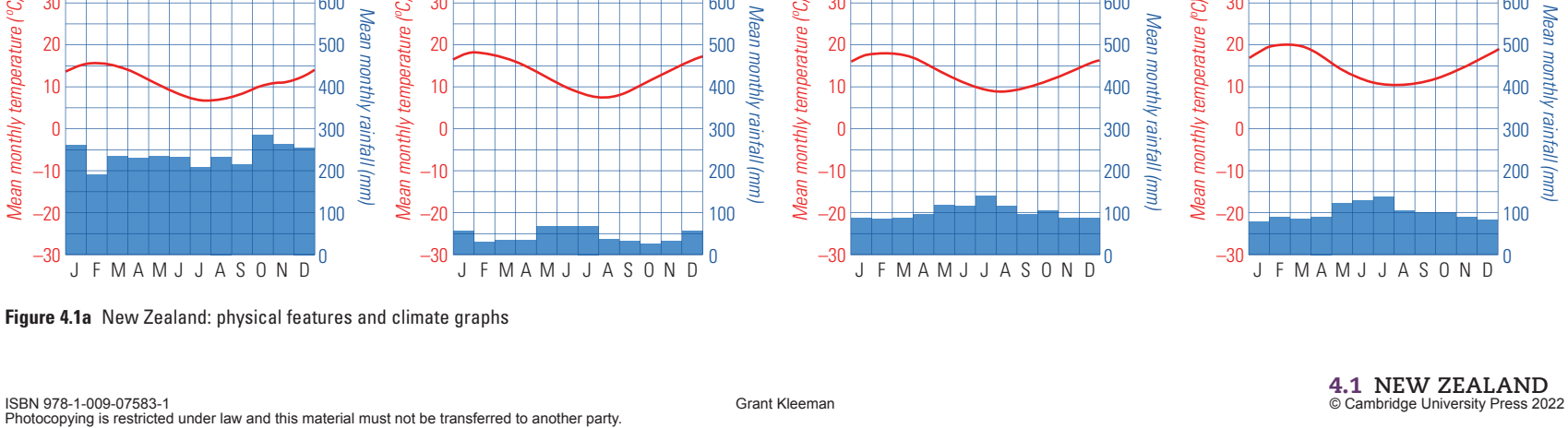

Figure 4.1a New Zealand: physical features and climate graphs

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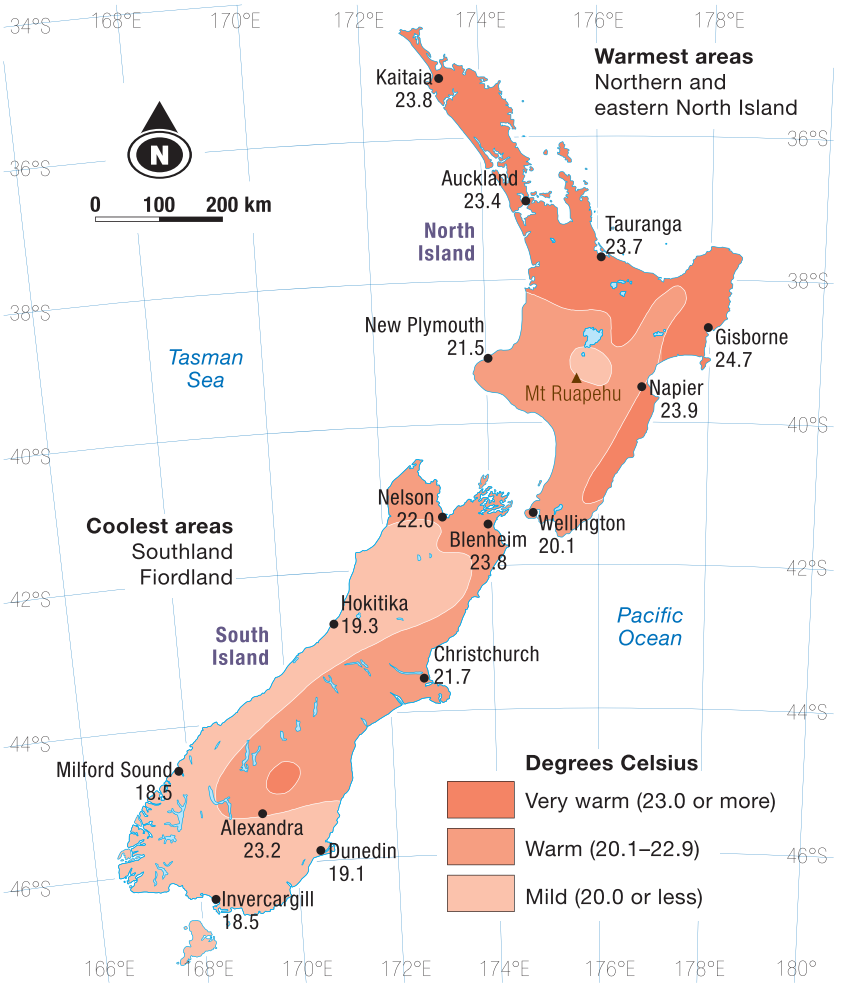

Figure 4.1e Maximum temperature (midsummer daily average)

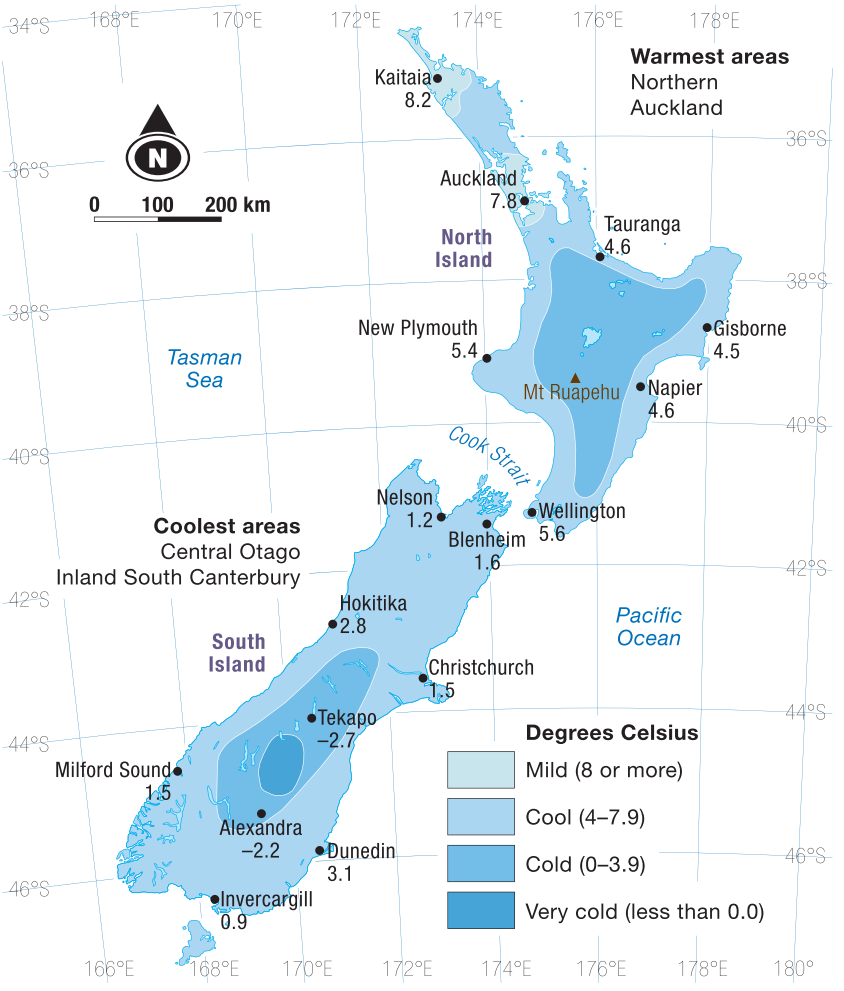

Figure 4.1f Minimum temperature (midwinter daily average)

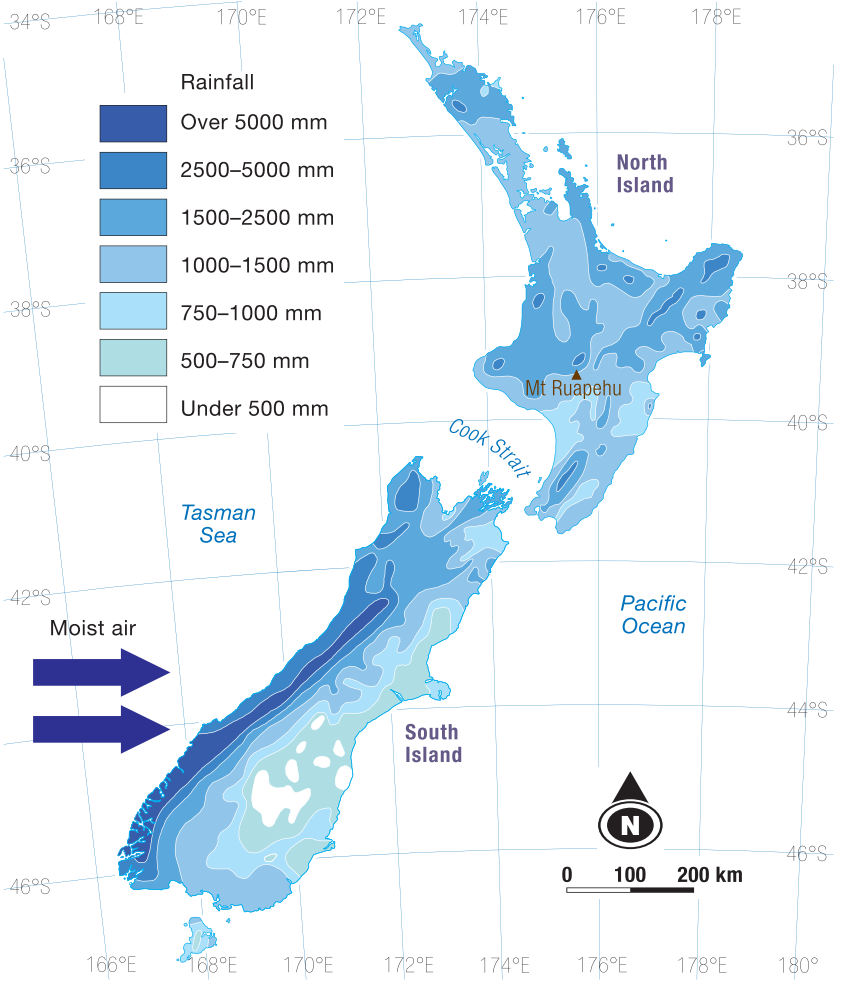

Figure 4.1g Annual average rainfall

ACTIVITIES

1 Study an atlas map of New Zealand and then complete the following tasks:
- a What is the capital city of New Zealand?
- b What is New Zealand's largest city?
- c List the New Zealand cities with a population greater than 100 000.
- d What strait separates the North Island from the South Island?
- e Name the highest peak on the South Island.
- f Name the highest peak on the North Island.
- g What mountain range runs the length of the South Island?
- h Name the feature of the physical environment located at the following latitudes and longitudes:
  - i 39°18′S, 174°05′E
  - ii 43°28′S, 170°10′E
  - iii 43°33′S, 170°10′E
  - iv 44°41′S, 167°55′E
  - v 46°30′S, 168°00′E
  - vi 39°18′S, 175°34′E.
- i Name the urban centre located at each of the following latitudes and longitudes:
  - i 38°09′S, 176°15′E
  - ii 46°25′S, 168°21′E
  - iii 45°02′S, 168°40′E
  - iv 45°53′S, 170°31′E
  - v 36°52′S, 174°45′E
  - vi 41°17′S, 174°47′E.
- j What is the straight-line distance between:
  - i Auckland and Wellington
  - ii Dunedin and Auckland?
  - iii Nelson from Wellington
  - iv Rotorua from Auckland?
- k What is the direction of:
  - i Wellington from Christchurch
  - ii Queenstown from Christchurch

2 Study the climate graphs in Figure 4.1a (page 127) and then answer the following questions.
- a Which station has:
  - i the highest mean monthly temperature
  - ii the lowest mean monthly temperature
  - iii the highest annual rainfall
  - iv the lowest annual rainfall?
- b What is the annual temperature range of the following:
  - i Auckland
  - ii Christchurch
  - iii Wellington
  - iv Hokitika?

3 Study Figures 4.1e to 4.1g and then answer the following questions.
- a What parts of New Zealand have midsummer daily average temperatures of more than 23.0°C (very warm)?
- b What parts of New Zealand have midwinter daily average temperatures below 0°C (very cold)?
- c Explain the pattern of average temperature on New Zealand's South Island.

4 Compare Figure 4.1a (page 127) and the map showing the annual distribution of rainfall (Figure 4.1g). Explain the annual distribution of rainfall.

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4.2 Russell topographic map extract

Russell topographic map extract (Russell: latitude 35°15′42′S, longitude 174°7′20′E)

SCALE 1:50 000

THE VERTICAL INTERVAL BETWEEN THE CONTOURS IS 20 METRES

1 0 1 2 3 4 5 kilometres

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 016997
- b GR 002949
- c GR 993973
- d GR 054004.

4 Identify the feature of the constructed environment located at:
- a GR 983973
- b GR 985969
- c GR 069998.

5 What is the area reference of Russell township?

6 What type of economic activity is found in AR 0394?

7 Name the type of vegetation found in AR 9796.

8 What is the direction of Tikitikioure (AR 0594) from Russell (AR 0297)?

9 What is the bearing of Tikitikioure (AR 0594) from Oturori Rock (GR 042987)?

10 What is the bearing of Captain Cook's Anchorage (AR 0699) from Hermione Rock (AR 9997)?

11 What is the straight-line distance between Tapeka Point (GR 021996) and Captain Cook's Anchorage (GR 069998)?

12 What is the length of the ferry run between Piahia (GR 993953) and Russell (GR 020974)?

13 What is the area of Motuarohia Island?

14 What is the density of buildings in AR 9794?

15 What is the difference in elevation of Tikitikioure (AR 0594) and Malki Hill (AR 0297)?

16 Study Video 4.2a (GR 018990). Describe the site of the settlement shown. Explain why people might choose to live in such a place.

Russell, the settlement after which this map has been named, was the first permanent European settlement and seaport in New Zealand. Nearby are the towns of Paihia and Waitangi. All are located in New Zealand's scenic Bay of Islands.

Waitangi is best known for being the location where the Treaty of Waitangi was first signed on 6 February 1840 between 500 Māori chiefs and representatives of the British Crown. It is also the place where He Whakaputanga o te Rangatiratanga o Nu Tirene, the Declaration of Independence of New Zealand, had been signed five years prior, on 28 October 1835 by 34 northern Māori chiefs. The He Whakaputanga agreement is regarded as the basis for Māori claims to self-determination.

Video 4.2a Aerial footage in the Bay of Islands (**00:35**)

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4.3 Lake Tekapo topographic map extract

Lake Tekapo topographic map extract (Lake Tekapo: latitude 44°01´S, longitude 170°29´E)

ACTIVITIES

1 What is the scale of the Lake Tekapo topographic map extract?

2 What is the contour interval used on the Lake Tekapo topographic map extract?

3 Identify the feature of the biophysical environment located at the following grid references:
- a GR 045309
- b GR 970320
- c GR 013319
- d GR 965275.

4 Identify the feature of the constructed environment located at the following grid references:
- a GR 979235
- b GR 967266
- c GR 973288
- d GR 026277.

5 Identify the productive activity taking place in AR 9623.

6 State the type of vegetation found at GR 000240.

7 Estimate the area of the following features:
- a Lake McGregor
- b Motuariki Island.

8 What is the density of buildings in AR 9626?

9 What is the straight-line distance between the summit of Mt John (AR 9626) and the summit of Mt Hay (AR 0430)?

10 What is the water surface height, or elevation, of:
- a Lake Tekapo
- b Roys Lagoon?

11 What is the difference in elevation of Mt Hay (AR 0430) and Wee McGregor (AR 0631)?

12 What is the local relief experienced in a traverse from the summit of Mt Hay (AR 0430) to the summit of Wee McGregor (AR 0631)?

13 What is the aspect of the slope in AR 0423?

14 What is the bearing of Mt John (AR 9626) from Mt Hay (AR 0430)?

15 Construct a cross-section from the summit of Mt Hay (AR 0430) to the summit of Wee McGregor (AR 0631) using a vertical scale of 1 cm = 100 m.

16 Calculate the vertical exaggeration of the cross-section drawn in Activity 15.

17 Calculate the gradient of the slope between the spot height in AR 0523 and GR 045240.

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4.4 Lake Coleridge topographic map extract

Lake Coleridge topographic map extract (Lake Coleridge: latitude 43°22′S, longitude 171°32′E)

ACTIVITIES

The scale on page 130 can also be used for this map.

1 Identify the feature of the biophysical environment located at:
   a GR 870993 b GR 839030
   c GR 850065.

2 Identify the feature of the constructed environment located at:
   a GR 772012 b GR 823001
   c GR 855998.

3 What is the grid reference of Lake Coleridge power station?

4 Name the type of vegetation found at GR 825038.

5 What waterway flows into Lake Coleridge at GR 815047?

6 What is the direction of Round Hill (AR 8207) from Peak Hill (AR 7702)?

7 In what direction is Ryton River flowing in AR 8107?

8 What is the bearing of Round Hill (AR 8207) from Laings Hill (GR 850065)?

9 What is the aspect of the slope in AR 8606?

10 Estimate the straight-line distance between the summit of Peak Hill (AR 7702) and the summit of Mt Barker (GR 870993).

11 What is the length of the Lake Coleridge power station hydro-electricity tunnels and pipelines?

12 What is the density of buildings in AR 8599?

13 What is the elevation of Lake Coleridge?

14 Estimate the height of the following landform features:
   a GR 862014 b GR 829027.

15 What is the difference in elevation of Peak Hill (AR 7702) and Mt Barker (GR 870993)?

16 Estimate the local relief experienced on a traverse from the summit of Carriage Drive (AR 8007) to the summit of Round Hill (AR 8207).

17 Construct the cross-section from point 1 to point 2 using a vertical scale of 1 cm = 200 m.

18 Calculate the vertical exaggeration used for the cross-section drawn in Activity 17.

19 What is the gradient of the slope between the summit of Peak Hill (AR 7702) and the water's edge at GR 785037?

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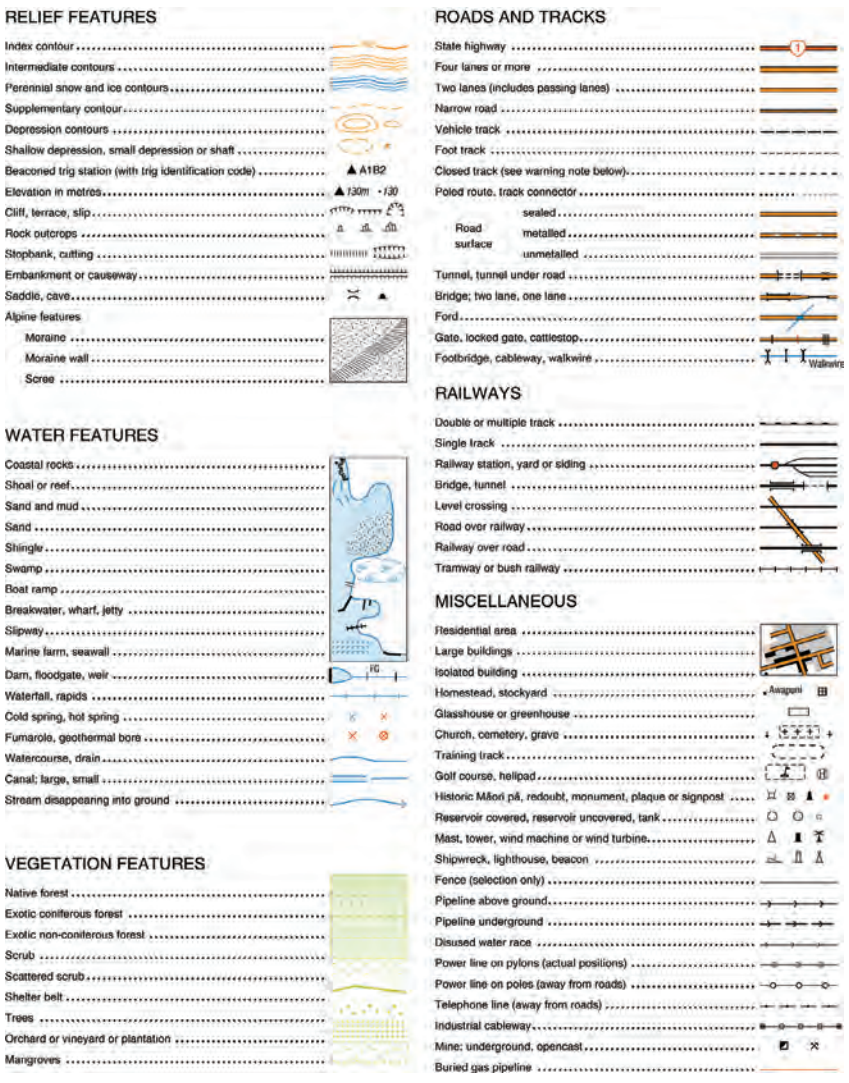
4.5 Queenstown topographic map extract

Queenstown is a resort destination located in the south-west of New Zealand's South Island. It is situated at Queenstown Bay on Lake Wakatipu, which is a waterway shaped by glaciers. The town is especially popular with winter sports enthusiasts. Some of New Zealand's most popular ski resorts are nearby.

Figure 4.5a Photograph of Queenstown



ACTIVITIES

1 What is the scale of the Queenstown topographic map extract?

2 What is the contour interval used on the Queenstown topographic map extract?

3 Identify the feature of the biophysical environment located at the following grid references:
- a GR 545069
- b GR 645089
- c GR 603097
- d GR 637077.

4 Identify the feature of the constructed environment located at the following grid references:
- a GR 573049
- b GR 594031
- c GR 638051
- d GR 644058.

5 What type of vegetation is found in AR 5705?

6 Name the two rivers that merge in AR 6606.

7 What creek flows into the lake at GR 537013?

8 In what direction is the Shotover River flowing in AR 6209?

9 What is the direction of Ferry Hill (AR 6408) from central Queenstown?

10 What is the aspect of the slope in AR 6005?

11 What is the bearing of Ferry Hill (GR 645089) from Peninsula Hill (GR 632036)?

12 What is the bearing of Queenstown Hill (GR 605071) from Peninsula Hill (GR 632036)?

13 What is the straight-line distance between the summit of Queenstown Hill (GR 605071) and Peninsula Hill (AR 632036)?

14 What is the length of the Skyline Gondola (AR 5704)?

15 Estimate the area of Lake Johnson.

16 What is the elevation of Lake Wakatipu?

17 Construct the cross-section from the summit of Queenstown Hill (GR 605071) to the summit of Peninsula Hill (GR 632036) using a vertical scale of 1:200 m.

18 Calculate the vertical exaggeration of the cross-section from Queenstown Hill (GR 605071) to the summit of Peninsula Hill (GR 632036).

19 What is the gradient of the slope between the summit of Queenstown Hill (GR 605071) and the shoreline of Lake Wakatipu at GR 615055?

20 What is the gradient of the slope between the summit of Peninsula Hill (GR 632036) and the bridge at GR 638050?

21 Is Arthurs Point (GR 588088) visible from the summit of Peninsula Hill (AR 6303)? Justify your answer.

22 Study Figure 4.5a. In what direction was the camera facing when the photograph was taken?

23 Study Figure 4.5b. Identify the features numbered 1–6.

Figure 4.5b Aerial photograph of Queenstown

SCALE 1:50 000

THE VERTICAL INTERVAL BETWEEN THE CONTOURS IS 20 METRES

1 0 1 2 3 4 5 kilometres

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Grant Kleeman

Queenstown topographic map extract (Queenstown: latitude 45°02´S, longitude 168°40´E)

ISBN 978-1-009-07583-1 Grant Kleeman

4.6 Milford Sound/Piopiotahi topographic map extract

Figure 4.6a Milford Sound

Milford Sound/Piopiotahi is located in New Zealand's Fiordland National Park. The park occupies the south-west corner of New Zealand's South Island. It is the largest of the nation's 14 national parks, with an area of 12 500 km^2. It forms part of the Te Wahipounamu World Heritage site.

When the world was colder, vast glaciers carved many deep fiords in New Zealand. Milford Sound is the most famous (and most frequently visited) of these fiords and if you visit, you can take a boat tour to see around the park.

The Māori name for this place, Piopiotahi, means 'a single piopio'. Piopio birds, like many of New Zealand's native species, are long extinct now. Introduced species have had a devastating effect on New Zealand's unique flora and fauna. At least 64 species are known to have become extinct since humans arrived, including bats, frogs, birds, lizards, and plants.

