Key Terms

climatograph
Köppen climate classification system
biome
ecozone
ecoregion

7.2 Describing Climates

To measure how climate is changing, scientists must first describe and classify the range of climates that exist around the world today. The planet can be divided into regions that share similar weather conditions. These regions are commonly called *climate zones*.

More than two thousand years ago, the Greek scholar Aristotle classified three major climate zones on the planet, based on their increasing distance from the equator. Scientists use a similar broad classification today, as shown in **Figure 7.14**. The centre of the planet, between the Tropic of Cancer (about 23°26' north of the equator) and the Tropic of Capricorn (about 23°26' south of the equator), is classified as the *tropical zone*. In the tropical zone, temperature is relatively warm and varies little throughout the year. The areas between the North Pole and about 66°33' north (the Arctic Circle) and between the South Pole and 66°33' south are classified as *polar zones*. Polar zones are characterized by cold temperatures and by ice cover for much or all of the year. Between the polar and tropical zones lie the *temperate zones*. In Earth's temperate regions, temperature may vary greatly during the year, and many regions experience distinctly warm and cold seasons.

The unequal warming of Earth's surface explains why Earth has hot and cold climate zones as well as hot and cold seasons. Polar regions receive less intense sunlight than equatorial regions do. Therefore, polar regions are colder than equatorial regions.

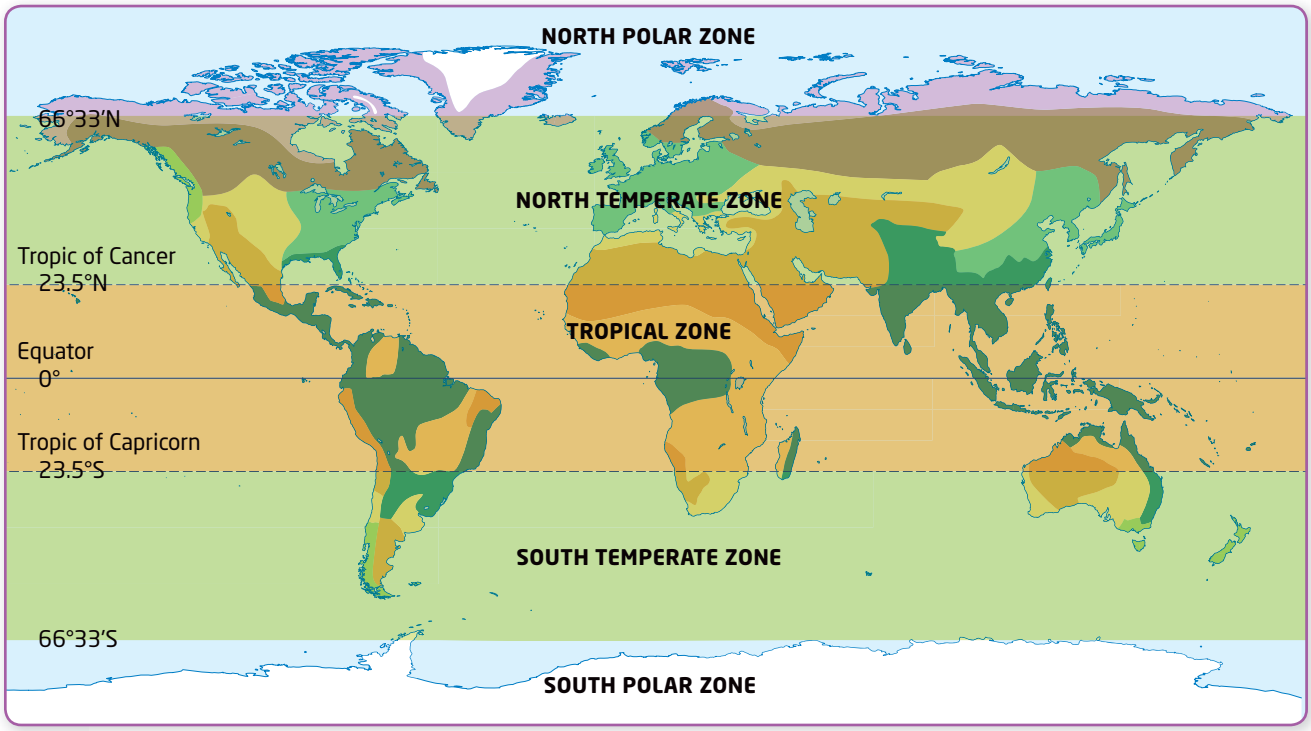

Figure 7.14 Distance from the equator affects both average temperature and average precipitation, creating three types of broad climate zones.