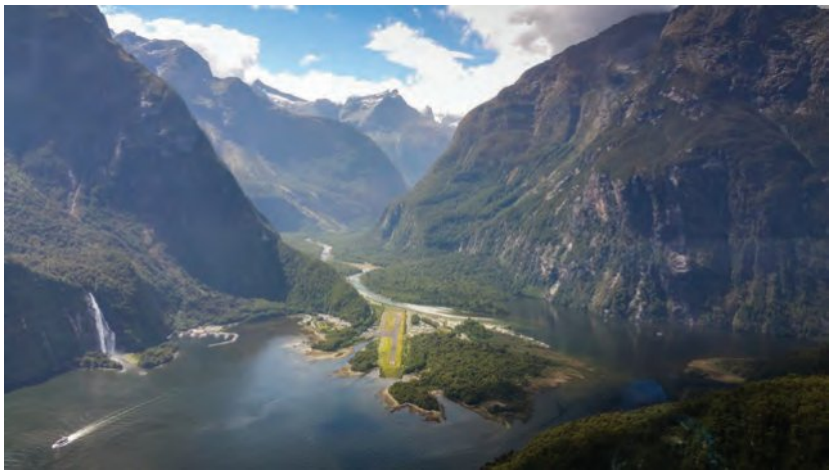
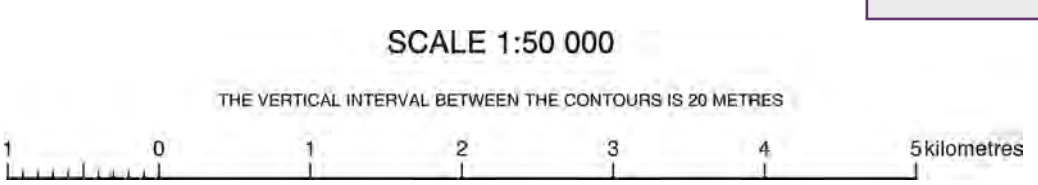


Figure 4.6b Milford Sound settlement and airport

Figure 4.6c Oblique aerial photograph of Milford Sound

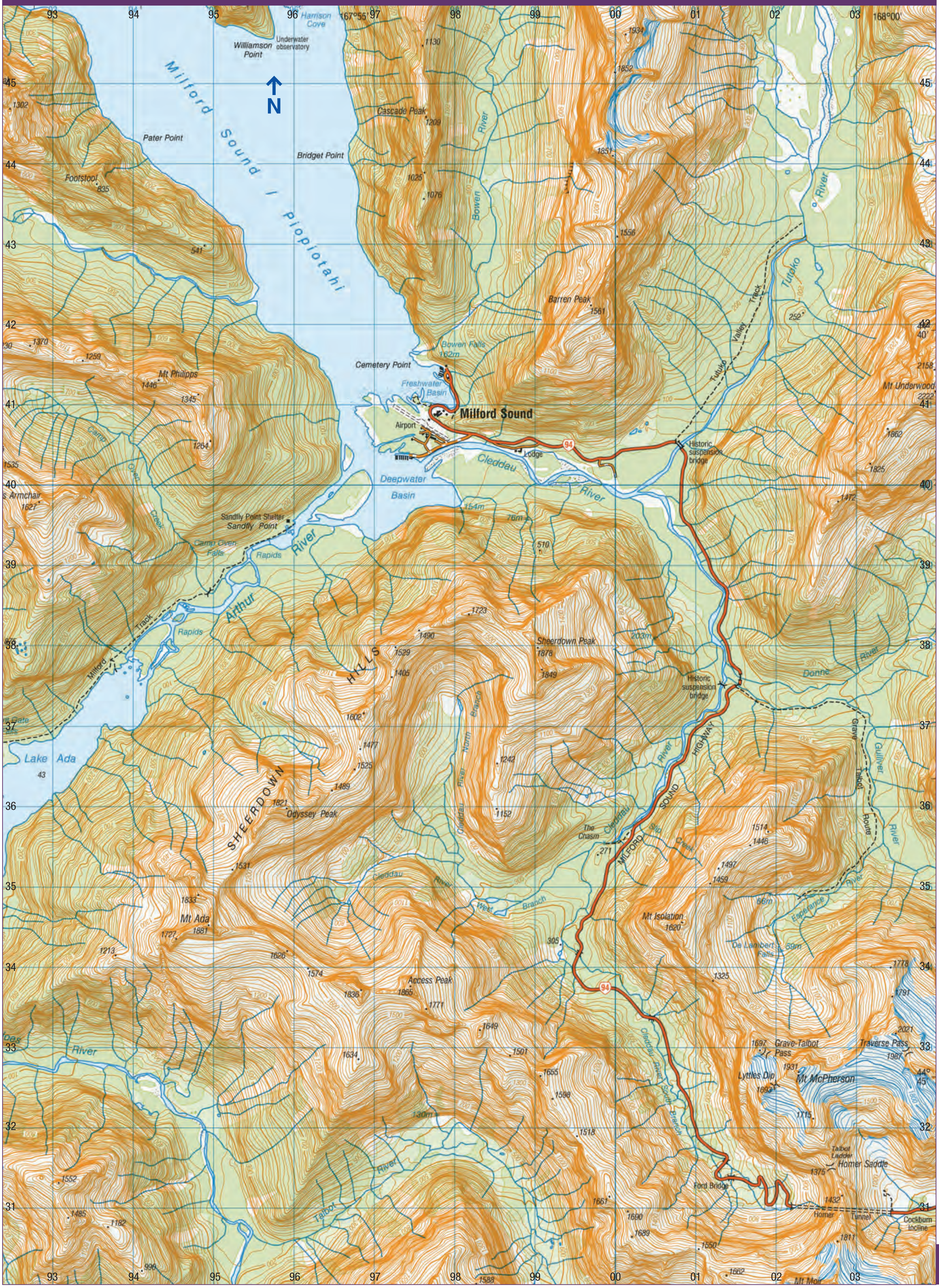


ACTIVITIES

1. Construct a photo sketch of Figure 4.6a.
2. Undertake research. Investigate the geographical processes responsible for the landscape of New Zealand's Fiordland.
3. What is the scale of the map extract?
4. What is the contour interval used on the map extract?
5. Identify the feature of the biophysical environment located at:
   a. GR 977417
   b. GR 957456
   c. GR 027315
   d. GR 997423.
6. Identify the feature of the constructed environment located at:
   a. GR 008405
   b. GR 959396
   c. GR 988405
   d. GR 957456.
7. What is the area reference of Milford Sound Airport?
8. Name the type of biophysical feature found in AR 9441.
9. Name the type of drainage pattern evident in the north-east quadrant of the map.
10. On what waterway is Camp Owen Falls (AR 9439) located?
11. What tributary joins the Cleddau River in AR0039?
12. What river flows into Milford Sound at GR 975416?
13. What is the direction of Sheerdown Peak (AR 9937) from Mt Phillips (AR 9441)?
14. In what direction is the Bowen River flowing in AR 9843?
15. What is the bearing of Mt Phillips (GR 943413) from Barren Peak (GR 997422)?
16. What is the straight-line distance between Barren Peak (GR 997422) and Sheerdown Peak (AR 9937)?
17. What is the distance by road from the Homer Tunnel exit to Milford Sound?
18. What is the length of the Tubuko Valley Track?
19. What is the length of Milford Sound Airport's runway?
20. What is the length of the road tunnel in the south-east quadrant of the map?
21. What is the aspect of the slope in AR 9531?
22. What is the elevation of the historic suspension bridge in AR 0137?
23. What is the difference in elevation of Access Peak (AR 9733) and Mt Ada (AR 9434)?
24. What is the elevation of the surface of Lake Ada?
25. What is the gradient of the slope from the summit of Cascade Peak (AR 9744) to the shoreline of Milford Sound at GR 967445?
26. Study Figure 4.6b. In which direction was the camera facing when this photograph was taken?

ISBN 978-1-009-07583-1

Milford Sound / Piopiotahi topographic map extract (Milford Sound: latitude 44°41´S, longitude 167°47´E)



ISBN 978-1-009-07583-1

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4.7 Fox Glacier/Te Moeka o Tuawe topographic map extract

Figure 4.7a Fox Glacier's retreating base

Figure 4.7b View directly down Fox Glacier. Millions of tons of ice slowly cascade down from peaks of the Southern Alps and terminate within the sub-tropical rainforests of New Zealand's South Island.

Fox Glacier/Te Moeka o Tuawe is a 13 km long glacier located on the west coast of New Zealand's South Island. The glacier flows down 2600 m on its journey from the Southern Alps. During the last ice age, the glacier reached the present coastline.

While Fox Glacier has been retreating for most of the past century, it advanced between 1985 and 2009. In 2006 the average rate of advance was about a metre a week. Since 2009 there has been a significant retreat. Between January 2014 and January 2015 the glacier retreated about 300 m.

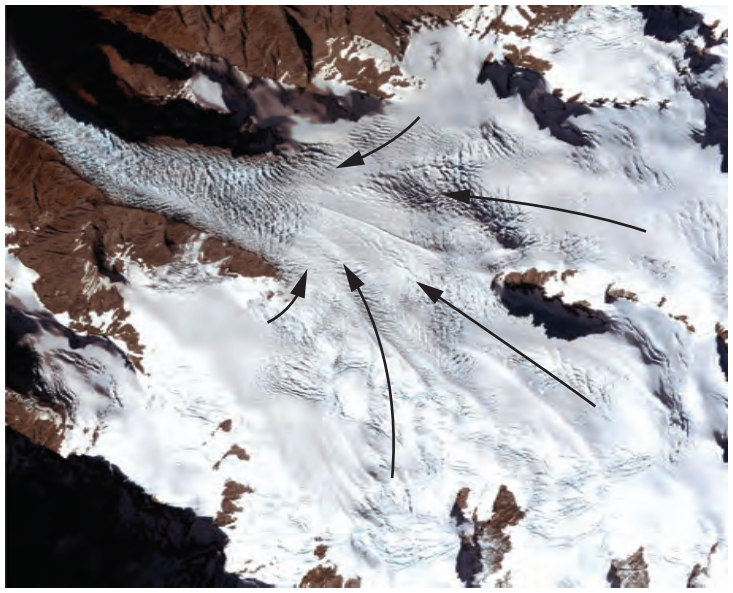

Figure 4.7c Aerial photograph of Fox Glacier, with arrows showing the direction of the flow

SCALE 1:50 000

THE VERTICAL INTERVAL BETWEEN THE CONTOURS IS 20 METRES

1 0 1 2 3 4 5 kilometres

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 600799
- b GR 685785
- c GR 658758
- d GR 638797.

4 Identify the feature of the constructed environment located at:
- a GR 676691
- b GR 598808
- c GR 663785
- d GR 594810.

5 Identify the landform features in AR 6070.

6 Name the two ridges that line each side of Fox Glacier.

7 What is the grid reference of the base of the Fox Glacier?

8 Name the waterway flowing into the lake in AR 6379.

9 What is the general direction of flow of the glaciers shown on the Fox Glacier topographic map extract?

10 What is the direction of flow of Boyd Creek in AR 6377?

11 What is the direction of Chancellor Dome (AR 6878) from Mt Mitchell (AR 6381)?

12 What is the bearing of Mt Mitchell (AR 6381) from Chancellor Dome (AR 6878)?

13 What is the aspect of the slope in AR 6178?

14 What is the distance by road from the intersection in Fox Glacier (GR 587833) to the beginning of the Fox Glacier Access Track (GR 610798)?

15 What is the straight-line distance between the base of Fox Glacier (GR 623793) to GR 685775 via GR 645795?

16 What is the average gradient of Fox Glacier from the base of the glacier (GR 623793) to GR 685775 via GR 645795?

17 State the area references of the flattest sections of Fox Glacier (i.e. the sections with the gentlest gradient).

18 What is the difference in elevation of Chancellor Dome (AR 6878) and Mt Garnier (AR 6577)?

19 What is the elevation of Empress Hut (AR 6769)?

20 Construct the cross-section from point 1 to point 2 using a vertical scale of 1 cm = 200 m.

21 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 20.

22 Draw a photo sketch of either Figure 4.7a or 4.7b.

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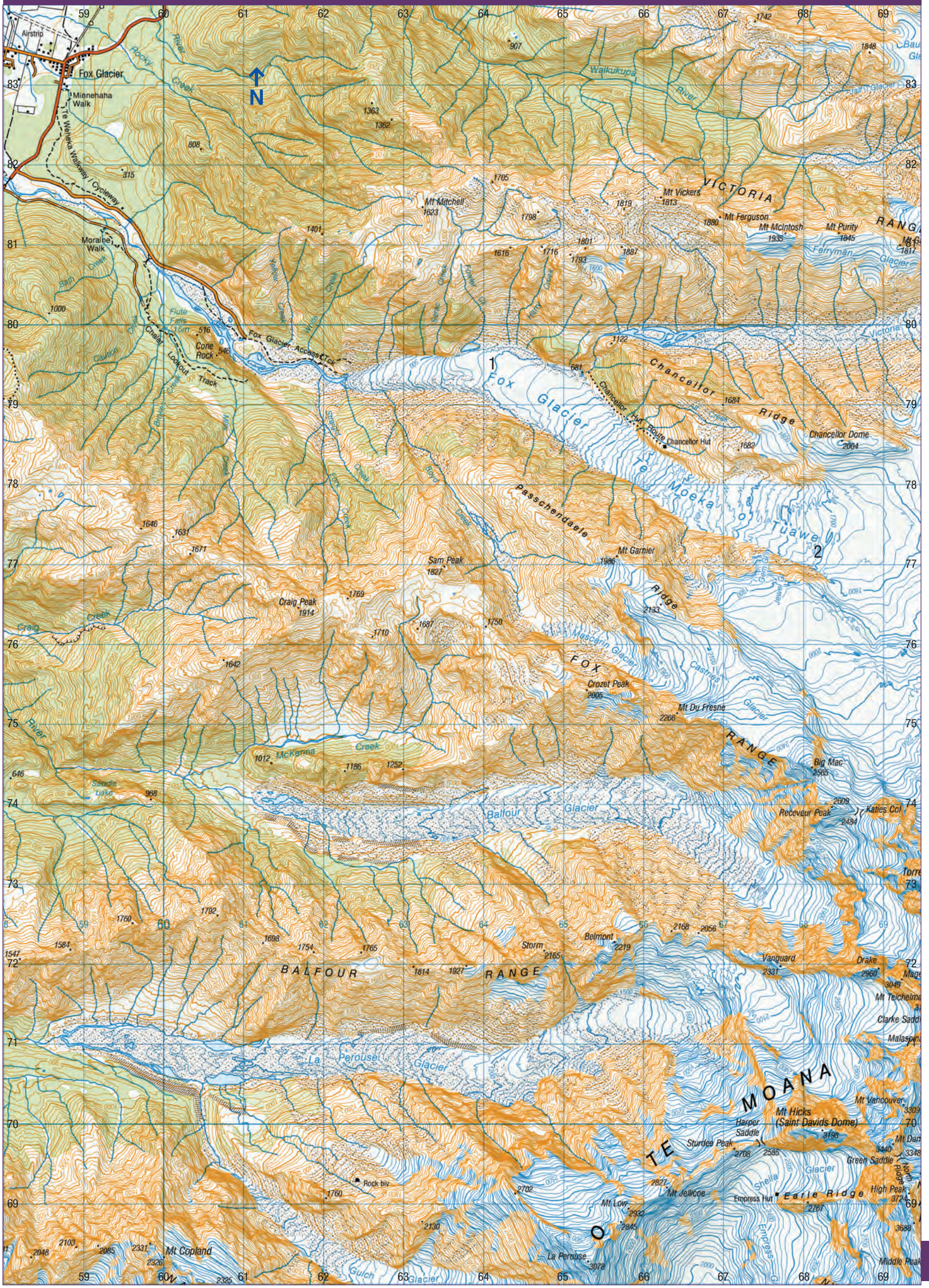
Fox Glacier / Te Moeka o Tuawe topographic map extract (Fox Glacier: latitude 43˚27´S, longitude 170˚1´E)



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4.8 Mt Ruapehu topographic map extract

Mt Ruapehu (often known as simply Ruapehu) is located within Tongariro National Park on New Zealand's North Island. It is one of the world's most active volcanoes and the largest such volcano in New Zealand. It is also the highest point on the North Island and includes three major peaks: Tahurangi (the tallest at 2797 m), Te Heuheu and Paretetaitonga. A deep, active crater lies between the three peaks. Between major eruptions the crater fills with water to form a crater lake. (See Figure 4.8b.)

The North Island's major ski fields and its only glaciers are on the slopes of Mt Ruapehu.

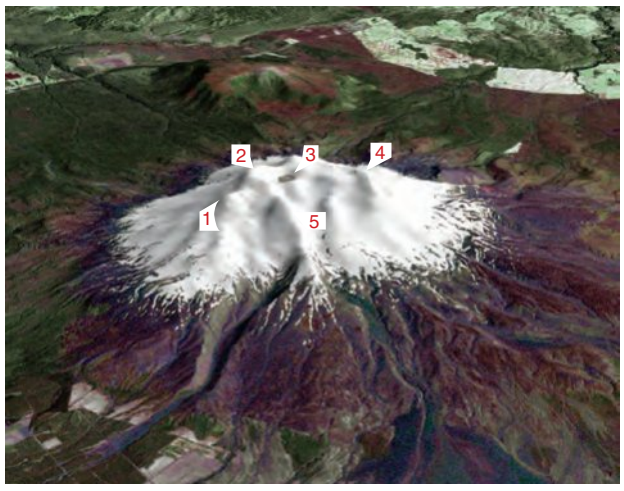


Figure 4.8a Enhanced-colour image of Mt Ruapehu, facing north-west

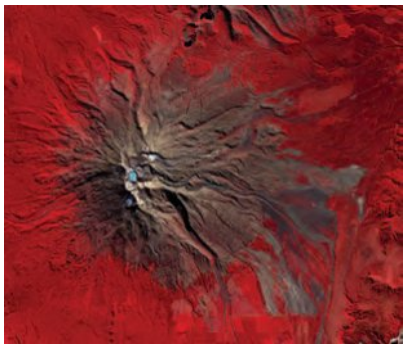
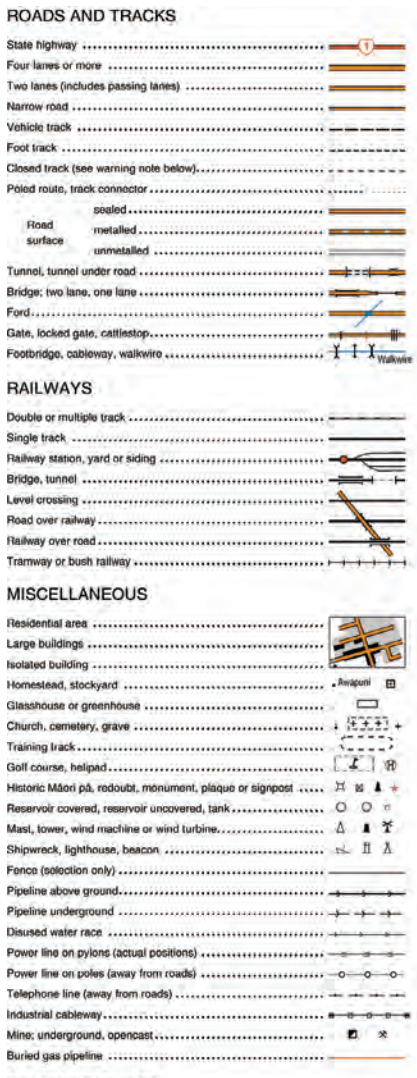


Figure 4.8b This is a false-colour satellite image of Mt Ruapehu. It is one of the most active volcanoes in New Zealand. The last major eruption was in 1995.

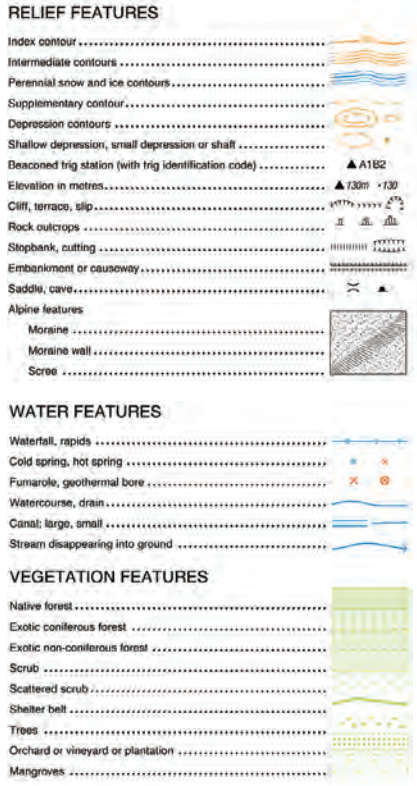
Figure 4.8c Ash cloud erupting from Mt Ruapehu



SCALE 1:50 000

THE VERTICAL INTERVAL BETWEEN THE CONTOURS IS 20 METRES

0 1 2 3 4 5 kilometres



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Study Figure 4.8a and the map extract. Identify the topographic features labelled 1–5.

4 Identify the feature of the biophysical environment located at:
- a GR 215488
- b GR 206495
- c GR 214471
- d GR 225500
- e GR 184565.

5 Identify the feature of the constructed environment located at:
- a GR 173538
- b GR 255471
- c GR 247448
- d GR 263466.

6 What is the area reference of Iwikau Village?

7 Name the type of biophysical feature found in AR 1855.

8 Name the type of land use found in AR 2051.

9 On what waterways is the Punaruku Falls (AR 1856) located?

10 What is the direction of the Tukino Skifield (AR 1947) from the Whakapaoa Skifield (AR 2051)?

11 What tributary joins Whakapapanui Stream in AR 1956?

12 In what direction is Tawhainui Stream flowing in AR 1954?

13 What is the bearing of Girdlestone Peak (AR 2147) from Cathedral Rocks (GR 219497)?

14 What is the bearing of Paretetaitonga (AR 2049) from Girdlestone Peak (AR 2147)?

15 What is the aspect of the slope in AR 1950?

16 What is the straight-line distance between Paretetaitonga (AR 2049) and Girdlestone Peak (AR 2147)?

17 What is the length of the ski lift in AR2051?

18 What is the area of the Summit Plateau?

19 What is the area of Crater Lake?

20 What is the height of Pyramid Peak (AR 2148)?

21 What is the difference in elevation of Tahurangi (GR 210480) and Girdlestone Peak (AR 2147)?

22 Estimate the local relief experienced on a traverse from the summit of Paretetaitonga (AR 2049) to the summit of the Dome (AR 2149).

23 Construct the cross-section from GR 180510 to the summit of Paretetaitonga at GR 207495. Use a vertical scale of 1 cm = 200 m.

24 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 23.

25 What is the gradient of the slope in the cross-section that you constructed in Activity 23?

26 Construct the cross-section from GR 170480 to Tahurangi (GR 210470). Use a vertical scale of 1 cm = 100 m.

27 Calculate the vertical exaggeration of the cross-section you constructed in Activity 26.

28 What is the gradient of the slope in the cross-section you constructed in Activity 26?

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Mt Ruapehu topographic map extract (Mt Ruapehu: latitude 39˚28′W, longitude 175˚57′S)

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4.9 Christchurch topographic map extract

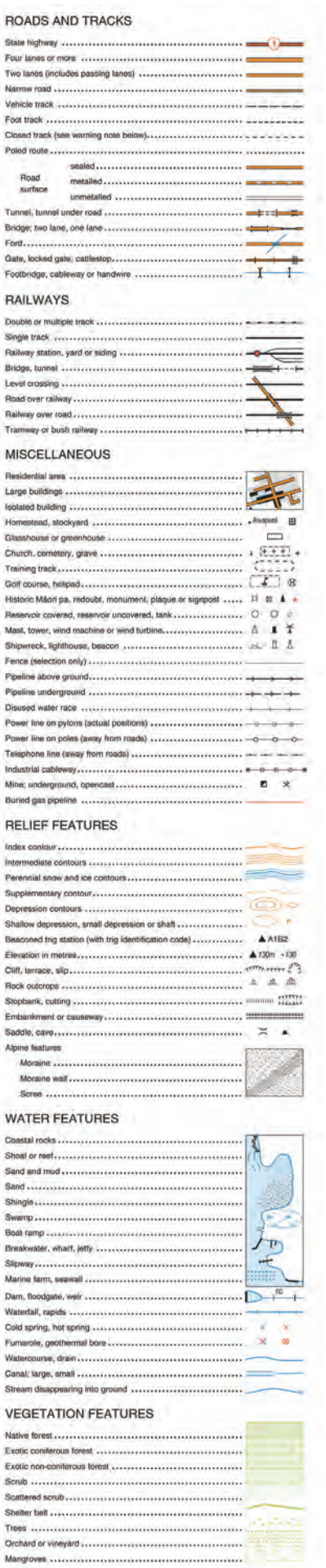
Christchurch (population 383 200) is the largest city on the South Island of New Zealand and the principal city of Canterbury Region.

Between September 2010 and January 2012, the city suffered a series of earthquakes. The most destructive of these took place at 12.51 p.m. on 22 February 2011. One hundred and eighty-five people were killed and thousands of buildings across the city collapsed or were severely damaged. As a result, 1 500 buildings in the city were demolished. Rebuilding is ongoing.

Figure 4.9a Oblique aerial photograph of Lyttelton Harbour

Figure 4.9b This is a damaged Catholic Cathedral. The earthquake of 2011 killed 185 people and damaged thousands of buildings in Christchurch.

Figure 4.9c Google Earth image of Christchurch and surrounds © 2021 Google



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Describe the site of Christchurch.

4 Study Figure 4.9c. Name the features numbered 1–5 on the Google Earth image of Christchurch and surrounds.

5 Identify the feature of the biophysical environment located at:
- a GR 795748
- b GR 802703
- c GR 791721
- d GR 806764
- e GR 756743

6 Identify the feature of the constructed environment located at:
- a GR 776805
- b GR 748795
- c GR 760713
- d GR 765804
- e GR 769710

7 What is the area reference of Kamautaurue a Island?

8 Name the type of biophysical feature found in AR 7573.

9 Name the type of land use found in AR 7771.

10 Name the type of vegetation found in AR 7171.

11 What is the direction of Windsor Castle (AR 7974) from Mt Pleasant (GR 780738)?

12 In what direction is the Church Gully stream flowing in AR 7768?

13 What is the bearing of Mt Pleasant (GR 780738) from Windsor Castle (GR 795748)?

14 What is the bearing of Mt Pleasant (GR 780738) from Sugarloaf (GR 716721)?

15 What is the straight-line distance between Sugarloaf (GR 716721) and Windsor Castle (AR 7974)?

16 What is the length of the Lyttelton Tunnel (ARs 7673 and 7672)?

17 What is the aspect of the slope in AR 8068?

18 What is the area of Otamahua/Quail Island?

19 What is the density of buildings in AR 8066?

20 What is the height of the ridge at GR 783659?

21 What is the difference in elevation of Windsor Castle (AR 7974) and Sugarloaf (AR 7172)?

22 What is the elevation of the monument at GR 793679?

23 Construct the cross-section from Point A (AR 7667) to Point B (AR7865). Use a vertical scale of 1 cm = 20 m.

24 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 23.

25 What is the gradient of the slope in the cross-section that you constructed in Activity 23?

26 Study Figure 4.9c and the topographic map extract. Working in groups, speculate on the origins of Lyttelton Harbour.

27 State the direction in which the camera was facing when Figure 4.9a was taken.

28 Construct an annotated precis sketch of Figure 4.9c. Name the key features of the biophysical and constructed environments.

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Grant Kleeman

Christchurch topographic map extract (Christchurch: latitude 43° 31'S; longitude 172° 37'E)

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Grant Kleeman

4.10 Whakaari/White Island topographic map extract

Whakaari/White Island is an active volcano situated 48 km off the east coast of New Zealand's North Island. The island has an area of approximately 325 ha. The part that can be seen, however, is only the peak of a much larger submerged volcano.

Whakaari/White Island is the most active of New Zealand's cone volcanoes and is the result of 150 000 years of volcanic activity.

The local Māori population were probably aware of volcanic activity for hundreds of years. An early written record occurred when James Cook made note of the volcano in his journal as he sailed past the island in 1769.

The volcano erupted almost continually from late 1975 until mid-2000.

Sulphur was mined on the island until the 1930s with 10 miners losing their lives in 1914 when part of the crater wall collapsed. The ruins of the processing plant are still visible on the island.

Until recently, the only activities on the island were guided tours and scientific research. Access to the island was limited and only possible if you joined a tour conducted by a registered tour operator.

In December 2019, an eruption resulted in the deaths of 22 tourists (including 14 Australians) and guides. Twenty-five survivors were seriously injured, many critically. Most suffered severe burns. Two bodies were never recovered. Tourists are currently banned from visiting the island.

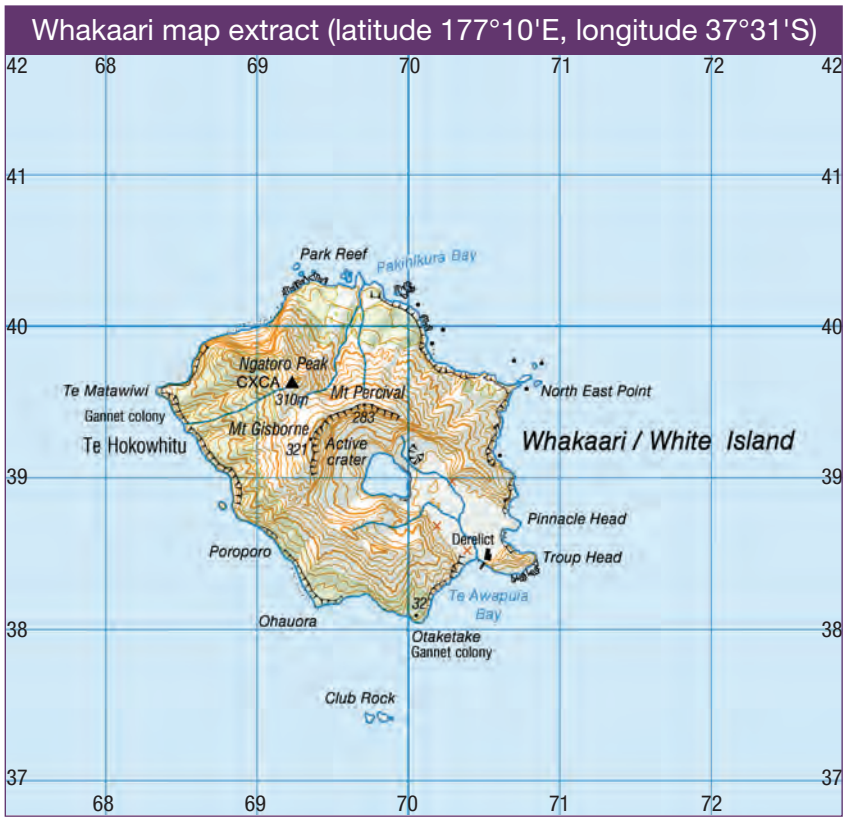

Figure 4.10d Tourists visiting the crater of Whakaari/White Island

Figure 4.10e Ruins of the Whakaari/White Island sulphur processing works

0 1 2 kilometres
SCALE 1:50 000

Figure 4.10b Oblique aerial photograph of Whakaari/White Island

Figure 4.10f The eruption of Whakaari/White Island on 9 December 2019

Figure 4.10a Satellite photograph of Whakaari/White Island.

Figure 4.10c Oblique aerial photograph of Whakaari/White Island

Figure 4.10g This is a Satellite photograph of Whakaari/White Island post eruption. The light-coloured ash emitted by the eruption reflects the sun's rays.

ACTIVITIES

1 State the scale of the Whakaari/White Island topographic map extract.

2 Identify the features of the biophysical (natural) environment located at:
- a GR 692397
- b GR 698390
- c GR 707397
- d GR 697394

3 Name the features of the constructed (human) environment located at:
- a GR 705384
- b GR 705385

4 State the general aspect of the slope in AR 6938.

5 Describe the shoreline of Whakaari/White Island.

6 State the elevation of Whakaari/White Island.

7 State the general aspect of the slope in AR 6938.

8 Identify the indicators that lifeforms (other than humans) exist on Whakaari/White Island.

9 Describe the topography surrounding the island's volcanic grater.

10 State from where the island is accessible by boat.

11 Describe the shape and estimate the area of Whakaari/White Island.

12 Study Figures 4.10b and 4.10c. State the direction in which the camera was facing in each photograph.

13 Construct an annotated photosketch of Figure 4.10c. Label the principal features of the biophysical environment on you sketch.

14 Study Figure 4.10d. Investigate the potential dangers of visiting such a site.

15 Study Figure 4.10e. Investigate the relationship between sulphur mining and volcanic activity. Present your findings as a written report.

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Grant Kleeman

SECTION 5 United Kingdom

5.1 United Kingdom

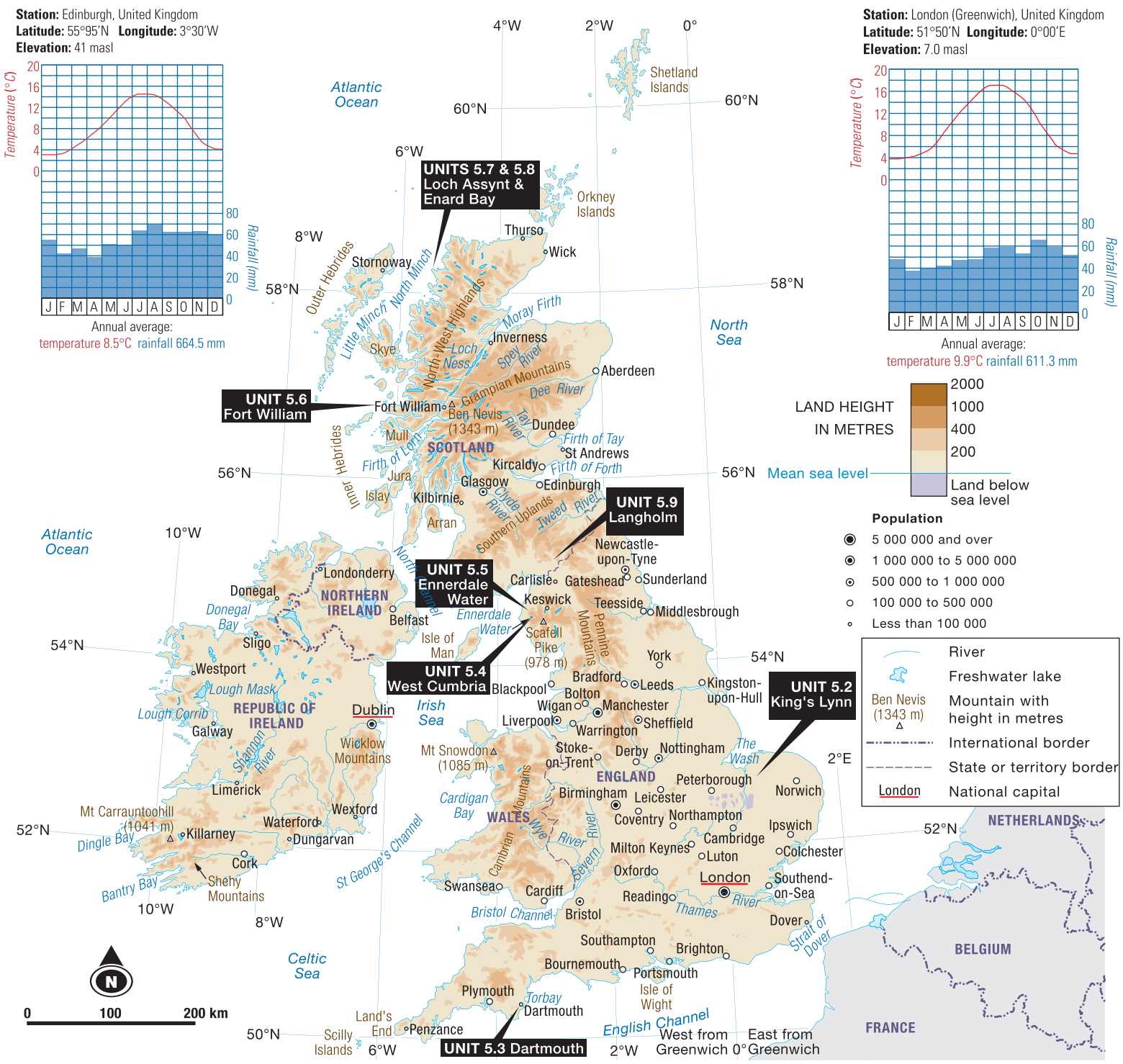

Figure 5.1a United Kingdom (England, Wales, Scotland and Northern Ireland) and the Republic of Ireland: physical features

ACTIVITIES

1 What is the latitude and longitude of the following physical features:
- **a** Lough Mask (Republic of Ireland)
- **b** Mt Carrauntoohill (Republic of Ireland)
- **c** Isle of Wight (England)
- **d** Scafell Pike (England)
- **e** Ben Nevis (Scotland)?

2 What cities are located at the following latitudes and longitudes:
- **a** 55°57´N, 3°01´W
- **b** 50°48´N, 1°05´W
- **c** 51°30´N, 0°10´W
- **d** 52°30´N, 1°50´W?

3 What is the name of the waterway separating Ireland from England and Wales?

4 What is the name of the waterway separating the United Kingdom from Northern France?

5 What is the capital city of the Republic of Ireland?

6 What is the direction of the Strait of Dover from London?

7 What is the direction of Dublin from London?

8 What is the straight-line distance between:
- **a** Dublin and London
- **b** Edinburgh and London?

9 Name the mountain range located in Wales.

10 Name the mountain range to the north-west of Edinburgh.

11 Name the mountains in the north of England.

12 Name the highest mountain in the United Kingdom.

13 Name three cities with a population of more than 1 million in the United Kingdom.

14 Name the river on which London is located.

15 Study the climate graphs of London and Edinburgh and then answer the following questions:
- **a** What is the range of average monthly temperatures experienced by London and Edinburgh?
- **b** Which months receive the most rainfall in both London and Edinburgh?
- **c** Describe the seasonal distribution of rainfall in both London and Edinburgh.

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5.2 King's Lynn topographic map extract

King's Lynn is a market town in Norfolk, near the mouth of the River Great Ouse, draining into the Wash on the coast of the North Sea. The Wash is a shallow bay and estuary, fed by four rivers, with numerous sandbanks, and its strong tidal and river currents can be treacherous. Since medieval times King's Lynn and other ports of the Wash have traded across the North Sea with the Netherlands and other European countries.

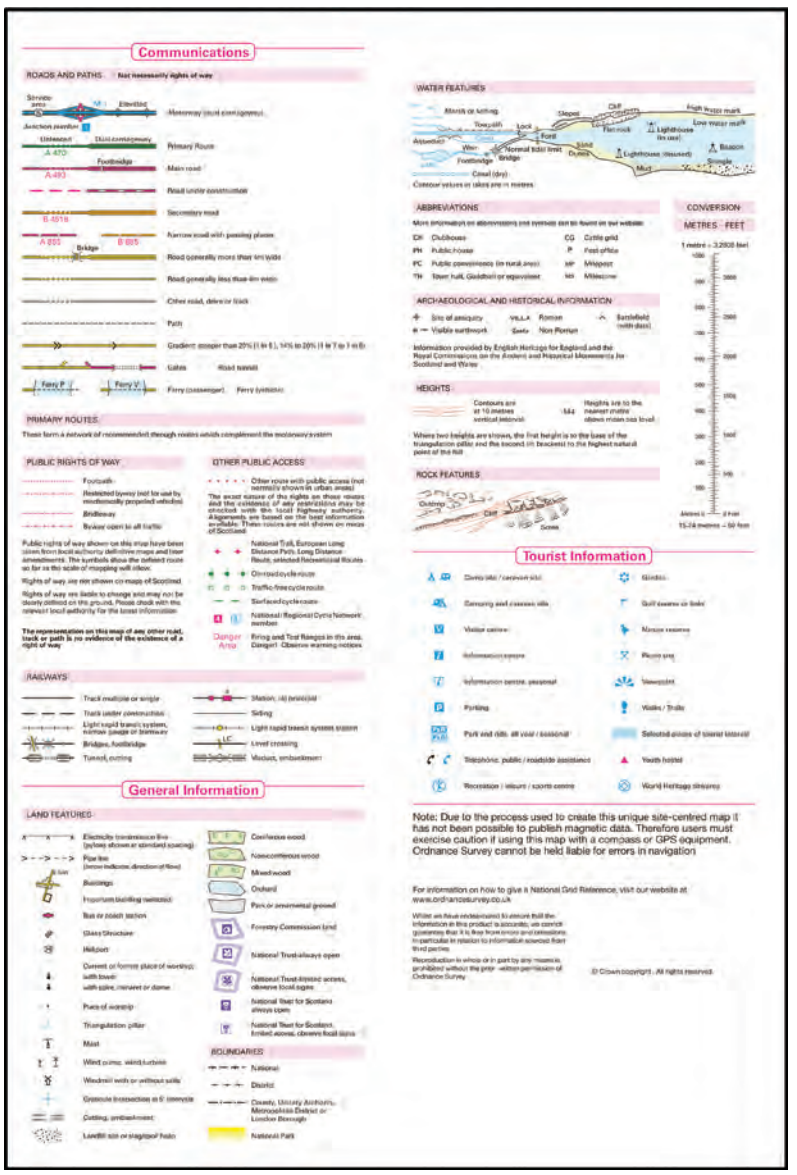
The land around the Wash is flat and low lying. Extensive marshes to the south and east, called the Fens, were drained forming rich agricultural land, some of it now below mean sea level requiring pumping stations and flood defences. In recent centuries deposition of sediment has moved the coastline further out to sea, and King's Lynn, once on the coast, is now five kilometres inland.

Approximately 10 km from the town is **Sandringham House**, a private home belonging to the reigning British monarch (currently Queen Elizabeth II). While a house has stood on the site since the late 1500s, the current Jacobethan-style building was constructed between 1870 and 1900.

The 8100 ha Sandringham estate includes seven villages, the occupants of which earn a living from tourism, farming and forestry.

Figure 5.2a Oblique aerial photograph of Sandringham House

Figure 5.2b Google Earth image of the area covered by the King's Lynn topographic map extract



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the features numbered 1–10 on Figure 5.2b.

4 Identify the feature of the biophysical environment located at:
- **a** GR 675215
- **b** GR 671288
- **c** GR 703253.

5 Identify the feature of the constructed environment located at:
- **a** GR 695288
- **b** GR 675196
- **c** GR 666246
- **d** GR 713265
- **e** GR 635190
- **f** GR 614219.

6 What type of road links King's Lynn to Hillington (AR 7125)?

7 What is the land cover found in
- **a** AR 6026
- **b** AR 6130?

8 Name the recreational feature found in both AR 7025 and AR 6726.

9 Name the type of land use found in AR 7127.

10 Name the type of vegetation found in:
- **a** AR 6627
- **b** AR 6721
- **c** AR 6824.

11 On what waterway is King's Lynn located?

12 What is the direction of Sandringham House from King's Lynn?

13 In what direction is Caywood River flowing in AR 6521?

14 In what general direction does the Babingley River flow?

15 What is the bearing of the roundabout at GR 668230 from the roundabout at GR 653203?

16 What is the bearing of Sandringham House (GR 6928) from King's Lynn railway station (AR 6220)?

17 What is the straight-line distance between Sandringham House (GR 6928) and King's Lynn railway station (AR 6220)?

18 What is the length by road from the roundabout at GR 668230 to the roundabout at GR 683293?

19 What is the area of Grimston Warren (AR 6721)?

20 What is the height of the small hill at (GR 242244)?

21 What evidence is there that the area shown on the map extract is low-lying and subject to inundation?

22 Construct a precis map showing the distribution of agricultural and urban land uses.

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King's Lynn topographic map extract (King's Lynn: latitude 52˚ 45' N; longitude 0˚ 24' E)

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Grant Kleeman

5.3 Dartmouth topographic map extract

Figure 5.3a Google Earth image of Dartmouth and surrounds, Google Earth, Image © Getmapping plc, © 2016 Google, Image © 2016 TerraMetrics

Dartmouth is a historic town set on the western bank of the estuary of the River Dart, which is a long narrow tidal ria that runs inland as far as Totnes.

Dartmouth was of strategic importance as a deep-water port for sailing vessels. Two fortified castles – Dartmouth Castle and Kingswear Castle – protected the narrow mouth of the Dart.

Dartmouth was once an important port for the Royal Navy. Warfleet Creek, close to Dartmouth Castle, was named for the vast fleets which often assembled there.

The town is still home to the Royal Navy's officer training college (Britannia Royal Naval College), where all officers of the Royal Navy and many foreign naval officers are trained.

Video 5.3a
Aerial footage of Kingswear and Dartmouth Harbour (**00:32**)

ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1 What is the scale of the Dartmouth map extract?

2 What is the contour interval used on the Dartmouth map extract?

3 Identify the feature of the biophysical environment located at the following grid references:
- a GR 919497
- b GR 888496
- c GR 858556
- d GR 919507.

4 Identify the feature of the constructed environment located at the following grid references:
- a GR 946567
- b GR 897563
- c GR 876521.

5 Identify the historical feature located at the following grid references:
- a GR 801606
- b GR 888537
- c GR 892504.

6 Identify the recreational activity available in the following area references:
- a AR 9056
- b AR 8759.

7 Estimate the height of the landform feature located at the following grid references:
- a GR 839536
- b GR 828559
- c GR 869538.

8 Calculate the gradient of the slope from the spot height at GR 798559 to the road intersection at GR 808563. What is the aspect of this slope?

9 What is the aspect of the slope in AR 8753?

10 Name three tributaries of the River Dart.

11 State the number of vehicle ferries that cross the River Dart.

12 What type of road connects Kingswear (AR 8851) to Higher Brixham (AR 9255)?

13 What type of agricultural land use is found near the village of Aish (GR 843589)?

14 What is the direction of:
- a Paignton from Berry Head
- b Dartmouth from Brixham?

15 What is the direction of flow of the River Wash in AR 8055?

16 Estimate the length of the Breakwater in the north-east quadrant of the map extract.

17 What is the distance by road from the bus station (GR 923561) to the Totnes roundabout (GR 808605)?

18 Calculate how long it would take for a bus to travel from the bus station (GR 923561) to the Totnes roundabout (GR 808605) at an average speed of 30 km/h.

19 Estimate the distance by rail from Kingswear Station (GR 882511) to Churston Station (GR 894563).

20 Estimate the length of the tunnel through which this railway line passes. Select a, b, c or d.
- a 250 m
- b 300 m
- c 450 m
- d 600 m

21 Describe the coastal landform features found in the area extending from Scabbacombe Head (AR 9251) and Duri Head (GR 941557). Explain how these landform features were formed.

22 What evidence is there that tourism is an industry in the area covered by the map extract?

23 What evidence is there that Dartmouth was once an important naval facility?

24 How might the local topography have favoured the location of a naval facility at the mouth of the River Dart?

25 Study Figure 5.3a and the map extract. Locate the following features on the satellite image of Dartmouth and surrounds:
- a River Dart
- b Dartmouth
- c Totnes
- d Paignton
- e Berry Head (AR 9456)
- f Scabbacombe Head (AR 9251)
- g Dartmouth Marina (AR 8851)
- h Old Mill Creek (AR 8652)
- i Britannia Royal Naval College (GR 875520)
- j St Mary's Bay (AR 9355).

26 Study Video 5.3a (AR 8851) then complete the following activities:
- a What direction was the drone moving when the film was taken?
- b Describe the topography and land uses evident in the area shown in the footage.
- c Describe the nature of the constructed environment evident in the footage.
- d Locate the terminus of the Paignton and Dartmouth Steam Railway.
- e What evidence shows that boating is a popular recreational activity in this part of the United Kingdom?

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Dartmouth topographic map extract (Dartmouth: latitude 50°21´N, longitude 3°35´W)

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Grant Kleeman

5.4 West Cumbria topographic map extract

West Cumbria is at the heart of England's mountainous Lake District, a UNESCO World Heritage site with the country's most-visited national park. The landscape was formed by glacial erosion of an upland massif forming u-shaped valleys now occupied by picturesque rivers and lakes. Tourism, sheep-farming and forestry are the main industries. The market town of Keswick is the largest in the Lake District and the centre of tourism. Ennerdale Water (Unit 5.5, page 150) lies to the southwest.

Figure 5.4a Bassenthwaite Lake and Derwent Water, © 2016 Google, © Infoterra Ltd & Bluesky

Figure 5.4b Keswick and Derwent Water, West Cumbria

ACTIVITIES

Refer to the legend on page 144 to complete the following tasks.

1 What is the scale of the West Cumbria topographic map extract?

2 What is the contour interval used in the West Cumbria map extract?

3 Identify the feature of the biophysical environment at the following grid references:
- a GR 264213
- b GR 248338
- c GR 278193.

4 Identify the feature of the constructed environment located at the following grid references:
- a GR 236254
- b GR 229316
- c GR 278225
- d GR 265241.

5 Identify the distinctive landform (rock) feature located in the following area references:
- a AR 2529
- b AR 2926.

6 Identify the historical feature located at the following grid references:
- a GR 291237
- b GR 297187.

7 What is the dominant vegetation type found in the following area references?
- a AR 2427
- b AR 2721

8 Identify the change in transport infrastructure evident in AR 2424.

9 Estimate the height of the following landform features:
- a Sale How (GR 277287)
- b Great Calva (GR 291312)
- c Knott (GR 295330).

10 Name the river that joins Derwent Water to Bassenthwaite Lake. State the direction in which it flows.

11 What is the grid reference of the deepest part of Bassenthwaite Lake?

12 Estimate the area of Derwent Water.

13 What is the direction of flow of Wiley Grill (stream) in AR 2931?

14 What is the grid reference of the confluence of Rigg Beck and Newlands Beck in the south-west quadrant of the West Cumbria map extract?