Climatographs

climatograph a graph of climate data for a specific region; the data are usually obtained over 30 years from observations made at local weather stations

To compare climates in different regions more precisely, scientists use a tool called a climatograph. A **climatograph** is a graph of climate data for a particular region based on average measurements taken over several years. A climatograph includes figures for average monthly temperature and an average of the total monthly precipitation.

For example, **Figure 7.15** shows a climatograph for Manokwari in Indonesia, a tropical rainforest region near the equator. The horizontal axis of the climatograph indicates the 12 months of the year. Temperature (in °C) is calibrated along the right vertical axis. Precipitation (in mm) is calibrated along the left vertical axis. This climatograph indicates that the average temperature in Manokwari remains close to 25°C throughout the year. Rainfall levels are high, with one wet season and one drier season in the year.

Climatographs are useful because they allow scientists to view how temperature and precipitation change throughout the year. These graphs also allow scientists to compare the weather patterns of different locations. For example, some locations have seasonal variations in temperature. Other regions have little variation in temperature, but they have wet and dry seasons. These variables can be used to classify and compare climates.

Study Toolkit

Interpreting Climatographs
When examining **Figure 7.15**, remember that both temperature and precipitation are plotted on the *y*-axis of a climatograph. How do these climate features vary throughout the year in Manokwari, Indonesia?

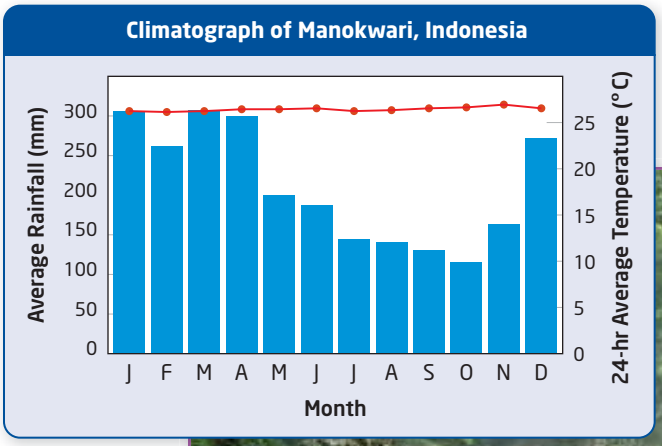

Figure 7.15 The climatograph on the left indicates the average yearly pattern of precipitation and temperature in Manokwari, Indonesia.

Activity 7-3

How to Make a Climatograph

How do scientists visually represent the climate of a particular region? In this activity, you will use climate data to make a climatograph like the one in **Figure 7.15**.

Materials

- coloured pencils (red and blue)
- graph paper
- ruler

Procedure

1. On a piece of graph paper, mark 12 intervals on the horizontal axis. Label each interval with the first letter of the month, starting with J for January, and label the axis "Month."
2. On the left vertical axis, mark nine intervals beginning at 0 and extending to 180. Each interval has a value of 20 mm. Label this axis "Average Precipitation (mm)."
3. Draw a second vertical axis for temperature on the right. On this axis, mark seven intervals beginning with −35°C and extending to 25°C. Each interval has a value of 10°C. Label this axis "Average Temperature (°C)."
4. Enter the data from the table for each month's average precipitation as a bar graph. Use a blue pencil to shade in the bars.
5. Enter the data from the table for each month's average temperature as a point in the middle of the space allocated for that month. Use a red pencil to draw a curve between the points.
6. Add a title to your climatograph.

Questions

1. Which month has the lowest average temperature?
2. Which month was the driest? Which month was the wettest?
3. Assume that a growing season must have average temperatures above +5°C. For how many months of the year can plants grow in this location?
4. Suppose each month's average temperature increased by 4°C. How long would the growing season be under these conditions?
5. Decide whether this climatograph better describes Thunder Bay, Ottawa, or Windsor, Ontario. Explain your reasoning.

Average Monthly Precipitation and Temperature for Location A

Month	Precipitation (mm)	Temperature (°C)
J	58	−10
F	59	−8
M	65	−2
A	69	6
M	76	13
J	77	18
J	88	21
A	92	19
S	83	14
O	75	8
N	86	1
D	83	−7

Classifying Climates

How would you describe the climate of southern Ontario? How would you compare its climate with that of Indonesia? Categorizing the abiotic and biotic components of a region allows scientists to more easily compare different parts of the world. Most climate classification systems involve creating and analyzing climatographs. The patterns in those climatographs help scientists classify regions of the world into groups by climate.

The Köppen Climate Classification System

Köppen climate classification system
a method of identifying and describing climates based on observable features such as temperature ranges and rates of precipitation

During the early 20th century, a German climatologist named Wladimir Köppen (1846–1940) developed a system of classifying climates that is still in wide use today. The **Köppen climate classification system** divides the world into five major climate zones based on three factors:

- average monthly temperature
- average monthly precipitation
- average annual precipitation

Each zone can be further divided into subcategories based on seasonal patterns. **Table 7.1** summarizes the characteristics of the five major groups. Southern Ontario is in category D, and Indonesia is in category A.

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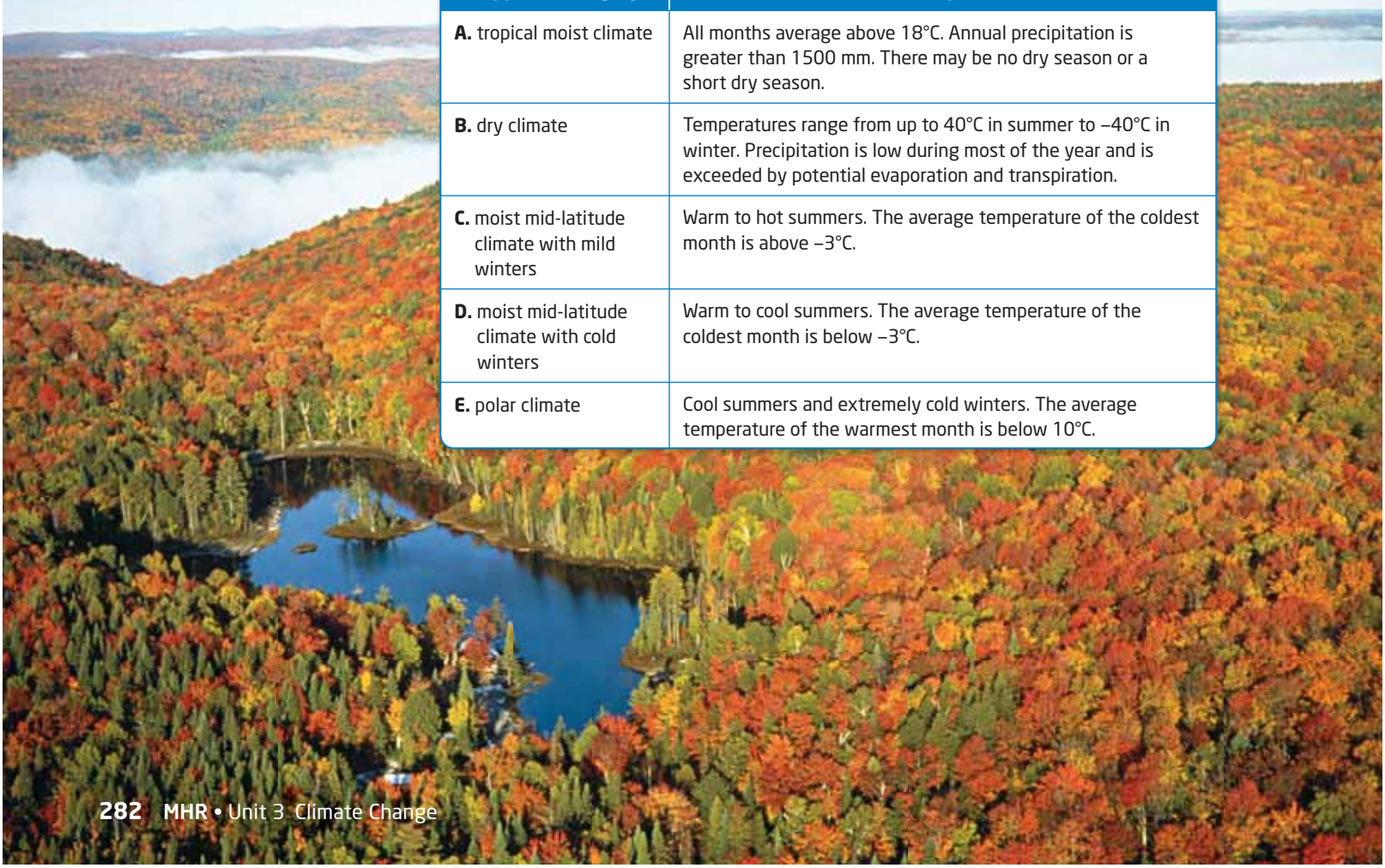
The Köppen system is not perfect, and some scientists have modified the system to try to clarify overly broad categories. These modifications commonly involve subdividing the C category and the B category described in **Table 7.1**. In addition, some other systems, including the Trewartha climate classification system, redefine the climate groups to tie the categories more closely with the zones inhabited by specific groups of plants. For example, the Köppen system classifies the New England region of the United States the same as the regions around the Gulf of Mexico. The Trewartha system defines these regions as separate climates based on the type of vegetation in the regions.