15 What is the bearing of Little Calva (GR 282315) from Great Cockup (GR 274333)?

16 What is the bearing of Kestrel Lodge (GR 244328) from Great Cockup (GR 274333)?

17 Estimate the distance by road from the roundabout at GR 263244 to the road junction at GR 234306.

18 Estimate the time it would take to travel from GR 263244 to GR 234306 at an average speed of 30 km/h.

19 What is the density of chimneys or towers in AR 2524?

20 What is the gradient of the stream flowing from GR 266299 to GR 275307?

21 What is the gradient of the slope from the summit of Lonscale Fell (GR 285271) to the end of the road at GR 290254?

22 What is the aspect of the slope in AR 2626?

23 Estimate the water level of Bassenthwaite Lake.

24 Construct a cross-section from Sale How (GR 276286) to Great Calva (GR 291312). Use a vertical scale of 1 cm = 100 m.

25 Calculate the vertical exaggeration of the cross-section you have drawn.

26 Name the type of public right-of-way you would travel along to visit Skiddaw (AR 2629) having parked your car in the parking area in AR 2825.

27 List the scenic attractions and recreational activities that would attract tourists to the area covered by the West Cumbria map extract.

28 List the types of infrastructure provided to support tourism.

29 Describe the impact of topography on the pattern of transport shown on the map extract.

30 List the features of Keswick's site that led to the establishment and growth of a settlement at this location.

Study Figure 5.4b. Compare it with the West Cumbria topographic map extract and complete the following tasks:

31 Construct a line drawing of the area shown in the photograph.

32 Locate and label the following features:
- a Derwent Water
- b Lord's Island
- c Derwent Isle
- d Swinside (mountain) (AR 2422)
- e Keswick
- f St Herbert's Island
- g Derwent Bay (AR 2521)
- h Cat Bells (AR 2419).

33 What is the direction in which the camera was facing when the photograph was taken?

34 Name the physical processes responsible for the development of this landscape.

35 State whether the area shown is predominantly characteristic of the biophysical or constructed environment.

36 Study Figure 5.4a and the West Cumbria topographic map extract. Locate the following features on Figure 5.4a:
- a Derwent Water
- b Bassenthwaite Lake
- c River Derwent
- d Keswick
- e Lord's Ireland
- f St Herbert's Ireland
- g Lonscale Fell
- h Braithwaite.

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West Cumbria topographic map extract (Keswick: latitude 54°35´N, longitude 3°10´W)

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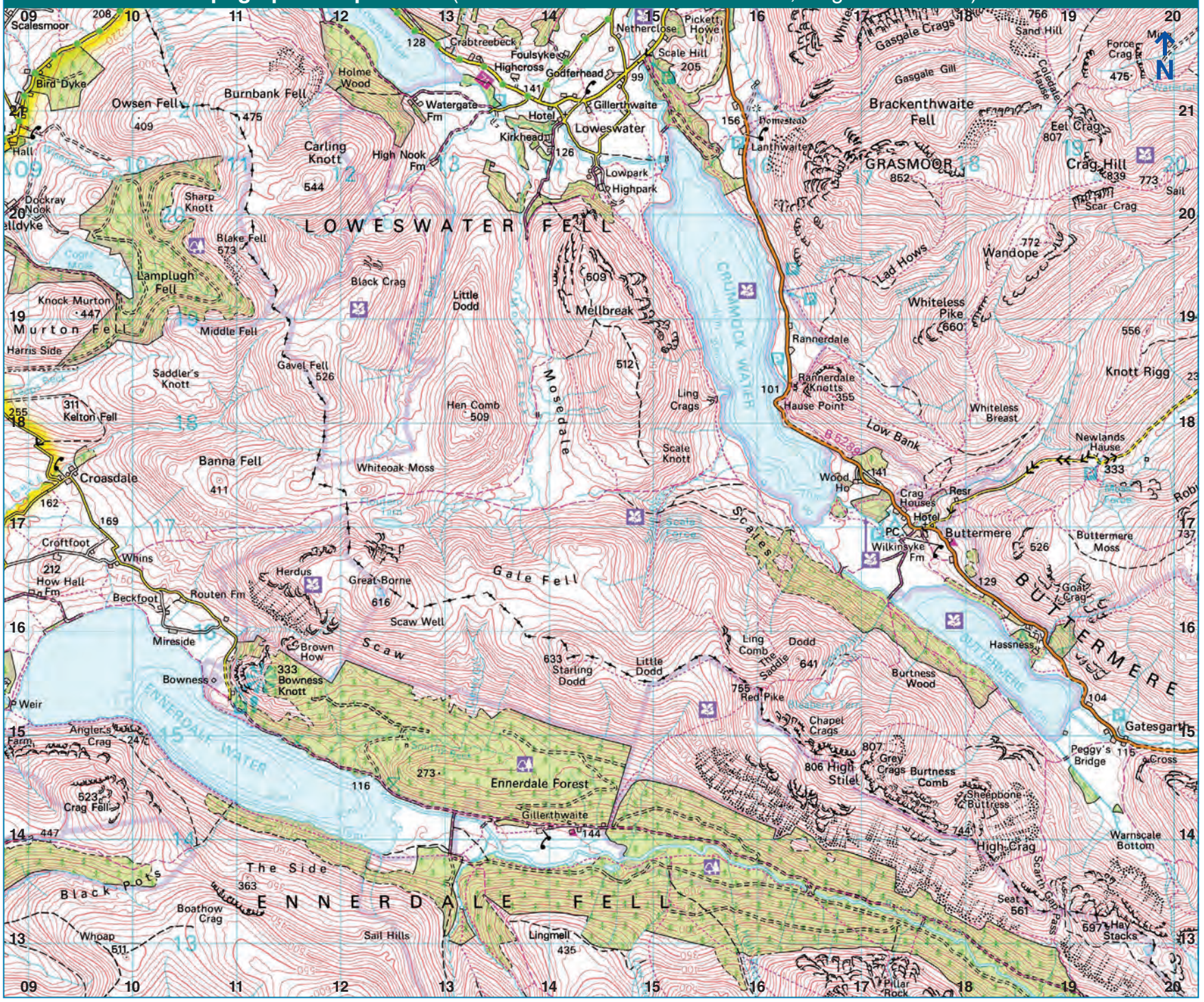
Grant Kleeman

5.5 Ennerdale Water topographic map extract

Ennerdale Water topographic map extract (Ennerdale Water: latitude 54°31´N, longitude 3°22´W)



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SCALE 1:50 000 — KILOMETRES

ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1 What is the scale of the Ennerdale Water topographic map extract?

2 What is the contour interval of the Ennerdale Water topographic map extract?

3 Identify the feature of the biophysical environment located at the following grid references:
- **a** GR 166154
- **b** GR 132181
- **c** GR 096197
- **d** GR 156183.

4 Identify the feature of the constructed environment located at the following grid references:
- **a** GR 194149
- **b** GR 176170
- **c** GR 127211
- **d** GR 088154.

5 Name the type of biophysical features found in AR 1714.

6 Name the type of vegetation found in AR 1314.

7 What rivers flow into Crummock Water in AR 1619?

8 What is the straight-line distance between Banna Fell (GR 108175) and Hen Comb (GR 132181)?

9 Estimate the area of Buttermere.

10 What is the direction of Crummock Water from Ennerdale Water?

11 In what direction is Mosedale Beck flowing in AR 1318?

12 What is the bearing of Hen Comb (GR 132181) from Banna Fell (GR 108175)?

13 What is the aspect of the slope in AR 1317?

14 What is the depth of Ennerdale Water?

15 Estimate the height of the landform features at the following grid references:
- **a** GR 117174
- **b** GR 121189.

Figure 5.5a Buttermere

16 Study Figure 5.5a. In what direction was the photographer facing when the image was captured?

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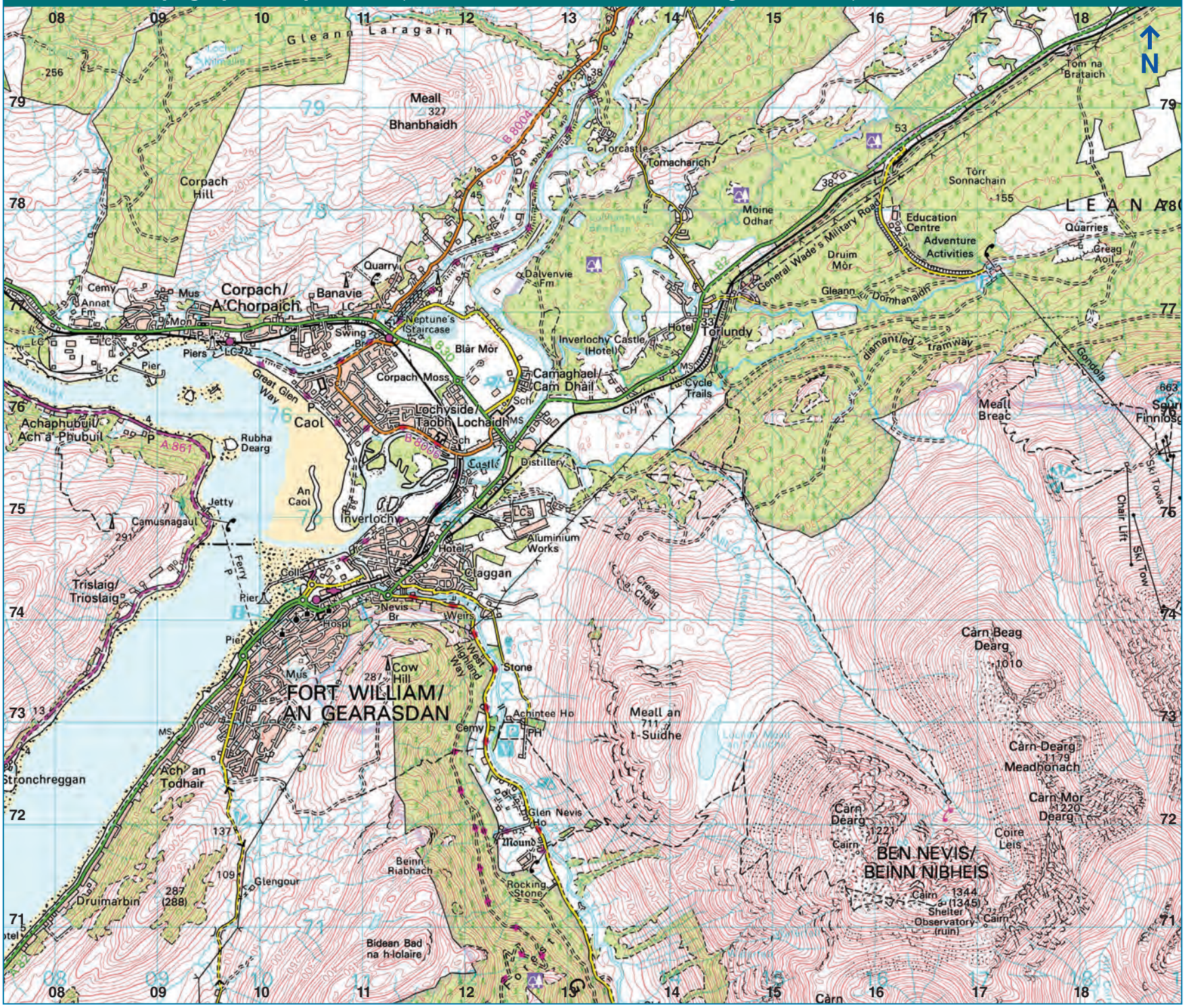
5.6 Fort William topographic map extract

Fort William topographic map extract (Fort William: latitude 56°49´N, longitude 5°6´W)



ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1. Identify the feature of the biophysical environment at the following grid references:
   - **a** GR 116789
   - **b** GR 144727.
2. Identify the feature of the constructed environment at the following grid references:
   - **a** GR 122755
   - **b** GR 126719
   - **c** GR 100743
   - **d** GR 167723.
3. Identify the productive activity occurring at the following grid references:
   - **a** GR 083767
   - **b** GR 126749.
4. What are the biophysical features found in AR 1572?
5. What type of vegetation is found in AR 1575?
6. What is the direction of Ben Nevis (AR 1671) from Fort William?
7. What is the aspect of the slope in AR 1674?
8. In what direction is Allt Daim flowing in AR 1775?
9. What is the bearing of Meall Bhanabhie (AR 1178) from Ben Nevis (AR 1671)?
10. What is the height of Ben Nevis (AR 1671)?
11. What is the difference in elevation between Ben Nevis (AR 1671) and Meall an t-Suidhe (GR 139729)?
12. Estimate the elevation of Lochan Meall an t-Suidhe (AR 1472).
13. Calculate the gradient of the slope from GR 170740 to GR 160750.
14. Study Figure 5.6a and the map extract. Identify the features labelled 1–5.

Figure 5.6a Satellite photograph of Fort William, © 2016 Google, Image © 2016 DigitalGlobe, Image © 2016 Getmapping plc

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5.7 Loch Assynt topographic map extract

Loch Assynt topographic map extract (Loch Assynt: latitude 58°15´N, longitude 5°01´W)

Scale 1:50 000

ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1. What feature of the biophysical environment is located at:
   - **a** GR 179364
   - **b** GR 220385?
2. What feature of the constructed environment is located at:
   - **a** GR 224374
   - **b** GR 202345?
3. What type of erosional material is found in AR 2129?
4. What vegetation type is found in AR 1936?
5. What tributary joins Bagh Chalbha at GR 172382?
6. What is the direction of flow of Allt nan Ramh in AR 2136?
7. What is the aspect of the slope in AR 2130?
8. What is the elevation of Loch an Leothaid?
9. What is the bearing of the spot height at GR 178329 from the spot height at GR 198305?

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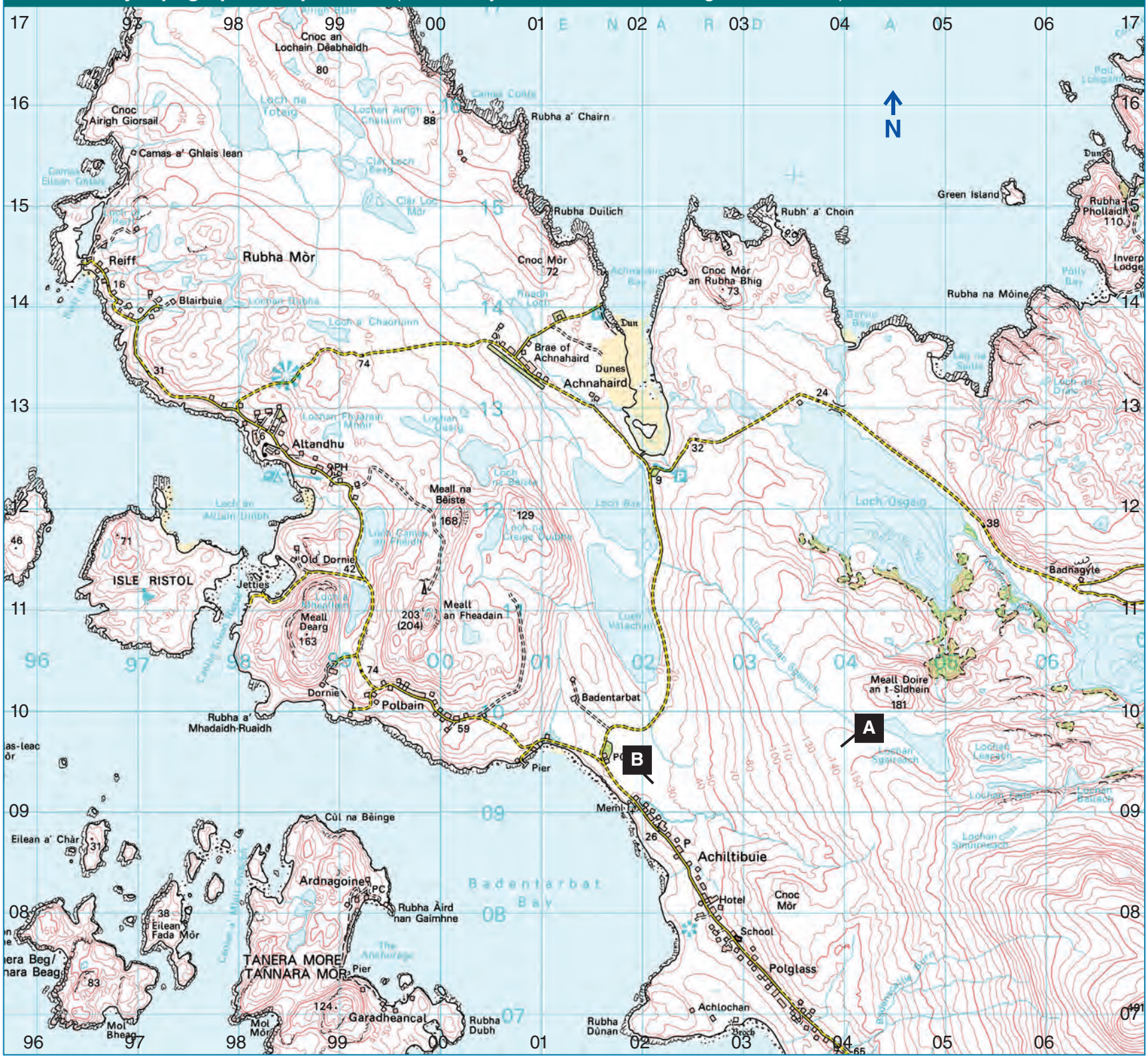
5.8 Enard Bay topographic map extract

Enard Bay topographic map extract (Enard Bay: latitude 58°02´N, longitude 5°22´W)



ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1. What is the contour interval used on the map extract?
2. Identify the feature of the biophysical environment located at:
   - a GR 986108
   - b GR 057152.
3. Identify the feature of the constructed environment located at:
   - a GR 027081
   - b GR 039130.
4. What type of depositional landform feature is centred on GR 983113?
5. What settlement pattern is evident in the south-east quadrant of the map?
6. What water body flows into the sea at Gavie Bay in AR 0413?
7. What is the direction of flow of Allt Lochan Sgeirich in AR 0310?
8. What is the direction of Cnoc Mor an Uubha Bhig (GR 028142) from Meall an Fheadain (GR 999110)?
9. What is the aspect of the slope in AR 0309?
10. What is the bearing of Cnoc Mor an Uubha Bhig (GR 028142) from Cnoc an Lochain deabhaidh (GR 988165)?
11. What is the straight-line distance between Cnoc Mor an Uubha Bhig (GR 028142) from Cnoc an Lochain deabhaidh (GR 988165)?
12. What is the local relief on Tanera More in the south-west quadrant of the map?
13. What is the approximate area of Tanera More in the south-west quadrant of the map?
14. What is the depth of Loch Osgaig at GR 048115?
15. Identify the principal geomorphological processes responsible for the landforms of the Enard Bay topographic map extract.

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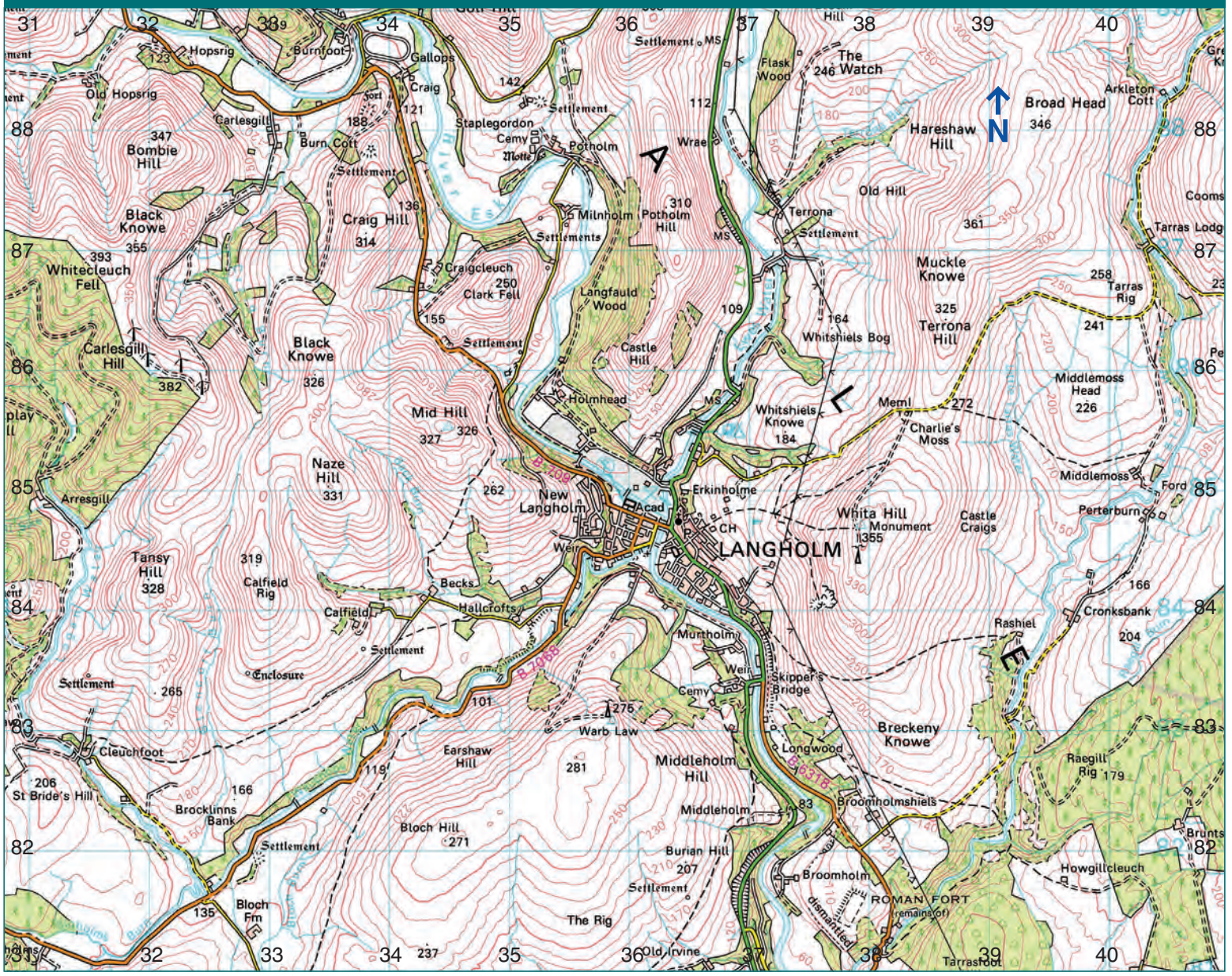
5.9 Langholm topographic map extract

Langholm topographic map extract (Langholm: latitude 55°15´N, longitude 2°59´W)



Scale 1:50 000

Langholm, a small town on the River Esk in Scotland, has long been home to the woollen milling trade. At one stage there were 22 mills in the town. Since then there has been some consolidation and closure of mills but many people still earn their living in the trade.

ACTIVITIES

Refer to the legend on page 144 to complete the following tasks:

1. What is the contour interval used on the map extract?
2. Identify the feature of the biophysical environment located at:
   - a GR 379847
   - b GR 335850
   - c GR 376841.
3. Identify the feature of the constructed environment located at:
   - a GR 373869
   - b GR 379845
   - c GR 362852.
4. Name the type of land use found in AR 3185.
5. Name the waterways flowing into the River Esk in AR 3684.
6. In what direction is Tarras Water flowing in AR 3982?
7. What is the direction of the Whita Hill (AR 3784) from the monument at AR 3583?
8. What is the bearing of Whita Hill (AR 3784) from the summit of Clark Fell (GR 348867)?
9. What is the straight-line distance between the summit of Tansy Hill (GR 320844) and Bloch Hill (AR 3482)?
10. What is the distance by road from the bridge at GR 366856 and Skipper's Bridge at GR 371835?
11. What is the aspect of the slope in AR 3482?
12. What is the elevation of the historic 'enclosure' at GR 328835?
13. What is the difference in elevation of Tansy Hill (GR 320844) and Skipper's Bridge at GR 371835?
14. Construct the cross-section from Tansy Hill (GR 320844) to the summit of Skipper's Bridge at GR 371835 using a vertical scale of 1 cm = 100 m.
15. Study Figure 5.9a and the map extract. Locate the following features: Langholm township, Ewes Water, River Esk and Skipper's Bridge.
16. Describe the nature of the biophysical, managed and constructed environments evident in the area surrounding Langholm.

Figure 5.9a Langholm, Scotland, © 2016 Google, Image © 2016 Getmapping plc

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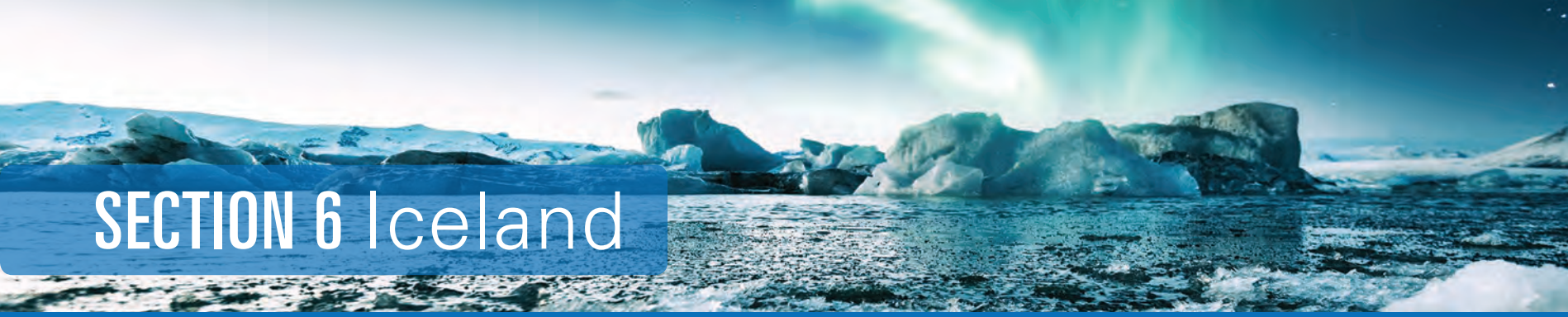

SECTION 6 Iceland

6.1 Iceland

Iceland, with an area of 103 000 km^2 and located in the North Atlantic Ocean, is volcanically and geologically active. As a result, it has some of the most dynamic and spectacular landscapes on Earth. The interior of the island features a plateau with sand and lava fields, mountains and glaciers. Glacial rivers flow to the sea across Iceland's lowlands. Iceland is the world's 18th largest island.

Geologically, Iceland sits on the Mid-Atlantic Ridge, a ridge along which the oceanic crust spreads and forms new oceanic crust. The ridge marks the boundary between the Eurasian and North American Plates, and Iceland was created by volcanism along the ridge.

There are many fjords along Iceland's 4970 km long coastline. Most settlements are on the coast, as the interior is cold and largely uninhabitable. The Highlands of Iceland, the interior, are a combination of sand, mountains, lava fields and ice.

About 10 per cent of the island is covered in ice, making it an integral part of Iceland's landscape. Like glaciers worldwide, Iceland's glaciers are retreating as a result of climate change. This has wide-ranging effects, with the potential to impact water resources, infrastructure, and other areas. It may even mean the land will rise, as it rebounds under the reduced weight of the ice.

Iceland's capital and largest urban centre, Reykjavík (64°08′N 21°56′W), is located in the country's south-west. The city, and its surrounds, is home to two-thirds of the country's population. See Figure 6.3b, page 158).

Most Icelanders are descendants of Norse and Gaelic settlers. Icelandic, the country's official language, is a North Germanic language.

Figure 6.3b shows the population structure of Iceland. Those born in Iceland make up 84.4 per cent of the country's residents. The rest (15.6%) are foreign-born.

Demographic snapshot

- Population: 369 000
- Average annual growth rate: 1.0%
- Density (persons per sq. km.): 3.5
- Total fertility rate (births per woman): 1.96
- Under 5 mortality rate (per 1 000): 2.6
- Life expectancy at birth: 83.5 years

Economy

Until the 20th century, the people of Iceland largely relied on subsistence fishing and agriculture. The industrialisation of the country's fisheries after World War II brought prosperity, and Iceland became one of the wealthiest and most developed nations in the world. As part of the European Economic Area since 1994, the country's economy has diversified. Finance, biotechnology and manufacturing are now important areas of economic activity.

Tourism

Iceland has, in recent years, become a popular tourist destination. In 2020, tourism contributed more than 10 per cent to the Icelandic GDP and the number of foreign visitors exceeded 2 000 000 for the first time. Before the COVID-19 pandemic, tourism accounted for nearly 30 per cent of the country's total export revenue. Tourists are attracted by the country's spectacular, largely untouched, landscapes.

Figure 6.1a Iceland physical features

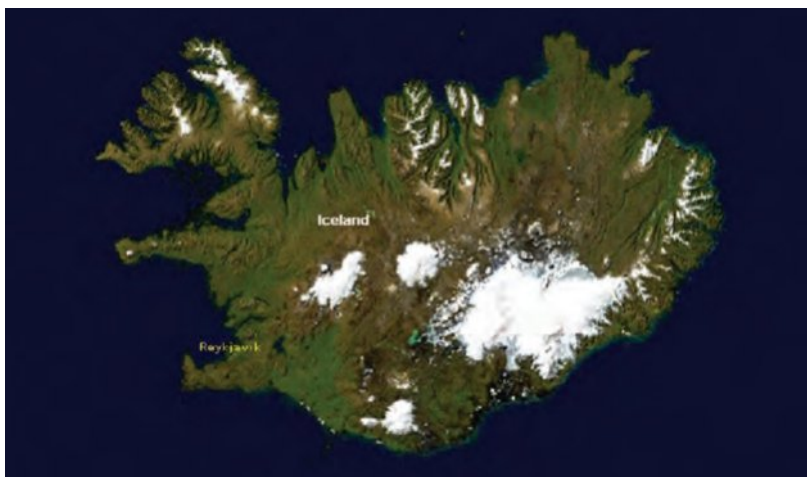

Figure 6.1b Satellite image of Iceland (summer)

Skýringar / Legends / Zeichenerklärung / Légende

Bær, Farm, Bauernhof, Ferme
Hvammur
Eyðibýli, Abandoned farm, Verlassener Hof, Ferme abandonnée
(Dalur)
Eyðibýli, rúst, Abandoned farm, ruins, Verlassener Hof, Ruine, Ferme abandonnée, ruines
(Selkot)
Vegur, bundið slitlag, Road, hard surface, Asphaltierte Straße, Route, goudronnée
Vegur, malarborinn, Road, gravel surface, Schotterstraße, Route, non-gourdronnée
Vegarslóð, Track, Piste, Chemin
Veggöng, Road tunnel, Tunnel, Tunnel
Ferja, Ferry, Fähre, Bateau
Gönguleið, Footpath, Wanderweg, Sentier
Reiðleið, Bridle path, Reitweg, Piste cavalière
Kirkja, Church, Kirche, Église
0
Skóli, School, Schule, École
Sumarhús, Summer house, Sommerhaus, Maison de vacances
Neyðarskýli, Emergency shelter, Nothütte, Abri de secours
Skáli, veiðihús, kofi, Tourist hut or shelter, Schutzhütte, Hütte, Refuge non gardé, baraque
Vatnsaflstöð, Hydro-electric power st., Wasserkraftwerk, Station hydro-électrique
Varmaaflstöð, Thermal power station, Geothermalkraftwerk, Station géo-thermique
Hæðarlína, 100 metra, Contour, 100 m, Höhenlinie, 100 m, Courbe de niveau, 100 m
Hæðarlína, 20 metra, Contour, 20 m, Höhenlinie, 20 m, Courbe de niveau, 20 m
Hæðarlína á jökli, Contour on glacier, Höhenlinie auf Gletscher, Courbe de niveau sur le glacier
Tjaldsvæði, Camping site, Campingplatz, Camping
Q
Sundlaug, Swimming pool, Schwimmbad, Piscine
F
Golfvöllur, Golf course, Golfplatz, Terrain de golf
!
Flugvöllur, Airfield, Flugplatz, Aéroport
p
Viti, Lighthouse, Leuchtturm, Phare
Rétt, Sheepfold, Schafscheideplatz, Parc de mouton
2
Raflína, Power line, Stromleitung, Ligne électrique
Hæð mæld í metrum, Spot elevation, meters, Höhen in Metern, Hauteur en mètres
132 756
Vegnúmer, Road number, Straßennummer, Numéro de route
43
Vað, Ford, Furt, Gué
Þéttbýli, Town, village, Orte, Agglomération
Vel gróið land, Land with vegetation cover, Geschlossene Vegetation, Terrain couvert de végétation
Lítt gróið land, Land with little vegetation, Spärliche Vegetation, Terrain peu couvert en végétation
Hraun, Lava, Lava, Lave
Sandur, aur, Sands, mudflats, Sandfläche, Lehmboden, Sable, marécage
Á, lækur, River, brook, Fluss, Bach, Rivière, ruisseau
Stöðuvatn, tjörn, lón, Lake, pond, reservoir, See, Teich, Stausee, Lac, étang, lagon
Stöðuvatn sem þornar upp, Intermittent lake, Zeitweiliger See, Lac intermittent
Strandlína, sjór, Coastline, sea, Strandlinie, Meer, Côte, mer
Jökull, Glacier, Gletscher, Glacier

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Grant Kleeman

6.2 Mýradfalsjökull (Mýradfals glacier) topographic map extract

Mýradfalsjökull topographic map extract 1 (Mýradfalsjökull: latitude 63° 32'N; longitude 19° 15'W)

Video 6.2a Aerial footage of the melting terminus of Sólheimajökull (**00:22**)

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Grant Kleeman

Mýradfalsjökull topographic map extract 2 (Eyjafjallajökull: latitude 63° 36'N, longitude 19° 35'W)

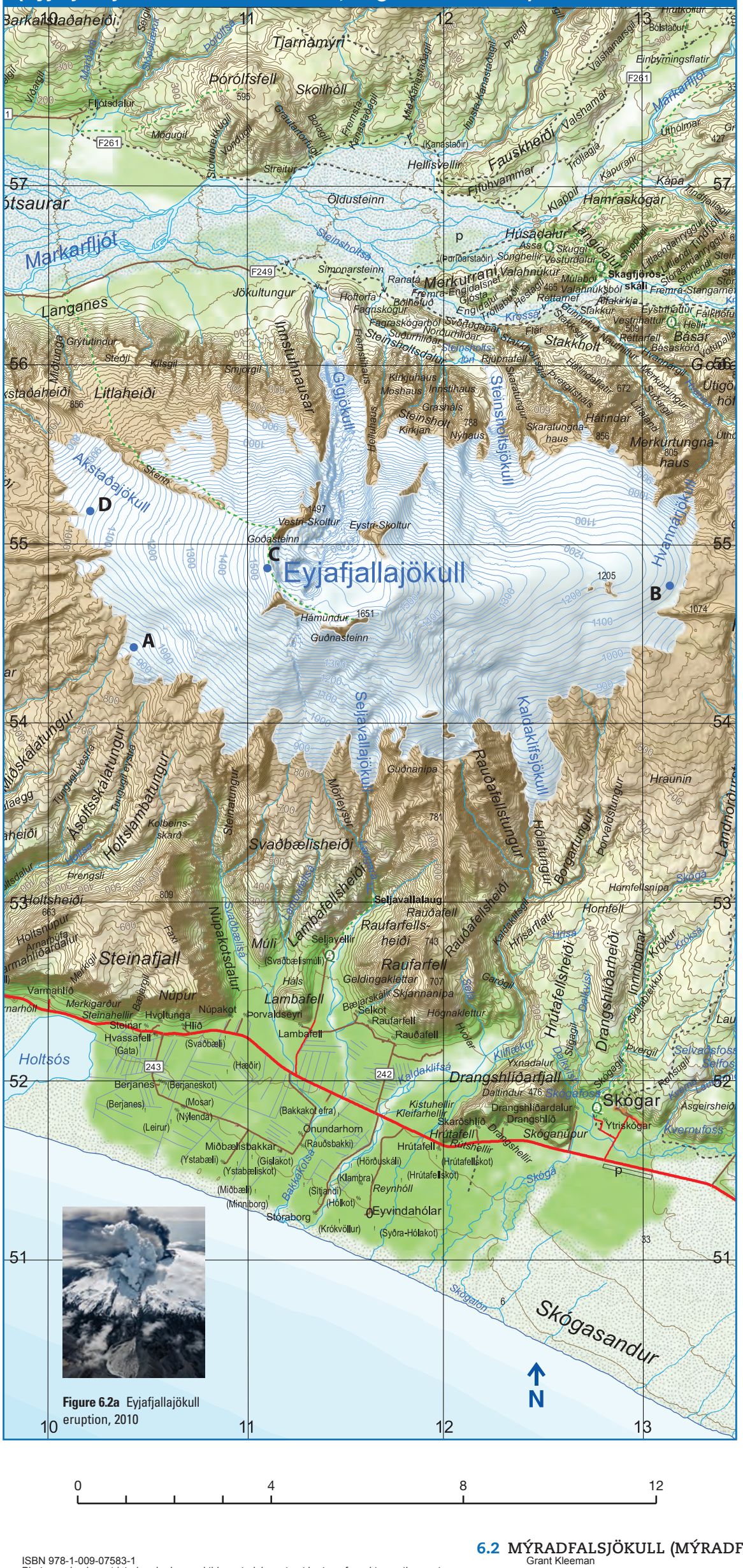

Figure 6.2a Eyjafjallajökull eruption, 2010

The legend for these maps can be found on pages 155 and 160.

ACTIVITIES (MAP EXTRACT 1)

1. What is the scale of the map extract?
2. What is the contour interval used on the map extract?
3. Identify the feature of the biophysical environment located at:
   - **a** GR 247668
   - **b** GR 265647.
4. Identify the feature of the constructed environment located at:
   - **a** GR 280654
   - **b** GR 281653.
5. What is the area reference of the Klifurárjökull Glacier?
6. What tributary joins Klifandi at GR 253667?
7. What river flows into (lake) Dyrhólaós at GR 265656?
8. Name the river that transports the meltwater from Sólheimajökull Glacier to the ocean.
9. What is the direction of Vík (AR 2865) from the Klifurárjökull Glacier?
10. In what direction is Hafursa flowing in AR 2667?
11. What is the dominant land cover found in AR 2366?
12. What is the aspect of the slope in AR 2569?
13. What is the length of Sólheimajökull Glacier from GR 258703 to its terminus?
14. What is the difference in elevation of (lake) Gæsavatn (AR 2767) and (lake) Heiðarvatn (AR 2866)?
15. Which AR has the ice cover with the greatest gradient: AR 2670 or AR 2569?
16. Identify an economic activity that could be conducted in a landscape such as this.
17. Study Video 6.3a then complete the following activities:
    - **a** What direction was the drone moving when the film was taken?
    - **b** Investigate the rate of glacial retreat being experienced in Iceland. What factors account for the retreat of glaciers such as the one shown?

ACTIVITIES (MAP EXTRACT 2)

1. Describe the nature of the landscape shown on the Mýradfalsjökull topographic map extract.
2. How many named glaciers extend from Eyjafallajökull?
3. Identify the features of the constructed environment located at:
   - **a** GR 114565
   - **b** GR 115527.
4. What are the principal landform features in AR 1052?
5. What is the straight-line distance between the summit of Eyjafallajökull (AR 1154) and the camp site in AR 1251?
6. What is the bearing of the camp site in AR 1251 from the summit of Eyjafallajökull (AR 1154)?
7. What is the aspect of the slope in AR 1254?
8. Estimate the area of Eyjafallajökull covered by ice and snow.
9. How many abandoned farms/ruins are there in AR 1151?
10. What is the elevation of Eyjafallajökull?
11. What is the difference in elevation between the summit of Eyjafallajökull and the fjord at GR 114565?
12. Construct the cross-section from point A to point B. Use a vertical scale of 1 cm = 200 m.
13. Calculate the vertical exaggeration of the cross-section that you constructed in Activity 12.
14. What is the gradient of the slope between points C and D?
15. Estimate the area covered by snow and ice.

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6.3 Skaftafell topographic map extract

Figure 6.3a Reykjavík, Iceland's capital in winter

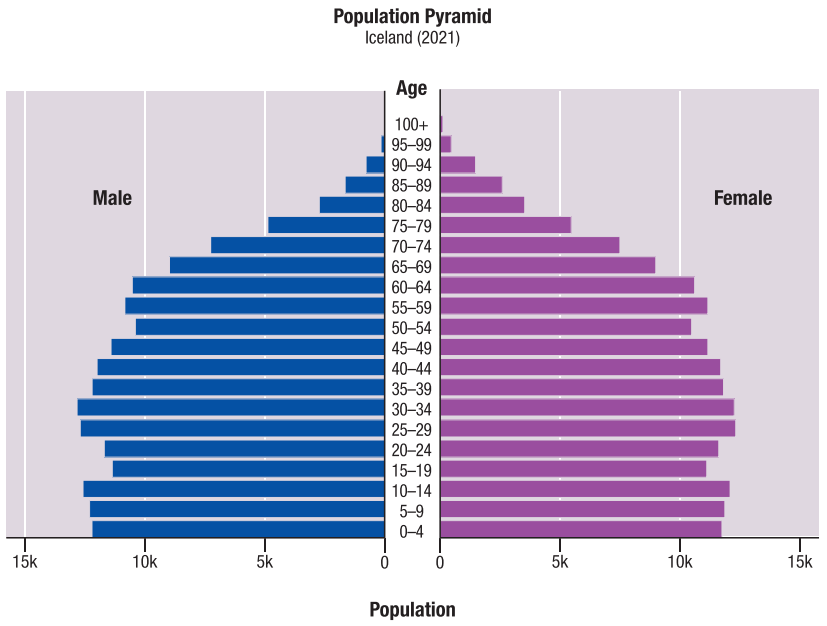

Figure 6.3b Iceland's population structure, 2021

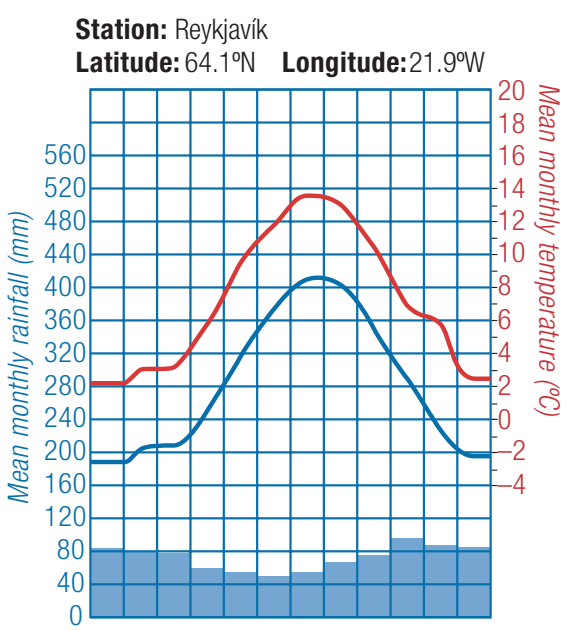

Figure 6.3c Reykjavík climate graph

Climate

Iceland, despite its high latitude (just outside the Arctic Circle) has a subarctic climate. The warm North Atlantic Current ensures that most of the country has generally higher annual temperatures than most places of similar latitude in the world. Despite its proximity to the Arctic, the island's coasts remain ice-free through the winter.

There is, however, some climate variation across the island. In general, the south coast is warmer, wetter and windier than the north. The coldest part of the country is the Central Highlands, and the most arid is the low-lying inland areas in the north. Winter snowfall is more common in the north than the south. See the climate graph for Reykjavík (Figure 6.3c).

Video 6.3a Aerial footage of Skaftafell Glacier (**00:15**)

ACTIVITIES

The legend for this map can be found on page 155.

1 Describe the nature of the landscape shown on the Skaftafell Topographic Map Extract.

2 Identify the feature of the biophysical environment located at:
- a GR 347723
- b GR 353715
- c GR 356716
- d GR 349732

3 What is the area reference of the Kotárjökull Glacier?

4 Name the type of biophysical feature found in AR 3473.

5 Name the land cover found in AR 3573.

6 Name the river flowing from the Stigárjökull Glacier.

7 In what general direction does the river flow?

8 What is the general direction of Breiðamerkurfjall (AR 3572) from the highest point of the Öræfajökull glacial ice cap (AR 3472)?

9 In what general direction is Fjallsjökull Glacier flowing in AR 3574?

10 What is the bearing of Snæbreið (AR 3472) from the summit of Staðarfjall (AR 3571)?

11 What is the straight-line distance between the spot height at Snæbreið (AR 3472) from the summit if Staðarfjall (AR 3571)?

12 What is the length of the airfield in AR 3470 and AR 3570 ?

13 What is the aspect of the slope centred on GR 347732?

14 What is the approximate area of Breiðamerkurfjall that is not covered by ice?

15 What is the difference in elevation of Snæbreið (AR 3472) and Staðarfjall (GR 3571)?

16 Construct the cross-section from Point A to Point B. Use a vertical scale of 1 cm = 200 m.

17 Calculate the vertical exaggeration of the cross-section you constructed in Activity 16.

18 What is the gradient of the slope in the cross-section that you constructed in Activity 16?

19 Class discussion. Speculate why the east flowing glaciers extend to a lower altitude than those flowing to the west and south-west.

20 Study Figure 6.3b. State the number of people under the age of 15 living in Iceland. What percentage of the population does this represent?

21 Study Figure 6.3c. Write a report describing the climate experienced in Reykjavík.

22 Construct an annotated photo sketch of either Figure 6.3d or 6.3e. Label key elements of the landscape.

Figure 6.3d Fjallsjökull Glacier and Fjallsárlón lake

Figure 6.3e Kviárjökull Glacier

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Skaftafell topographic map extract (Skaftafell: latitude 64° 0'N; longitude 16° 35'W)

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6.4 Langjökull (Lang glacier) topographic map extract

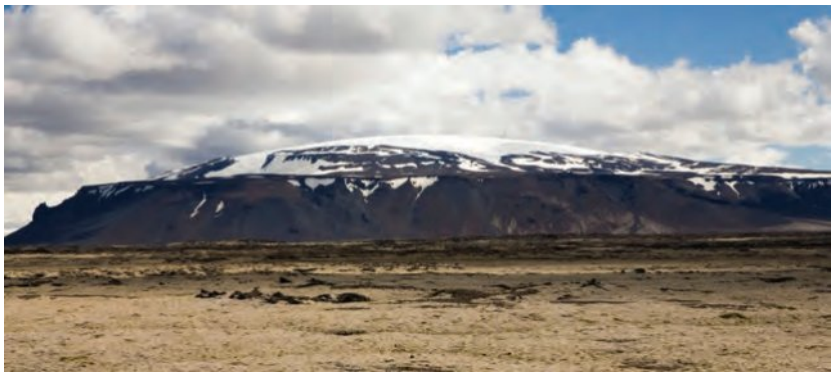

Figure 6.4a Eiriksjökull

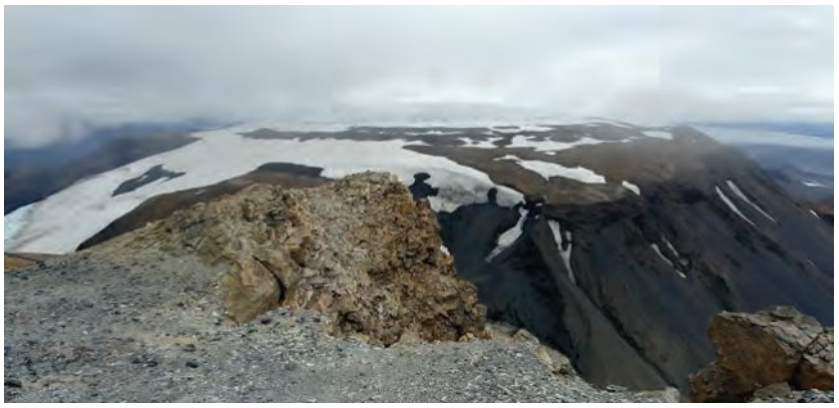

Figure 6.4b Geitlandsjökull as seen from adjacent Prestahnúkur

Langjökull is Iceland's second largest ice cap with an area of 953 km^2, after Vatnajökull. It is located in the west of the Icelandic interior or Highlands of Iceland. Two of the most prominent landforms on the map extract are Eiríksjökull and Geitlandsjökull.

Eiríksjökull is a glacier just north-west of the Langjökull ice cap. The glacier has an area of 22 km^2 and reaches a height of 1675 m. Rising over 1000 m above its surroundings, it forms the largest table-mountain in Iceland. The landform was formed by a single volcanic eruption. The mountain is covered by thick lava shield, which can been seen in Figure 6.4a. Eiríksjökull is currently dormant or extinct in terms of volcanic activity.

Geitlandsjökull is a glacier that once formed part of the larger Langjökull ice cap. The highest point of Geitlandsjökull, which lies on top of a tuya, reaches a height of 1390 m.

A **tuya** is a volcano that has steep sides and a flat top. It is formed when lava erupts through a thick sheet of ice, or a glacier. They are quite rare, as they only occur in regions which were covered by glaciers, and which also had active volcanism at this time.

ACTIVITIES

1 Identify the feature of the biophysical environment located at:
   - a GR 262542
   - b GR 249539
   - c GR 263535
   - d GR 253519

2 What is the area reference of (lake) Isalón?

3 Name a tributary that joins Hvitá (stream) in AR 2553?

4 What is the direction of Geitlandsjökull (glacier) (AR 2552) from Þórisjökull (AR 2451)?

5 In what direction is Nórólingafljót flowing in AR 2454?

6 What is the bearing of the summit of Geitlandsjökull (AR 2552) from the summit of Þórisjökull (AR 2451)?

7 What is the bearing of the spot height on the summit Strútur (AR 2453) from the summit of Eiríksjökull?

8 What is the straight-line distance between the spot height on summit of Strútur (AR 2453) from the summit of Eiríksjökull?