Table 7.1 Köppen Climate Classification

Köppen's Category	Description
A. tropical moist climate	All months average above 18°C. Annual precipitation is greater than 1500 mm. There may be no dry season or a short dry season.
B. dry climate	Temperatures range from up to 40°C in summer to –40°C in winter. Precipitation is low during most of the year and is exceeded by potential evaporation and transpiration.
C. moist mid-latitude climate with mild winters	Warm to hot summers. The average temperature of the coldest month is above –3°C.
D. moist mid-latitude climate with cold winters	Warm to cool summers. The average temperature of the coldest month is below –3°C.
E. polar climate	Cool summers and extremely cold winters. The average temperature of the warmest month is below 10°C.



Biomes

If you map the distribution of climate zones around the world and then map the distribution of different types of natural vegetation, you will find that the two are closely matched. Every type of plant requires certain conditions of temperature and precipitation in order to grow. In addition, specific animals are adapted to survive in each landscape. Large regions that have similar types of climate and similar plants and animals are known as **biomes**.

biome the largest division of the biosphere, that have includes large regions that have similar biotic components (such as plants and animals) and similar abiotic components (such as temperature and amount of rainfall)

Figure 7.16 shows the distribution of average annual precipitation and average annual temperature in eight major biomes found around the world. This classification system is useful because it indicates the interaction of climates with ecosystems. If the climate changes, then the distribution of plants and animals adapted to the climate will also change. For example, suppose you want to know what type of ecosystem is found where the average annual temperature is 25°C and the average annual precipitation is greater than 275 cm. Follow the data lines from each axis until the two lines intersect. The biome found in that type of climate is a tropical rainforest. Where the average annual temperature is 25°C but the average annual precipitation is less than 25 cm, the biome is a desert. Canada includes examples of all biomes except tropical rainforest.

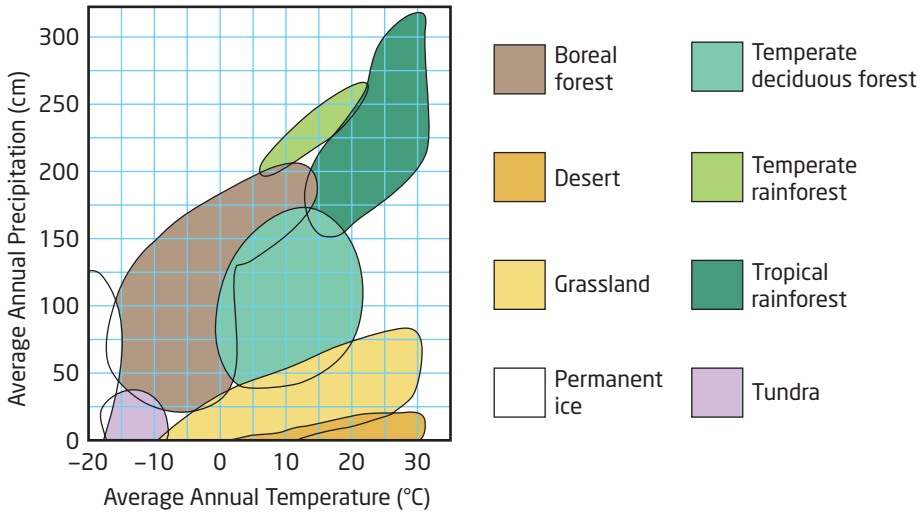


Figure 7.16 Average annual temperature and average annual precipitation of biomes can be graphed, and various biomes can be grouped together based on these factors.

Learning Check

1. Why are polar regions colder than tropical regions?
2. What two factors are plotted on a climatograph?
3. Create a Venn diagram to compare climates and biomes.
4. According to **Figure 7.16**, only one biome is characterized by receiving less than 25 cm of rain per year. What types of plants would you expect to find in that biome? Explain your answer.

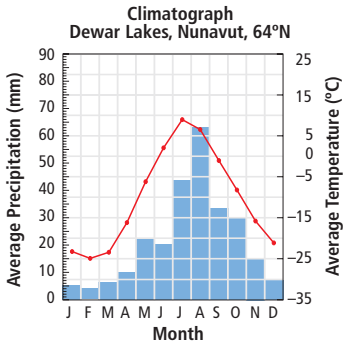
Climate Zones and Biomes in Canada

Examples of seven of the world's eight major biomes can be found across Canada. The only biome that is not found in Canada is the tropical rainforest biome, for which you saw the climatograph at the beginning of this section. Because Canada is located north of 41°41' north latitude, it falls within the temperate and polar climate zones. Therefore, temperature in Canada never gets high enough for long enough to support tropical plants and animals. However, Canada supports biomes as varied as temperate rainforests, deserts, and permanent ice. Each biome in Canada is described in **Figure 7.17**. Can you identify the biome in which you live?

Figure 7.17 Canada contains all of the major biomes on Earth except tropical rainforest.

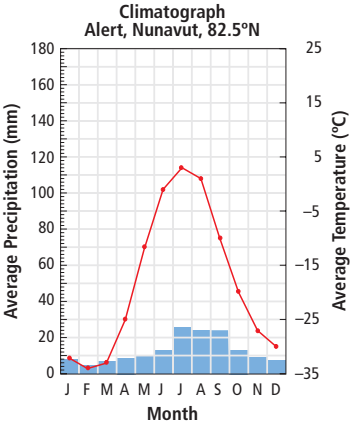
Permanent Ice

The polar icecaps of Canada's far north are permanently frozen zones with annual precipitation of less than 50 cm. Lichens and mosses can tolerate the cold and drought.



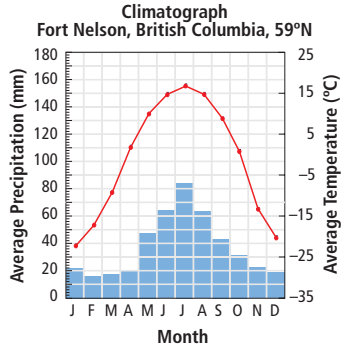
Tundra

The tundra has a layer of permanently frozen soil called permafrost. Few trees can survive the thin soils and lack of moisture. Plants grow close to the ground.



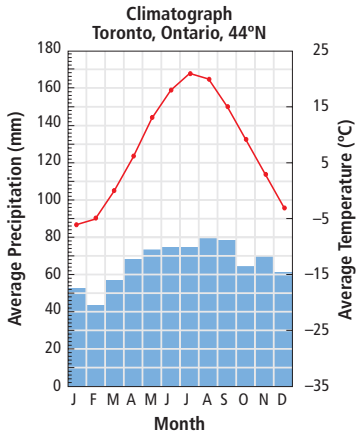
Boreal Forest

A broad band of northern Canada between latitudes 45° and 65° north is covered by a forest of coniferous trees such as black spruce and white spruce. Annual precipitation is between 30 cm and 85 cm, much of it falling as snow. Temperatures are below freezing for six months per year.



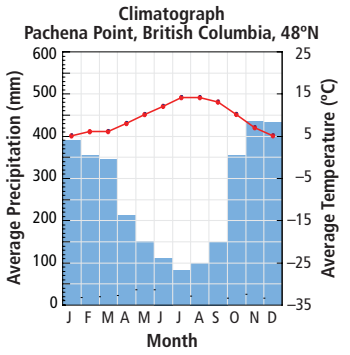
Temperate Deciduous Forest

Found mainly in eastern Canada, this zone has annual precipitation of 75 cm to 180 cm, distributed evenly throughout the year. Temperatures range from –30°C in winter to 30°C in summer. Maple, oak, and birch are typical trees in these forests.



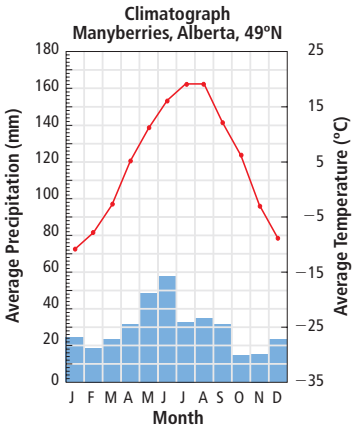
Temperate Rainforest

Coastal British Columbia is home to Canada's temperate rainforest, receiving more than 200 cm of precipitation per year. Average temperatures are mild, ranging from 5°C to 25°C. This climate produces very tall trees, such as Sitka spruce and Douglas fir.