9 What is the aspect of the slope centred on:
   - a GR 262522
   - b GR 255527
   - c GR 247518
   - d GR 253535

10 What is the difference in elevation of Geitlandsjökull and Þórisjökull?

11 What is the difference in elevation of the lakes centred on GR 259537 and GR 265538?

12 Construct the cross-section from Point A to Point B. Use a vertical scale of 1 cm = 200 m.

13 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 12.

14 Construct the cross-section from Point C to Point D. Use a vertical scale of 1 cm = 100 m.

15 Calculate the vertical exaggeration of the cross-section you constructed in Activity 14.

16 What is the gradient of the slope in the cross-section that you constructed in Activity 12?

17 What is the gradient of the slope in the cross-section you constructed in Activity 14?

18 Study Figure 6.4b and its caption. In what direction was the camera facing when the photograph was taken.

19 Class discussion. As a class discuss why the Vestri-Brækur glacier (NE map quadrant) extends to a lower elevation that the Eiríksjökull snow and ice cap.

20 Class discussion. As a class speculate why there is so little evidence of human activity in the area covered by the map extract.

21 Study the text box. How were the Eiríksjökull and Geitlandsjökull formed? What is a tuya?

Skýringar / Legends / Zeichenerklärung / Légende

Hvammur	Bær Farm Bauernhof Ferme	0	Kirkja Church Kirche Église	Q	Tjaldsvæði Camping site Campingplatz Camping
(Dalur)	Eyðibýli Abandoned farm Verlassener Hof Ferme abandonnée	·	Skóli School Schule École	F	Sundlaug Swimming pool Schwimmbad Piscine
(Selkot)	Eyðibýli, rúst Abandoned farm, ruins Verlassener Hof, Ruine Ferme abandonnée, ruines		Sumarhús Summer house Sommerhaus Maison de vacances	!	Golfvöllur Golf course Golfplatz Terrain de golf
	Vegur, bundið slitlag Road, hard surface Asphaltierte Straße Route, goudronnée	#	Neyðarskýli Emergency shelter Nothütte Abri de secours	p	Flugvöllur Airfield Flugplatz Aéroport
	Vegur, malarborinn Road, gravel surface Schotterstraße Route, non-gourdronnée	#	Skáli, veiðihús, kofi Tourist hut or shelter Schutzhütte, Hütte Refuge non gardé, baraque		Viti Lighthouse Leuchtturm Phare
	Vegarslóð Track Piste Chemin	»	Vatnsaflstöð Hydro-electric power st. Wasserkraftwerk Station hydro-éléctrique	2	Rétt Sheepfold Schafscheideplatz Parc de mouton
	Veggöng Road tunnel Tunnel Tunnel	»	Varmaaflstöð Thermal power station Geothermalkraftwerk Station géo-thermique		Raflína Power line Stromleitung Ligne électrique
	Ferja Ferry Fähre Bateau		Hæðarlína, 100 metra Contour, 100 m Höhenlinie, 100 m Courbe de niveau, 100 m	132 756	Hæð mæld í metrum Spot elevation, meters Höhen in Metern Hauteur en mètres
	Gönguleið Footpath Wanderweg Sentier		Hæðarlína, 20 metra Contour, 20 m Höhenlinie, 20 m Courbe de niveau, 20 m	43	Vegnúmer Road number Straßennummer Numéro de route
	Reiðleið Bridle path Reitweg Piste cavalière		Hæðarlína á jökli Contour on glacier Höhenlinie auf Gletscher Courbe de niveau sur le glacier	V	Vað Ford Furt Gué

	Þéttbýli Town, village Orte Agglomération		Á, lækur River, brook Fluss, Bach Rivière, ruisseau
	Vel gróið land Land with vegetation cover Geschlossene Vegetation Terrain couvert de végétation		Stöðuvatn, tjörn, lón Lake, pond, reservoir See, Teich, Stausee Lac, étang, lagon
	Lítt gróið land Land with little vegetation Spärliche Vegetation Terrain peu couvert en végétation		Stöðuvatn sem þornar upp Intermittent lake Zeitweiliger See Lac intermittent
	Hraun Lava Lava Lave		Strandlína, sjór Coastline, sea Strandlinie, Meer Côte, mer
	Sandur, aur Sands, mudflats Sandfläche, Lehmboden Sable, marécage		Jökull Glacier Gletscher Glacier

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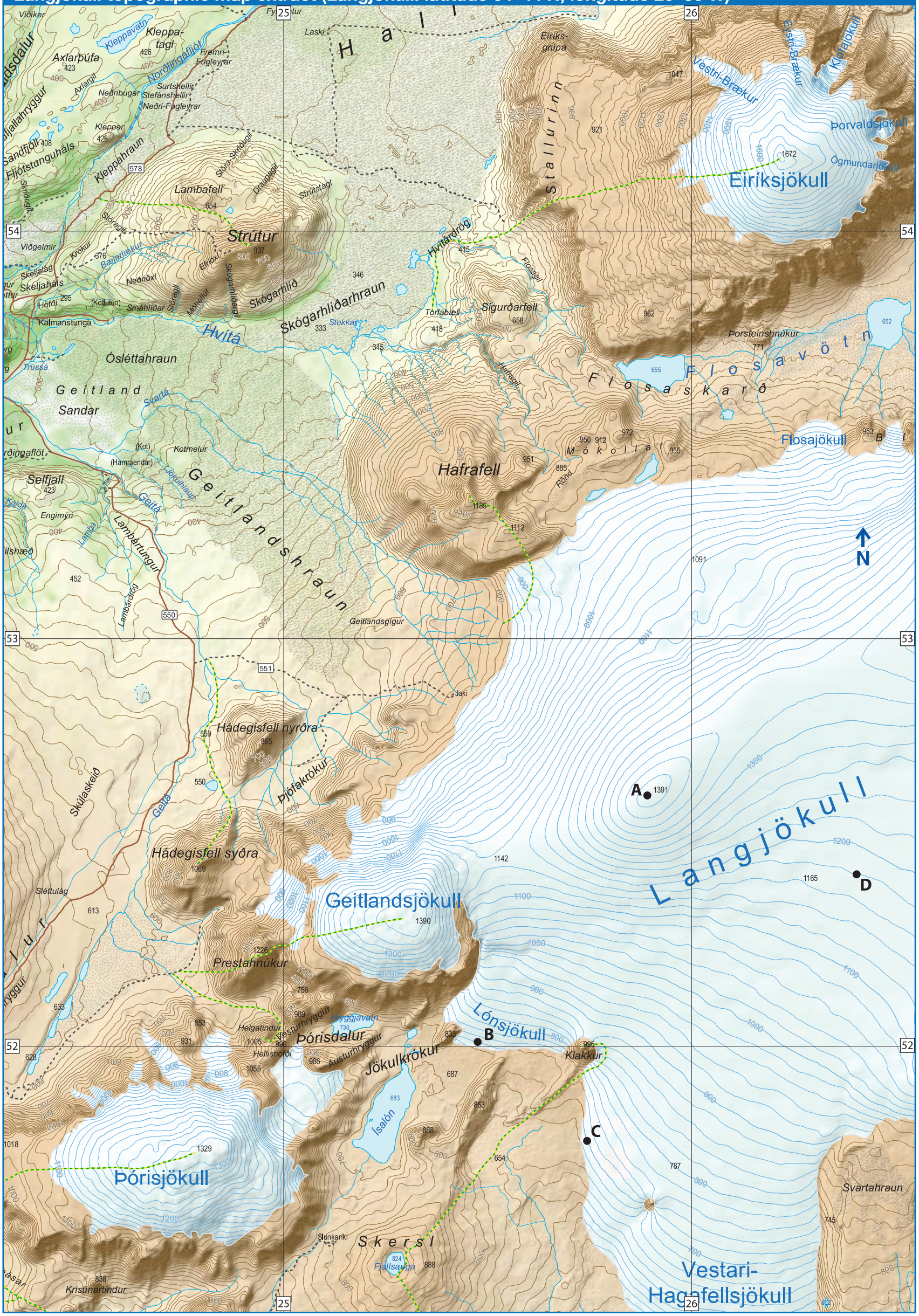
Langjökull topographic map extract (Langjökull: latitude 64° 44’N, longitude 20° 30'W)



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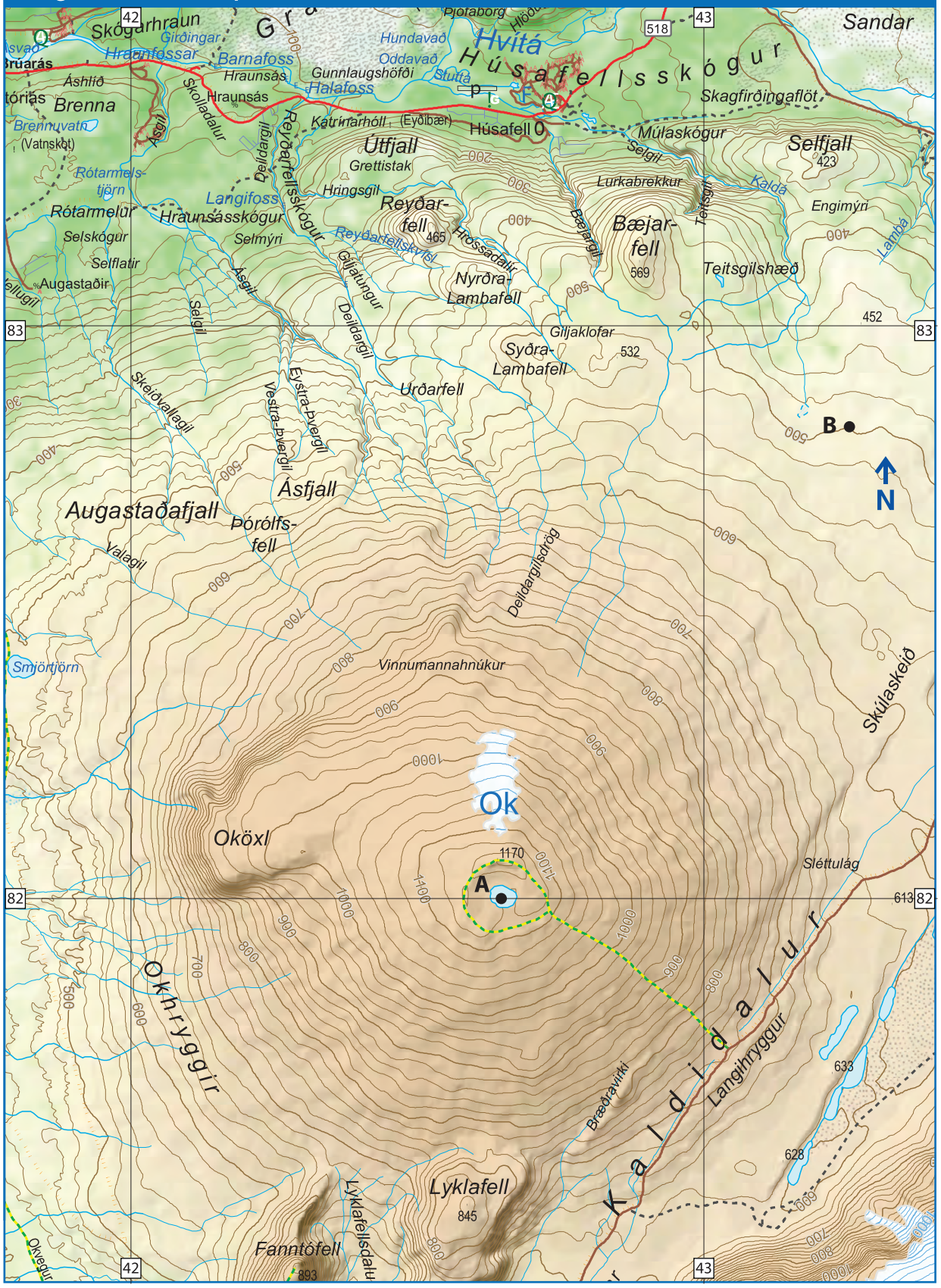
6.5 Okjökull (Ok glacier) topographic map extract

Okjökull (Ok glacier) topographic map extract (Okjökull: latitude 64° 35'N, longitude 20° 52'W)



The loss of the Okjökull glacier

On 18 August, 2019, scientists gathered on the summit of Ok volcano in west-central Iceland. They came to mourn the loss of Okjökull – a once-iconic glacier that melted away throughout the 20th century and was declared dead in 2014.

A map from 1901 estimated Okjökull spanned an area of about 38 square kilometres. In 1978, aerial photography showed the glacier was 3 square kilometres. Today, less than 1 square kilometre remains. The satellite images (Figures 6.5a and b) show the glacier during the latter part of its decline, on 14 September 1986 and 1 August 2019.

The dome-shaped glacier appears in the 1986 image as a solid-white patch, just north of the snow-filled crater. Snow is also visible around the glacier's edges. In the August 2019 image, only patches of thin ice remain.

Figure 6.5a Satellite image of Okjökull glacier in 1986

Figure 6.5b Satellite image of Okjökull glacier in 2019

ACTIVITIES

Refer to the linear scale on page 160.

1 Identify the feature of the biophysical environment located at:
   - a GR 418824
   - b GR 426815
   - c GR 426822
   - d GR 429832.

2 Name the type of land cover found in GR 424835.

3 What is the direction of Ok from Selfjall (AR 4383)?

4 In what direction is Asgil flowing in AR 4283?

5 What is the bearing of Bæjarfell (AR 4285) from Lyklafell (AR 4281)?

6 What is the straight-line distance between the summit of Lyklafell (AR 4281) and Bæjarfell (AR 4283)?

7 What is the aspect of the slope centred on GR 423819?

8 What is the elevation of the surface of Smjörtjörn Lake?

9 What is the difference in elevation of Bæjarfell (AR 4283) and Lyklafell (AR 4281)?

10 Construct the cross-section from the summit of Ok (Point A) to Point B. Use a vertical scale of 1 cm = 100 m.

11 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 10.

12 What is the gradient of the slope in the cross-section that you constructed in Activity 10?

13 What evidence is there that Ok is a volcanic landform?

14 Study Figures 6.5a and b. Describe the change in land cover on Ok between 1986 and 2019. What is the stated cause of this change?

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Grant Kleeman

SECTION 7 North America

7.1 North America

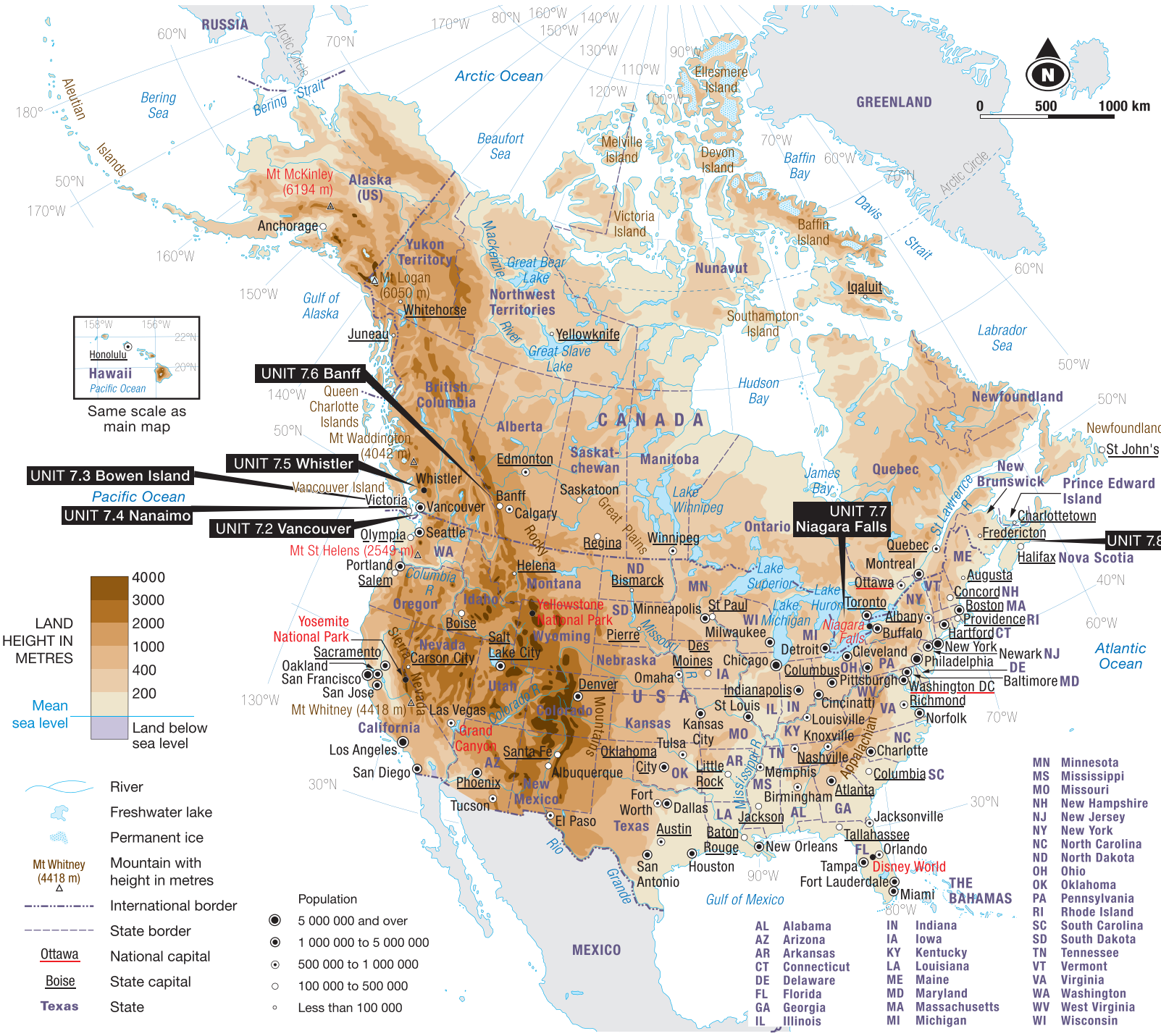

Figure 7.1a Canada and the United States: physical features

ACTIVITIES

1 Name the capital cities of Canada and the United States.

2 What oceans lie to the north, east and west of North America?

3 What is the water body to the immediate south of the mainland of the United States?

4 Name three of the Great Lakes located in the north-east of the United States.

5 What is the width of the United States from west to east along 40° latitude?

6 What major river system drains into the Gulf of Mexico at New Orleans?

7 What mountain range lies parallel to the east coast of the United States?

8 What mountain range is located in California?

9 What mountain range runs the full length of continental North America?

10 What landform feature stretches across central Canada and the northern states of the central United States?

11 Name the capital of the following US states and Canadian provinces:
- a British Columbia
- b Alberta
- c Ontario
- d California
- e Washington
- f Texas
- g Florida
- h Hawaii.

12 Name five cities with a population greater than 5 million.

13 Name three Canadian cities with a population greater than 1 000 000 but less than 5 000 000.

14 What is the direction of:
- a New York from Washington, DC
- b San Francisco from Austin, Texas?

15 In what US state would you find the following tourist attractions:
- a the Grand Canyon
- b Yellowstone National Park
- c Yosemite National Park
- d Niagara Falls
- e Disney World?

16 Identify the feature of the physical environment located at the following latitudes and longitudes:
- a 46°12′N, 122°11′W
- b 63°02′N, 151°01′W.

17 What is the latitude and longitude of the following cities:
- a New York
- b Washington, DC
- c Vancouver
- d Montreal?

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Grant Kleeman

7.2 Vancouver, Canada, topographic map extract

Figure 7.2a Oblique aerial photograph of central Vancouver

Vancouver, British Columbia, ranks as one of the world's most 'liveable' cities. The Greater Vancouver urban area has a population of 2.6 million, making it the third-largest metropolitan area in Canada.

The city occupies a most spectacular coastal setting and features a mountain backdrop. The North Shore Mountains dominate the cityscape as does Stanley Park. At 404.9 ha it is North America's largest urban park.

Because of its coastal location Vancouver's climate is quite mild, especially by Canadian standards. The summer months are typically dry, with an average of only one in five days receiving rain in July and August. Between November and March, however, rain or snow fall on nearly half the days.

Vancouver is one of the most ethnically diverse cities in Canada. For 52 per cent of the population, English is not their first language. Almost 30 per cent of the city's population has Chinese heritage. Other significant Asian communities in Vancouver are the South Asian (mainly Punjabi, 5.7 per cent), Filipino (5.0 per cent), Japanese (1.7 per cent) and Korean (1.5 per cent).

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at each of the following grid references:
- a GR 911604
- b GR 944704
- c GR 899614
- d GR 915609
- e GR 955558.

4 Identify the feature of the constructed environment located at the following grid references:
- a GR 919582
- b GR 917668
- c GR 919675
- d GR 900637.

5 Identify the land use in AR 9860.

6 What river flows into Vancouver Harbour in AR 8963?

7 What creek flows into Vancouver Harbour in AR 9362?

8 What is the area reference of False Creek's Granville Island?

9 What is the direction of flow of the Capilano River in AR 9063?

10 What is the direction of Prospect Point (AR 8962) from Brockton Point (AR 9160)?

11 What is the bearing of Elsje Point (AR 8958) from Brockton Point (AR 9160)?

12 What is the length of the Grouse Mountain cable car from GR 928688 to GR 939697?

13 What is the elevation of the landform feature at GR 987703?

14 What is the density of buildings in AR 9468?

15 Identify the recreational facility located in the following area references:
- a AR 8960
- b AR 9060.

16 What is the area of Stanley Park?

17 Estimate the area of Lost Lagoon (AR 8960).

18 What is the aspect of the slope in AR 9368?

19 What is the general aspect of North Vancouver?

20 What is the gradient of the slope from the summit of Grouse Mountain to Vancouver Harbour's shoreline at GR 950614?

21 In what general direction was the camera facing when Figure 7.2a was taken?

22 Using Figure 7.2b locate the features of the physical and human environments identified in Activities 3–4.

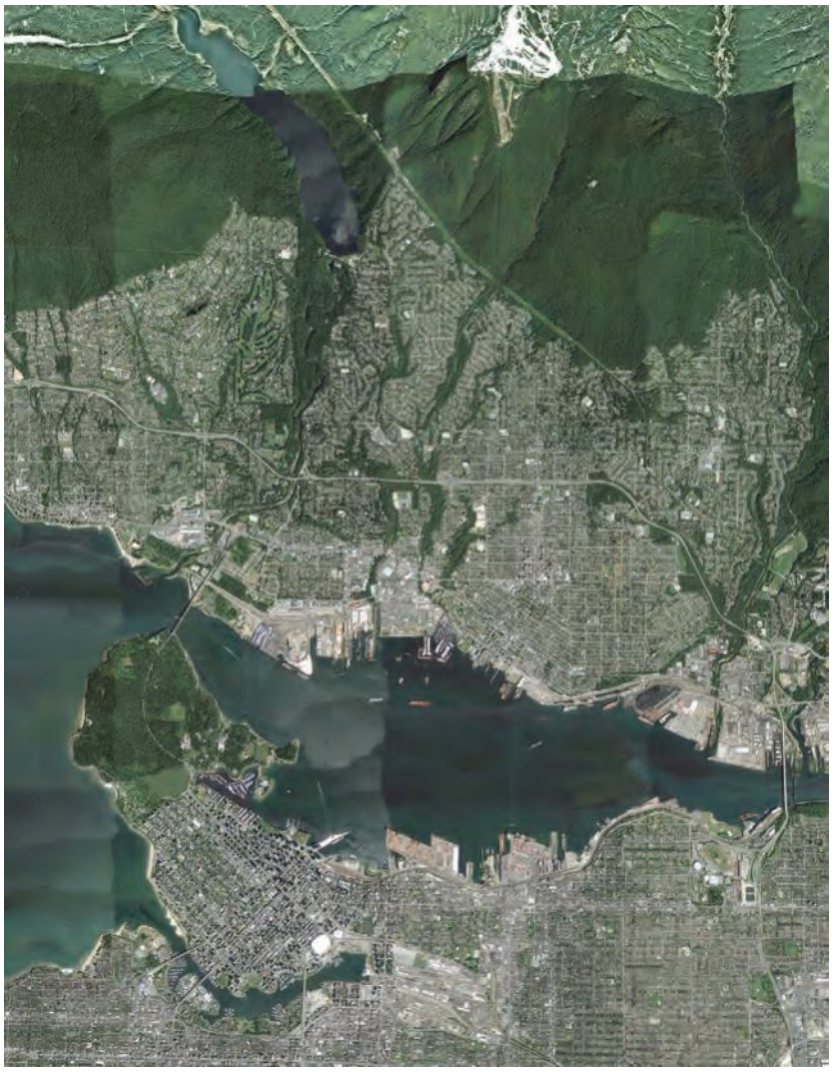

Figure 7.2b Satellite photograph of Vancouver, Google Earth, Image © 2016 DigitalGlobe, © 2016 Google, Image © Province of British Columbia

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Vancouver topographic map extract (Vancouver: latitude 49°13′N, longitude 123°06′W)

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Grant Kleeman

7.3 Bowen Island, Canada, topographic map extract

Figure 7.3a Snug Cove ferry terminal and marina

Bowen Island, British Columbia, is an island in Howe Sound. The island is approximately 6 km wide by 12 km long. At its closest point it is just 3 km west of the mainland.

Various First Nations peoples used the island as a seasonal hunting ground, and a place to stop when travelling along the coast.

Today, there is a regular ferry service to the island from Horseshoe Bay. The island is a popular vacation home location for British Columbians.

Figure 7.3b Horseshoe Bay

Figure 7.3c Snug Cove

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 763679
- b GR 775740
- c GR 716694
- d GR 803696
- e GR 733690
- f GR 800654.

4 Identify the feature of the constructed environment located at:
- a GR 733754
- b GR 804672
- c GR 752699
- d GR 798683.

5 What is the area reference of Passage Island?

6 Name the types of vegetation found in AR 7471.

7 On what waterway is Honeymoon Lake (AR 7472) located?

8 What waterway flows into Snug Cove in AR 7569?

9 What is the direction of Horseshoe Bay (AR 8069) from Snug Cove (AR 7669)?

10 In what direction is Lee Creek flowing in AR 7366?

11 What is the bearing of:
- a Hope Point (AR 7375) from Finisterre Island navigation light (GR 776740)
- b Crebe Islets (GR 880654) from Mount Gardner (GR 717694)?

12 What is the straight-line distance between Hope Point (AR 7375) and Finisterre Island navigation light (GR 776740)?

13 What is the length of the ferry route from Snug Cove (GR 760697) to Horseshoe Bay (GR 803693)?

14 What is the aspect of the slope in AR 7468?

15 What is the area of Bowyer Island?

16 What is the density of buildings in AR 7471?

17 What is the height of:
- a Mount Gardiner (GR 717694)
- b Mount Collins (AR 7572)?

18 What is the elevation of the surface of Killarney Lake?

19 Estimate the local relief experienced on a traverse from the summit of Mount Gardiner (AR 7169) to the summit of the hill in AR 7367.

20 Construct the cross-section from the summit of Mount Gardiner (AR 7169) to the summit of Mount Collins at GR 758726. Use a vertical scale of 1 cm = 100 m.

21 Calculate the vertical exaggeration of the cross-section that you constructed in Activity 20.

22 What is the gradient of the slope between the summit of Mount Gardiner (GR 717694) to the point where the creek flows into the sea in AR 7070?

23 What is the gradient of Warwick Creek (AR 7466)?

24 Study Figure 7.3b and the map extract. Identify the features labelled 1–6.

25 In what direction was the camera facing when the image in Figure 7.3b was taken?

26 Study Figure 7.3c and the map extract. Identify the features labelled 1–5.

CONTOUR INTERVAL 20 METRES

1 0 1 2 3 4

SCALE 1:50 000 KILOMETRES

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Grant Kleeman

Bowen Island topographic map extract (Snug Cove: latitude 49°23′N, longitude 123°19′W)

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Grant Kleeman

7.4 Nanaimo, Canada, topographic map extract

Figure 7.4a Oblique aerial photograph of Nanaimo, Vancouver Island

Nanaimo is a small city on British Columbia's Vancouver Island. It is located on the unceded, ancestral territory of the Snuneymuxw, one of Canada's many First Nations peoples.

The earliest documented European contact was with Spanish explorers in 1792, but the town itself began as a Hudson Bay Co. trading post in 1852. The discovery of coal led to the city becoming known for the export of coal. Nanaimo is surrounded by agricultural land and timber resources. The city's ferry terminal is an important transport link for those travelling between Vancouver Island and the mainland.

Figure 7.4b Nanaimo's waterfront

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 326530
- b GR 378498
- c GR 308530
- d GR 281531.

4 Identify the feature of the constructed environment located at:
- a GR 374432
- b GR 291442
- c GR 324494
- d GR 283503.

5 What is the area reference of Five Finger Island?

6 Name the type of biophysical feature found in AR 3342.

7 Name the type of land use found in AR 3245.

8 Name the type of vegetation found in AR 3442.

9 What river flows into Nanaimo Harbour at GR 314470?

10 What is the direction of Snake Island (AR 3551) from Five Finger Island (AR 3353)?

11 In what direction is Millstone Creek flowing in AR 2847?

12 What is the bearing of Horswell Rock (AR 3151) from the navigation light on Snake Island (GR 352520)?

13 What is the length of the ferry route from Nanaimo (GR 319465) to Descanso Bay (GR 374475)?

14 What is the length of the ferry route from Nanaimo to Protection Island?

15 What is the aspect of the slope in AR 2953?

16 What is the area of Newcastle Island?

17 What is the density of buildings in AR 3747?

18 What is the height of the hill at GR 294529?

19 What is the height of the hill at GR 284452?

20 What is the elevation of the surface of Westwood Lake (AR 2745)?

21 What is the gradient of the slope between GR 294529 and the shoreline at GR 298535?

22 List the main economic activities found in and around Nanaimo.

23 Study Figure 7.4a and the map extract. Locate the following features in the photograph: Newcastle Island, Protection Island, Newcastle Passage, Mark Bay, Departure Bay and Jesse Island.

24 Study the climate graph of Nanaimo in Figure 7.4c and then complete the following tasks:
- a What is the hottest month?
- b What is the coldest month?
- c What is the seasonal range of maximum and minimum temperatures?
- d Which are the wettest and driest months?
- e Describe the seasonal distribution of precipitation.

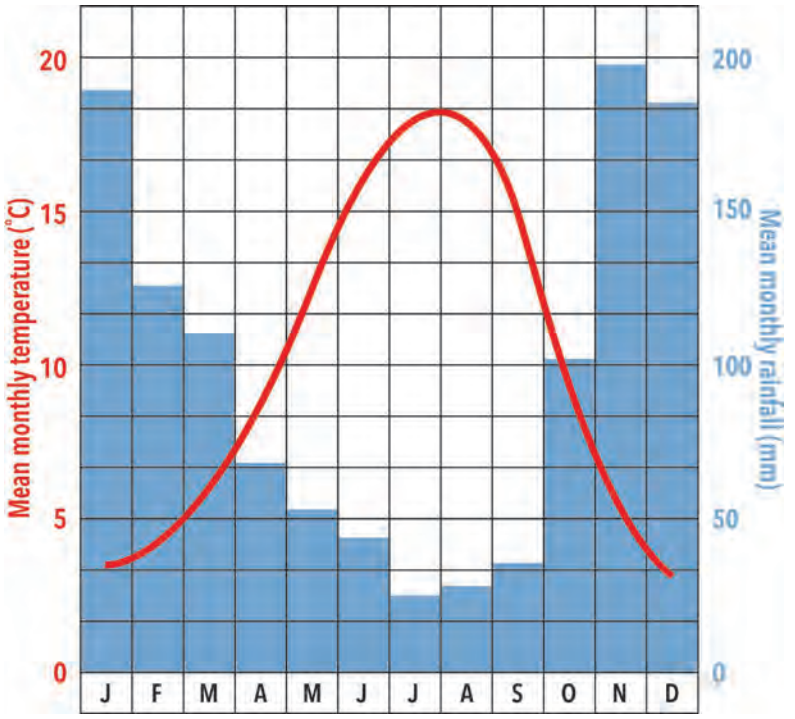


Figure 7.4c Climate data for Nanaimo, British Columbia

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Av. max. (°C)	6.9	8.5	11.0	14.1	17.7	20.8	23.9	24.3	20.9	14.6	9.3	6.3	14.8
Av. min. (°C)	0.1	0.0	1.7	3.9	7.2	10.3	12.3	12.1	8.9	5.2	1.8	–0.2	5.3
Daily mean (°C)	3.5	4.3	6.3	9.0	12.5	15.6	18.1	18.2	14.9	9.9	5.6	3.1	10.1
Precip. (mm)	187.9	126.0	113.0	67.4	54.3	43.4	25.4	28.4	35.8	102.2	197.2	184.3	1165.4

ISBN 978-1-009-07583-1

Nanaimo topographic map extract (Nanaimo: latitude 49°17′N, longitude 123°94′W)

ISBN 978-1-009-07583-1

Grant Kleeman

7.5 Whistler, Canada, topographic map extract

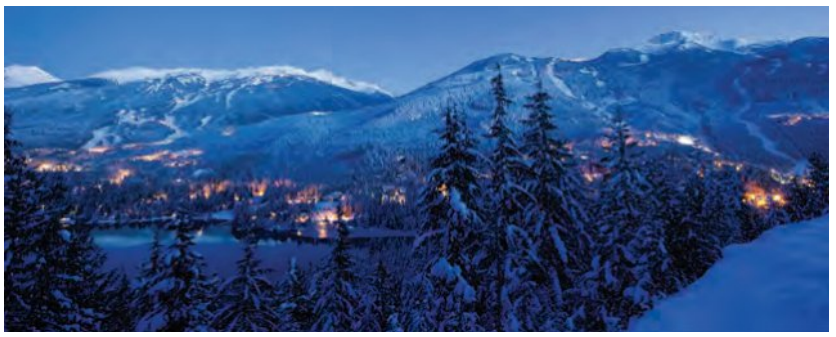


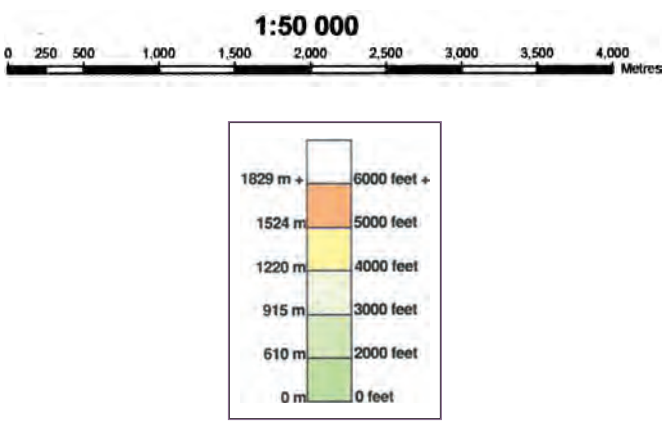
Figure 7.5a Blackcomb and Whistler mountains

Whistler is one of the world's leading winter sports resorts. Over 2 million people visit Whistler each year, primarily for skiing and snowboarding and, in summer, mountain bike riding, golfing and hiking.

Whistler is located approximately 125 km north of Vancouver and has a permanent population of about 10 000 people, plus a larger seasonal worker population, typically young people from Australia, New Zealand and Europe.

In the summer of 2021, Whistler and the surrounding areas were badly affected heat waves, and then wildfires.

Figure 7.5b Whistler Village, Google Earth, Image © 2016 DigitalGlobe, © 2016 Google



ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the features of the bio-physical environment located at:
- a GR 452865
- b GR 514890
- c GR 425909
- d GR 470857
- e GR 457862
- f GR 465851.

4 Identify the features of the constructed environment located at:
- a GR 452916
- b GR 495918
- c GR 424908
- d GR 494906
- e GR 451969
- f GR 454953.

5 What is the grid reference of the base station of the Whistler Creekside Gondola?

6 Name the biophysical feature(s) that are found in:
- a AR 5189 and AR 5190
- b AR 4586.

7 What type of land use is found in AR 4794?

8 What type of alpine transport links Whistler Village to the Roundhouse Restaurant and Ski Lodge (GR 459881)?

9 What type of ski lift is Harmony Express in the south-east quadrant of the map extract?

10 How many golf courses are there in Whistler? Why do you think there would be so many courses in an alpine resort destination?

11 Identify the winter recreational activities available at:
- a AR 4687
- b AR 4694.

12 Using area references, identify at least six recreational activities available to tourists during summer.

13 Into what waterway does Harmony Creek flow at GR 481889?

14 What is the name of the waterway joining Green Lake and Alta Lake?

15 What creek flows into Nita Lake in AR 4290?

16 What is the direction of:
- a Whistler Mountain (AR 4586) from Blackcomb Peak (GR 514890)
- b Blackcomb Peak (GR 514890) from the Upper Village (AR 4693)?

17 In what direction is Wedge Creek flowing in AR 5095?

18 In what direction is Oboe Creek flowing in AR 4986?

19 What is the bearing of Whistler Mountain (GR 453864) from Blackcomb Peak (GR 514890)?

20 What is the aspect of the slope in:
- a AR 4297
- b AR 5087?

21 Estimate the straight-line distance between Whistler Mountain (AR 4586) and Blackcomb Peak (GR 514890).

22 What is the difference in elevation of Whistler Village Gondola's base (GR 455926) and its terminus at the Roundhouse Restaurant and Ski Lodge?

23 What is the length of the Whistler Village Gondola?

24 What is the elevation of Symphony Lake (GR 470857)?

25 What is the difference in elevation (in metres) between Blackcomb Peak (AR 5189) and Whistler Mountain (AR 4586)?

26 What is the height of the landform feature located at GR 517885?

27 Estimate the area of Alta Lake.

28 Construct the cross-section of the valley over which the new peak-to-peak gondola will pass (that is, from point A to point B). Use a vertical scale of 1 cm = 2000 ft.

29 Visit the Whistler Blackcomb website and then complete the following tasks:
- a Locate the resort's weather statistics. Construct a column graph showing the monthly snowfall totals for the most recent season for which complete data are available.
- b Using the resort's weather statistics, construct a line graph showing the average low and high valley temperatures.
- c View the resort's webcams. Use the topographic map extract to locate the positioning of these webcams.

30 Study Figure 7.5b and the map extract. Locate the following features: Green Lake, Lost Lake, Whistler Golf Course, Chateau Whistler Golf Course, Upper Village, Whistler Village, and the Alpine Meadows residential area.

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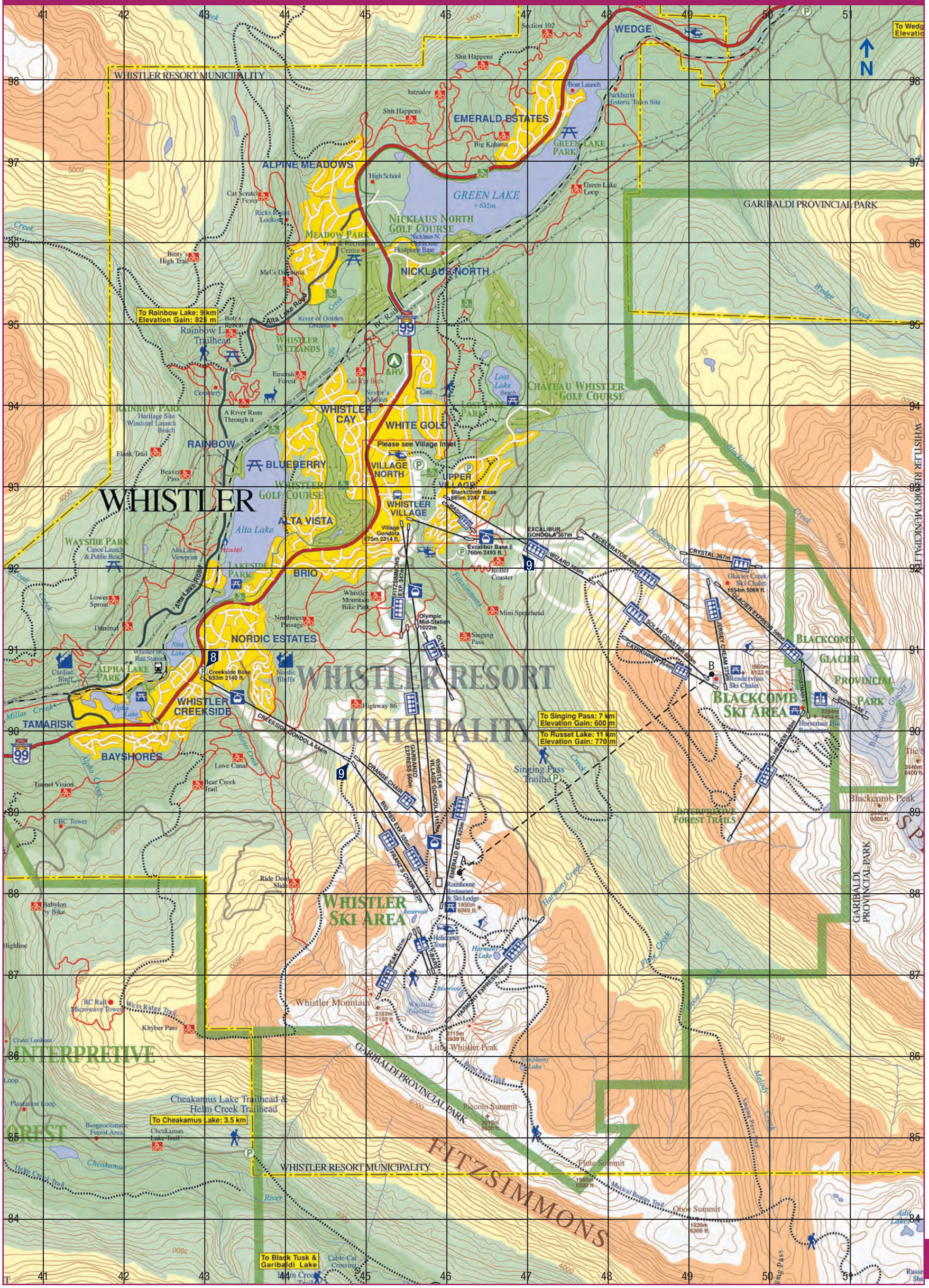
Grant Kleeman

Whistler topographic map extract (Whistler: latitude 49°58′N, longitude 123°09′W)



ISBN 978-1-009-07583-1

Grant Kleeman

7.6 Banff, Canada, topographic map extract

Figure 7.6a Moraine Lake

Figure 7.6b Agnes Lake

Figure 7.6c Banff Springs Hotel, Banff

Figure 7.6d Lake Louise and the Chateau Lake Louise

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 233726
- b GR 267765
- c GR 323717
- d GR 351743.

4 Identify the feature of the constructed environment located at:
- a GR 249723
- b GR 276721
- c GR 313665
- d GR 244721.

5 What is the grid reference of Castle Junction?

6 What biophysical feature is found in AR 3568?

7 What type of recreational land use is found in AR 2872?

8 What is the name of the creek flowing from Kaufmann Lake in AR 2768?

9 What is the name of the tributary that joins the Bow River at GR 327683?

10 What is the direction of Lake Louise (AR 2872) from Banff (AR 3666)?

11 In what direction does Bow River flow in AR 2970?

12 Study Figure 7.6d. In which direction was the camera facing when this photograph was taken?

13 What is the bearing of Mount Brett (AR 3366) from Panther Mountain (AR 3574)?

14 What is the aspect of the slope in AR 3769?

15 What is the straight-line distance from Castle Junction (AR 3168) to Lake Louise (AR 2872)?

16 What is the straight-line distance from the summit of Mount Brett (AR 3366) to the summit of Panther Mountain (AR 3574)?

17 Estimate the area of Bonnet Glacier (AR 3172).

18 Estimate the height of the following landform features:
- a Pulsatilla Mountain (GR 309714)
- b Mt Cory (GR 348674)
- c Lake Louise (GR 274719).

19 Estimate the height of the camping ground at GR 331694.

20 What is the difference in elevation of Mount Brett (AR 3366) and Panther Mountain (AR 3574)?

21 Identify the principal agents of erosion responsible for the landforms featured on the map extract.

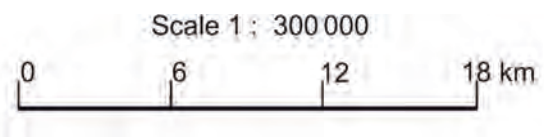
22 Describe the relationship between transport and topography on the map extract.

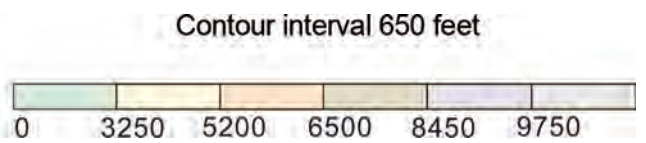
23 Construct a precis map showing the relationship between topography and transport on the map extract.

24 Study Figures 7.6a–d. Using grid and area references, locate each of these features on the Banff Springs topographic map extract.

Banff National Park is Canada's oldest national park and one of the world's great scenic wonders. The park covers 6641 km^2 of mountainous terrain, with numerous glaciers, ice fields and dense coniferous forest. Some of the most famous sights include Lake Louise and Moraine Lake. The main commercial centre of the park is the town of Banff in the Bow River valley.

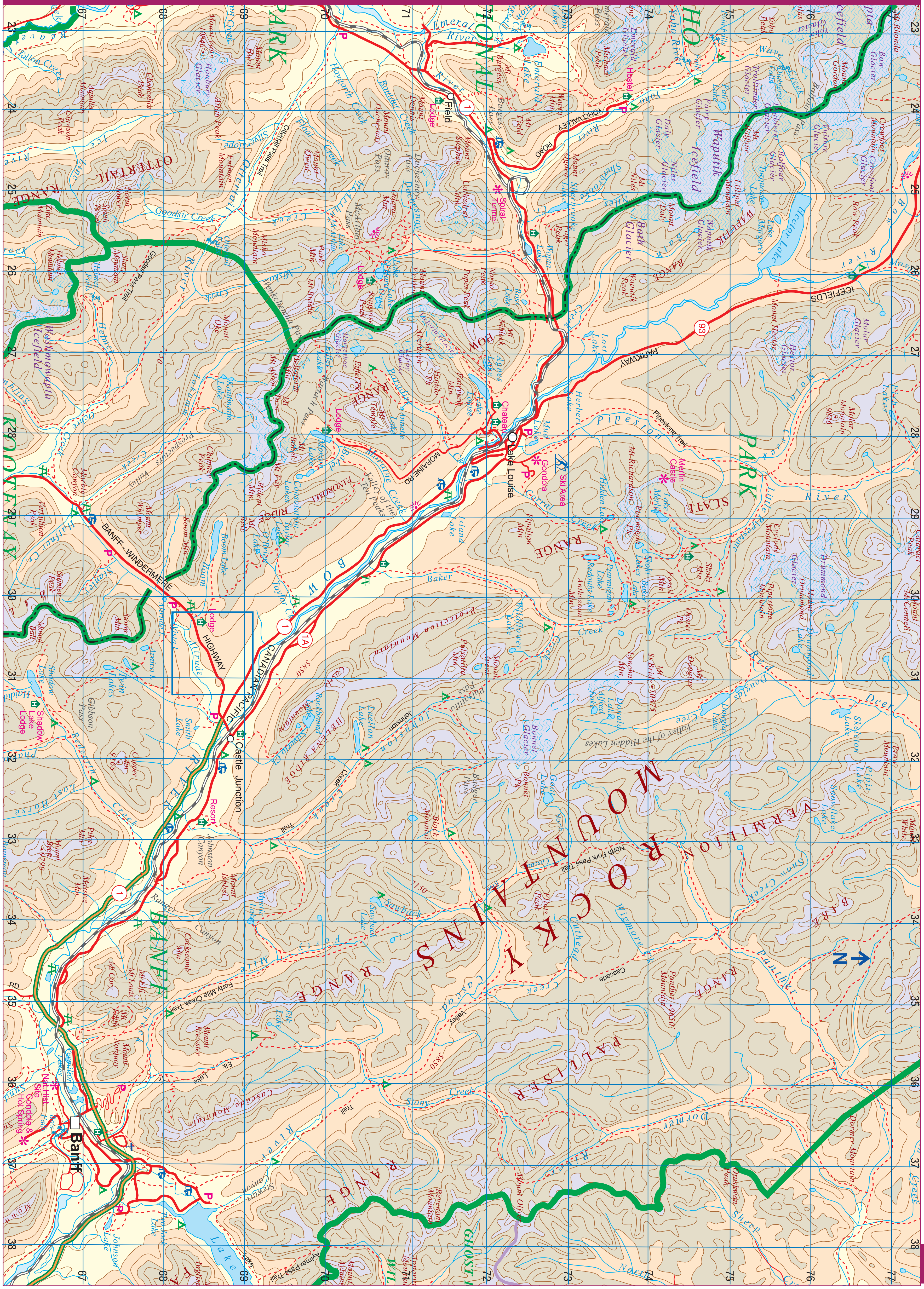
Before European settlement, a number of Canadian First Nations peoples shared the area for travel, hunting and fishing.





ISBN 978-1-009-07583-1

Banff topographic map extract (Banff: latitude 51°10′N, longitude 115°34′W)



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Grant Kleeman

7.7 Niagara Falls, Canada and the United States, topographic map extract

Figure 7.7a Oblique aerial photograph of Niagara Falls

Niagara Falls is the name for three waterfalls that straddle the border of Canada and the United States. From largest to smallest, the three waterfalls are the Horseshoe Falls, the American Falls and the Bridal Veil Falls.

Located on the Niagara River, which links Lake Erie to Lake Ontario, the falls collectively have the highest flow rate of any fall in the world. Horseshoe Falls is the most powerful waterfall in North America, as measured by vertical height and flow rate.

Niagara Falls has been a tourist destination, particularly for honeymooners, for more than a century. There is a history of people undertaking dangerous stunts at Niagara Falls, including going over the falls in a barrel, or walking across them on a tightrope. Some have died in the attempt.

ACTIVITIES

1 What is the scale of the Niagara Falls topographic map extract?

2 What is the contour interval of the Niagara Falls map extract?

3 Identify the feature of the biophysical environment located at:
- a GR 569762
- b GR 571720
- c GR 565714
- d GR 574717.

4 Identify the feature of the constructed environment located at:
- a GR 527698
- b GR 585696
- c GR 594785
- d GR 555730.

5 State the productive activity located in the following locations:
- a AR 5369
- b AR 5482
- c AR 5669
- d AR 5978.

6 Name the three bridges that span the Niagara River.

7 In which nations are the Horseshoe and American Falls located?

8 What is the direction of the Whirlpool (AR 5675) from Navy Island?

9 What is the length of the Queenston–Chippawa power canal from GR 534696 to the generating station located at GR 590793?

10 What is the length of the aerial cableway from GR 571758 to GR 571763?

11 Estimate the area of the reservoir centred on GR 570790.

12 Estimate the area of Navy Island located in the south-east quadrant of the map extract.

13 What is the bearing of Niagara Falls City Hall (GR 575744) from the senior citizens home located at GR 539717?

14 Describe the settlement pattern in the north-west quadrant of the Niagara Falls map extract.

15 Describe the pattern of tourist-related facilities along State Highway 20 in the south-west quadrant of the map extract.

16 Describe the features of the Niagara Falls river channel from American Falls and Horseshoe Falls to GR 588803.

17 What evidence is there that Niagara Falls is a major centre of industrial production?

18 List the range of goods produced by industries in the area covered by the map extract.

19 Describe the extent to which people have modified the water cycle in the area covered by the Niagara Falls map extract.

20 Study Figure 7.7a. In what direction was the camera facing when the photograph was taken?

21 Study Video 7.7a. In which direction was the drone's camera facing when the image was taken? What might the boat featured in the short video clip be doing?

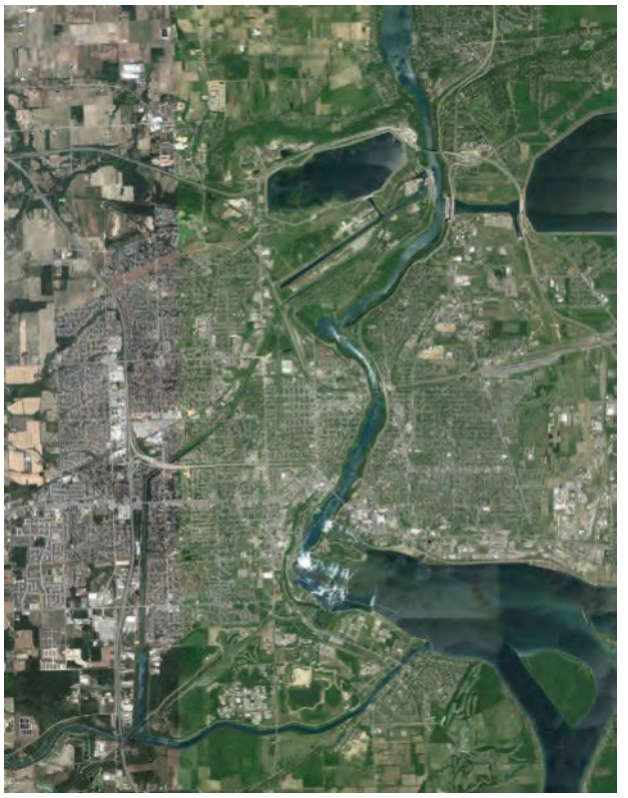
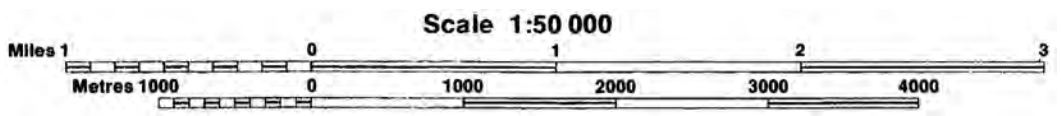


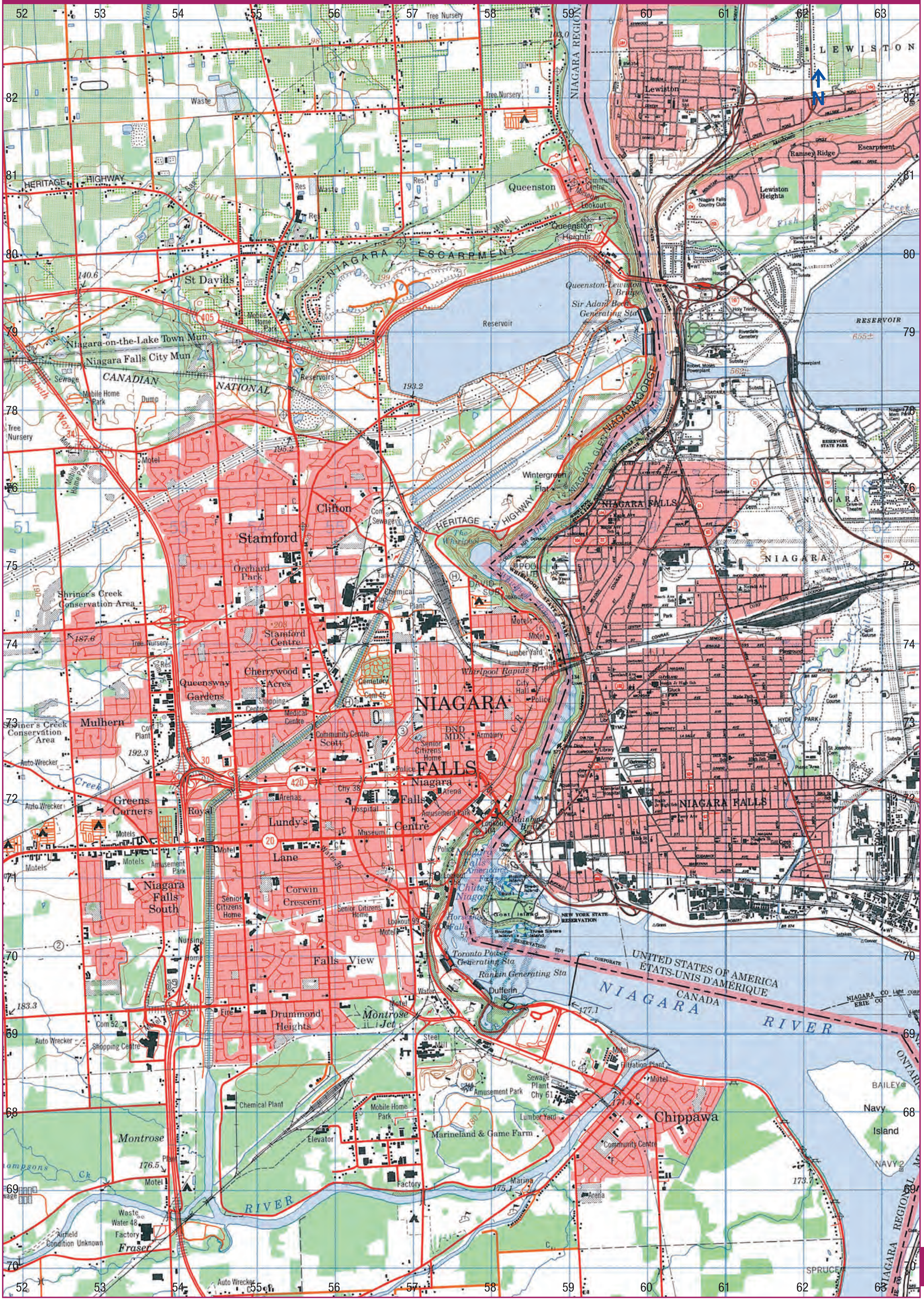
Figure 7.7b Satellite photograph of Niagara Falls, Google Earth, © 2016 Google, Images © 2016 DigitalGlobe

Video 7.7a Aerial footage of a boat approaching Horseshoe Falls (**00:28**)



CONTOUR INTERVAL 10 METRES IN CANADA
Elevation in metres above mean sea level
CONTOUR INTERVAL 25 FEET IN USA

ISBN 978-1-009-07583-1



ISBN 978-1-009-07583-1 Grant Kleeman

7.8 Halifax, Canada, topographic map extract

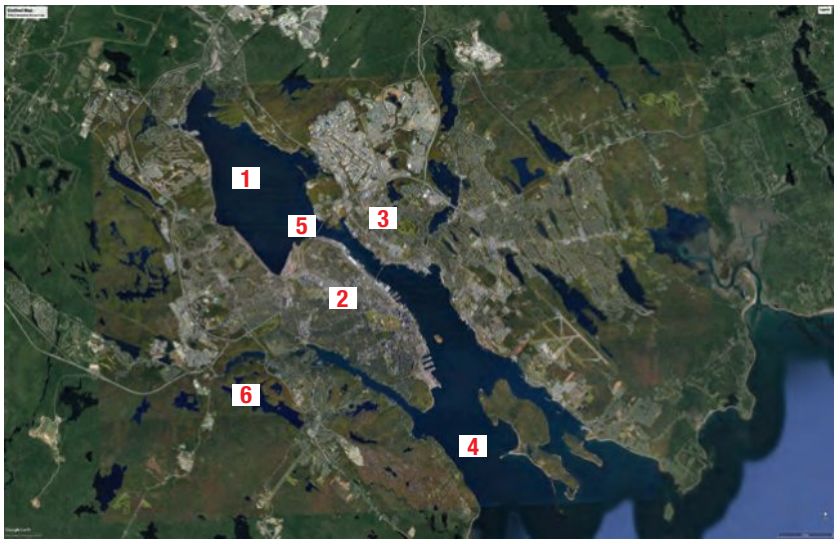


Figure 7.8a Google Earth Image of Halifax © 2021 Google

ACTIVITIES

1 What is the scale of the map extract?

2 What is the contour interval used on the map extract?

3 Describe the site of Halifax.

4 Study Figure 7.8a. Name the features numbered 1–6.

5 Identify the feature of the biophysical environment located at:
- a GR 556433
- b GR 543381
- c GR 499463
- d GR 478417.

6 Identify the feature of the constructed environment located at:
- a GR 430428
- b GR 515479
- c GR 571414
- d GR 546473.

7 What is the area reference of Russell Lake?

8 Name the type of biophysical feature found in AR 5840.

9 Name the type of land use found in AR 5851.

10 Name the type of vegetation found in AR 5338.

11 What waterway separates Halifax from the urban areas of Melville Cove, Jollimore and Boulderwood?

12 Study Figure 7.8c. Locate the Halifax Citadel using grid references.

13 Study Figure 7.8b. In what direction was the camera facing when the photograph was taken?

14 What is the direction of Dartmouth from McNabs Island?

15 In what direction is Bridge Rum flowing in ARs 5337 and 5437?

16 What is the bearing of Ives Point navigation light (AR 5741) from the navigation light at Horse Shoe (AR 5738)?

17 What is the straight-line distance between the northern ends of the Murray Mackay and Angus L Macdonald bridges?

18 What is the length of the Murray Mackay and Angus L Macdonald bridges?

19 What is the aspect of the Halifax waterfront?

20 What is the height of the small hill at GR 545397?

21 What is the elevation of the surface of Purcells Lake (AR 5439)?

22 Describe the landscape of area surrounding Halifax and its suburbs.

23 Identify, using area references, the evidence that Halifax is a major railway centre.

24 What locational factors make Halifax a suitable site for a harbour?

25 Investigate the history of the Halifax Citadel. Why was this site selected?

Halifax (population 316 700) is the capital of the Canadian province of Nova Scotia.

Prior to the arrival of Europeans, the land was occupied by the Mi'kmaq people. French settlers came in 1604, naming the colony Acadia and seem to have lived fairly cooperatively alongside the Mi'kmaq. In 1749 the British established Halifax and began a war with the Mi'kmaq and Acadians.

The city has played a key role in maritime history. It was from Halifax that the steamer *Mackay-Bennett* set sail to recover the bodies of those lost in the sinking of the *Titanic* in 1912. Normally a cable-laying and repair ship, for this voyage it carried ice, coffins and canvas bags. The ship and its crew, including a minister and an undertaker, spent five days carrying out its grim task. They recovered 306 bodies, 116 of which had to be buried at sea. Upon return to Halifax, only 59 of the recovered bodies were sent by train to their families. The remainder were buried in three cemetaries in Halifax. The sinking of the *Titanic* resulted in 1496 lost lives.

Halifax would also be the last sight of Canada many troops, headed for the battlefields of Europe in World Wars I and II, would ever see. It would also be the first sight of their new homeland thousands of immigrants would see as they arrived in Canada to start a new life.

Today, Halifax is a major economic centre, with both private sector companies and government services. These include the Department of National Defence, Dalhousie University, Saint Mary's University, the Halifax Shipyard, various levels of government, and the Port of Halifax.

Primary industries found in the area around Halifax include agriculture, fishing, mining, forestry, and natural gas extraction.

Figure 7.8b Oblique aerial photograph of Halifax's CBD

Figure 7.8c This is an Oblique aerial photograph of Halifax's Citadel. Fortifications have been located on Citadel Hill since the British arrived in 1749.

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Halifax topographic map extract (Halifax: latitude 44° 52'N, longitude 63° 42'W)

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Grant Kleeman

7.9 Canadian map legends

Use the following map legend for Units 7.2, 7.3, 7.4, 7.7 and 7.8.

Road: hard surface, more than 2 lanes; toll gate; service centre
Route : revêtement dur, plus de 2 voies; poste de péage; centre de service

Road: hard surface, 2 lanes; less than 2 lanes; snowshed
Route : revêtement dur, 2 voies, moins de 2 voies; paravalanche

Road: hard surface, street; conduit bridge; loose or stabilised surface, street
Route : revêtement dur, rue; pont de canalisation; de gravier, aggloméré, rue

Road: loose or stabilised surface, all season, 2 lanes or more; less than 2 lanes
Route : de gravier, aggloméré, toute saison, 2 voies ou plus; moins de 2 voies

Road: loose surface, dry weather; vehicle track or winter road; trail; portage
Route : de gravier, temps sec; chemin de terre ou d'hiver; sentier; portage

Highway interchange; highway route number; built-up area
Échangeur; numéro de route; agglomération

Railway, single track; railway station; bridge; turntable; multiple tracks
Chemin de fer, voie unique; gare; pont; plaque tournante; voies multiples

Railway, abandoned; railway yard
Chemin de fer, abandonné; gare de triage

Rapid transit: rail, road; footbridge
Transport rapide : voie ferrée, route; passerelle

Causeway; covered bridge; tunnel; bridge; moveable bridge
Chaussée; pont couvert; tunnel; pont; pont mobile

Boundary: International; boundary monument
Limite : Internationale; repère d'arpentage

Boundary: Provincial and Territorial
Limite : Provinciale et territoriale

Boundary: unsurveyed provincial or territorial; area outline
Limite : Provinciale ou territoriale non arpentée; surface délimitée

Boundary: administrative; recreational
Limite : administrative; récréative

Boundary: geographic; unsurveyed geographic; small Indian reserve
Limite : géographique; géographique non arpentée; petite réserve indienne

Waterbody/shoreline; watercourse; disappearing stream
Plan d'eau/littoral; cours d'eau ou rive; cours d'eau disparaissant

Navigation light; ferry; crib or abandoned bridge pier
Feu de navigation; traversier; caisson ou pilier de pont abandonné

Coast guard station; seaplane base: active, condition unknown;marina
Station de la garde-côte; hydrobase : actif, condition inconnue; marina

Fish ladder; dam: small, large, carrying road
Échelle à poissons; barrage : petit, grand, portant une route

Dyke/seawall; boat ramp; wharf; pier or dock; ford; breakwater
Digue/mur de protection; rampe de chargement; quai; jetée; gué; brise-lames

Slip; drydock; ford; small islands; navigational beacon
Cale; cale sèche; gué; îlots; balise de navigation

Navigable canal; lock; ditch, conduit, irrigation canal; spring
Canal navigable; écluse; fossé, canalisation, canal d'irrigation; source

Reservoir; underground reservoir; fish pound
Réservoir; réservoir souterrain; viviers dans l'eau

Alluvium: dry river bed, sand in water, foreshore flats
Alluvion : lit de rivière à sec, sable dans l'eau, estrans

Rapids; falls (height)
Rapides; chutes (hauteur)

Rocky ledge; reef; rocks in water; exposed shipwreck
Barre rocheuse; récif; rochers dans l'eau; épave émergée

Moraine, glacial debris; permanent snow and ice
Moraine, débris glaciaires; neige et glace permanentes

Marsh, swamp, marsh in water; string bog
Marais, marécage, marais dans l'eau; tourbière réticulée

Tundra ponds; tundra polygons; palsa bog
Étangs de toundra; polygones de toundra; tourbière à palse

Sand; esker; pingo; wooded area
Sable; esker; pingo; région boisée

Contours: index; intermediate; approximate
Courbes de niveau : maîtresses; intermédiaire; approximative

Depression contour; spot elevation; cave
Courbes de cuvette; point coté; caverne

Wall; fence
Mur;clôture

Power transmission line; multiple lines; submarine cable
Ligne de transport d'énergie; lignes multiples; câble sous-marin

Pipeline: oil, natural gas; control valve; multi-use; underground
Pipeline : pétrole, gaz naturel; valve de contrôle; multi-utilisateur; souterrain

Mine; pit: sand, gravel, clay; quarry
Mine; banc : sable, gravier, argile; carrière

Airport/airfield: active, condition unknown; heliport
Aéroport/terrain d'aviation : actif, condition inconnue; héliport

Industrial building; chimney: industrial, flare stack, burner; lumberyard
Industrielle bâtiment; cheminée : industrielle, torche, brûleur; parc à bois débités

Oil tank; water tank
Réservoir de pétrole; réservoir d'eau

Silo; grain elevator; clearance tower; satellite tracking station
Silo; élévateur à grains; tour de dégagement; station de poursuite de satellite

Electric facility; oil or natural gas facility; wind-operated device
Installation électrique; installation pétrolière ou gazière; éolienne

Tower: communication, radar antenna; radio telescope; fire; control
Tour : communication, antenne radar; radiotélescope; feu; contrôle

Domestic waste; liquid waste; industrial solid depot
Déchet domestique; déchet liquide; dépôt de solide industriel

Sportsplex; arena; community centre
Centre sportif; aréna; centre communautaire

Lookout; historic site; zoo
Belvédère; lieu historique; zoo

Golf course; campground; ruins
Terrain de golf; terrain de camping; ruines

Ski lift; sports track
Remonte-pente; piste de course

Building(s): building(s), religious; educational; cabin
Bâtiment(s) : bâtiment(s); religieux; d'enseignement; cabine

Hospital; medical centre; senior citizens home; lodging
Hôpital; centre médical; résidence pour personnes âgées; gîte

City hall; Parliament Building; municipal hall
Hôtel de ville; édifice du Parlement; salle municipale

Customs post; ranger /warden station; cemetery
Poste de douane; poste de garde forestier /poste de garde de parc; cimetière

Court house; penal institution
Palais de justice; établissement pénitentiaire

Fire station; police station; armoury
Caserne de pompiers; poste de police; manège militaire

Use the following map legend for Unit 7.5.

ISBN 978-1-009-07583-1

GLOSSARY

aerial photograph a photographic image of part of the Earth's surface, taken from an aircraft

area reference a sequence of four numbers used to locate relatively large features on a topographic map

aspect the direction in which a slope faces

atlas a book of maps

bar graph a graph in which bars are drawn proportional in length to the value they represent

barometer an instrument used to measure atmospheric pressure

bearing a direction given in terms of degrees from the north

biome vegetation community occupying a large area of the Earth's surface

cardinal direction the four main points of the compass: north, south, east and west

cartographer a person who designs and draws maps

choropleth map a map that shows the relationship between quantity, or density, and area, using colouring or shading

climate the long-term weather pattern of a place or region

climate graph a graph that shows the average daily maximum and minimum temperatures and precipitation data for a particular place

column graph a special kind of bar graph in which the bars are drawn vertically

compass an instrument used to determine direction

contour line a line joining places of equal height above sea level (asl)

contour map a representation of some part of the Earth's surface, using lines along which all points are of equal elevation above and below sea level

cross-section a side view or profile of the land

density the population (or number of objects) per unit area; usually 1 km^2

distance the length from one point to another; usually expressed as a unit of measurement

distribution the arrangement of items over a specified area

dot map a map using dots to show the arrangement, or distribution, of a feature, such as population

elevation the height of a point or place above mean sea level

Equator a line drawn around the broadest part of the Earth, halfway between the North Pole and South Pole

flowline map a map with arrows and lines showing the movement of goods, information and people between places, and the quality of such movements

food security the availability of food and one's access to it

geomorphological hazard naturally occurring crustal processes and conditions that present risks to life and property

gradient a measure of the steepness of a slope

grid a pattern of lines on a chart or map that allows readers to determine absolute location and helps them to analyse distribution patterns

grid reference a sequence of six numbers used to locate features on a topographic map: the first three digits refer to the vertical grid lines, and the last three to the horizontal grid lines

hydrological hazard hazardous events originating in the hydrosphere; linked to changes to the water cycle (e.g. floods and droughts)

isobars lines on weather maps joining places of equal atmospheric pressure

landform a natural feature of the Earth's surface

landscape the overall appearance of an area, resulting from the interaction of landforms, vegetation, soils and rivers, together with transport networks, settlements, industry and agriculture

latitude the position of a point on the Earth's surface, expressed as its angular distance north and south from the Equator (0˚); the poles are 90˚ to the Equator

legend a set of symbols that represent features on a map or graph; the key to a map or graph

line graph a graph consisting of one or more straight or curved lines that show the relationship between two variables

line of sight whether one point on the Earth's surface is visible from another; that is, there is no landform feature obstructing the view

linear pattern an arrangement whereby points (or features, such as houses in the case of settlement) form or follow a line

liveability the qualities of a place (city, town, suburb or neighbourhood) that contribute to the quality of life experienced by those who live or visit there

local relief the difference in elevation between the highest and lowest points in a specified location

location the position of a feature on the Earth's surface expressed by means of a grid (latitude and longitude) or in relation to the position of other features or places

longitude the position of a point on the Earth's surface, expressed as the angular distance east or west of the Prime Meridian and 180˚

map a geographical representation of a section of the Earth's surface that is usually drawn to scale on a flat surface, such as a sheet of paper

map projection a map grid of lines of latitude and longitude, used as a base to draw the spherical Earth on a flat surface; there are hundreds of different map projections, all of which distort to some extent the surface features of the Earth's surface

natural hazard an event in the biophysical environment that is destructive to human life and property

oblique aerial photograph a photograph taken from an aircraft with the camera pointing at an oblique angle to the ground

picture graph a graph in which illustrations are used to represent data, with each symbol representing a certain value or quantity

pie graph a circle divided into segments by lines radiating from the centre; each segment of the graph is proportional to the value the segment represents

population pyramid a bar graph showing the distribution of a population by gender and age group

precis map a sketch map that highlights one particular feature of a map

quadrants the divisions of a map; maps are divided into quarters and named according to the points on the compass

relative location the location of a place or feature relative to other places and features

relief the shape of the land, including gradient and height differences within a landscape

remote sensing information gathering about the Earth's surface from a distance, using air photography, radar or satellites

satellite image an image produced by a variety of sensors (such as radar, microwave detectors and scanners), which measure and record electromagnetic radiation; the collected data are changed into a digital form for transmission to the ground, where they can be reconverted into imagery in a form resembling a photograph

scale the relationship or ratio between a linear measurement on a map and the corresponding distance on the Earth's surface

scatter graph a graph in which two sets of data are plotted to demonstrate the strength of their relationship

settlement a place inhabited by people on a permanent or semi-permanent basis

site the place where something is located, including its physical setting

situation the location of a feature or place relative to other features or places

sketch map a rough, hand-drawn map drawn in the field or from an aerial photograph; used to analyse landscapes

spot height points giving the exact height, or altitude, above sea level

ternary graph a triangular-shaped graph used when there are three sets of variables that together make up 100%

thematic map a map representing a specific spatial distribution, such as population density, climate and vegetation regions

time zones global divisions, usually 15˚ of longitude, where the time at the central meridian of the division represents the time for the whole division

topographic map a detailed map on a large scale (such as 1:25 000, 1:50 000 or 1:100 000) illustrating selected features of the physical and built environments

transect a cross-section showing the relationship between different features of the physical and built environments

trig station trigonometrical station, which is located on a prominent hill and used as a basis to survey the surrounding area

urbanisation the process by which an increasing proportion of a population lives in towns and cities; urbanisation is characterised by higher population densities than surrounding areas and provides an example of a constructed or built environment

vertical exaggeration the extent to which the vertical scale of a cross-section has been exaggerated in order to show any minor undulations in the topography

vertical photograph a photograph taken from an aircraft or satellite with the camera pointing directly down to the ground

weather the day-to-day state of the atmosphere at a particular place; the elements of weather are temperature, precipitation, humidity, atmospheric pressure and wind

weather map (also known as a synoptic chart) a map recording the meteorological conditions over a wide area for a particular time

wellbeing the quality of life experienced by people

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