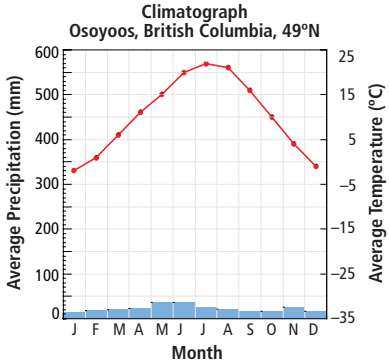
Grassland

The Canadian prairies have annual precipitation of 25 cm to 100 cm, with hot summers and cold winters. Limited rainfall restricts the growth of trees, and the typical vegetation is grasses with deep roots adapted for drought.



Desert

Canada's only desert zone is in southern British Columbia. It forms the northern end of the Great Basin Desert of the western United States. Rainfall is less than 25 cm annually. Plants have spiny leaves to conserve water and grow deep roots.



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Bioclimate Profiles

In the late 1980s, the Ontario government developed a new method of classifying climates at a glance by comparing temperature and moisture conditions in different locations over a period of several years. Graphs of climatic conditions and related factors are known as bioclimate profiles. They include such elements as

- minimum, maximum, and mean temperature
- probability of frost
- monthly total precipitation
- number of days with rain and days with snow
- water surplus and deficit

One goal for bioclimate profiles is to apply them to projected changes in climate. For example, researchers can compare bioclimate profiles of a particular region from the 1960s to 1990s with profiles from the 1990s to the present. This analysis will help governments and industries plan for such events as higher temperatures during crop growing seasons or increased demand for heating homes and buildings in winters.

Ecozones

ecozone a division of Earth's surface that has developed over a long period of time and is separated from neighbouring ecozones by a geological feature such as an ocean, desert, or mountain range

ecoregion a subdivision of an ecozone that is characterized by local landforms such as plains, lakes, mountains, and rivers

Concerns about the effect of climate change on resource management led to the development of another classification system. That system combines climate with geology, landscape, soil, vegetation, wildlife, water, and human factors. This holistic approach classifies broad distinctive areas of land into **ecozones**. Like a biome, an ecozone is an area of Earth's surface that is characterized by particular climate features and living things. However, an ecozone is separated from neighbouring ecozones by a geological feature such as an ocean, desert, or mountain range. **Figure 7.18** shows the 15 ecozones that have been classified across Canada.

Ecoregions

Within each ecozone are smaller subdivisions known as **ecoregions**. These regions are characterized by local landforms such as plains, lakes, mountains, and rivers. Climatic conditions, wildlife, and human activities are affected by these features. Scientists have mapped 867 distinct ecoregions around the world. **Figure 7.18** shows the ecoregions found within Canada's boreal shield ecozone. In Ontario, the boreal shield ecozone contains many ecoregions, such as the LakeAbitibi and Lake Temagami ecoregions. Together, these two ecoregions cover about 18 percent of Ontario's land area. Although these ecoregions share many similar plant and animal species, white pine trees are far more common in the Lake Temagami Ecoregion. The minor climatic differences between these two ecoregions are important to conservationists who study the white pine populations.

Suggested Investigation

Data Analysis Investigation 7-B, Comparing Ecoregions of Canada, on page 302

Terrestrial Ecozones of Canada

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Boreal Shield
- Atlantic Maritime
- Mixedwood Plains
- Boreal Plains
- Prairies
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Hudson Plains

Boreal Shield Ecoregions

1. Athabasca Plain
2. Churchill River Upland
3. Hayes River Upland
4. Lac Seul Upland
5. Lake of the Woods
6. Rainy River
7. Thunder Bay-Quetico
8. Lake Nipigon
9. Big Trout Lake
10. Abitibi Plains
11. Lake Temiscaming Lowland
12. Algonquin-Lake Nipissing
13. Southern Laurentians
14. Riviere Rupert Plateau
15. Central Laurentians
16. Anticosti Island
17. Mecatina Plateau
18. Paradise River
19. Lake Melville
20. Strait of Belle Isle
21. Northern Peninsula
22. Long Range Mountains
23. Southwestern Newfoundland
24. Long Range Mountains
25. Long Range Mountains
26. Central Newfoundland
27. Northeastern Newfoundland
28. Maritime Barrens
29. Avalon Forest
30. South Avalon-Burin Oceanic Barrens

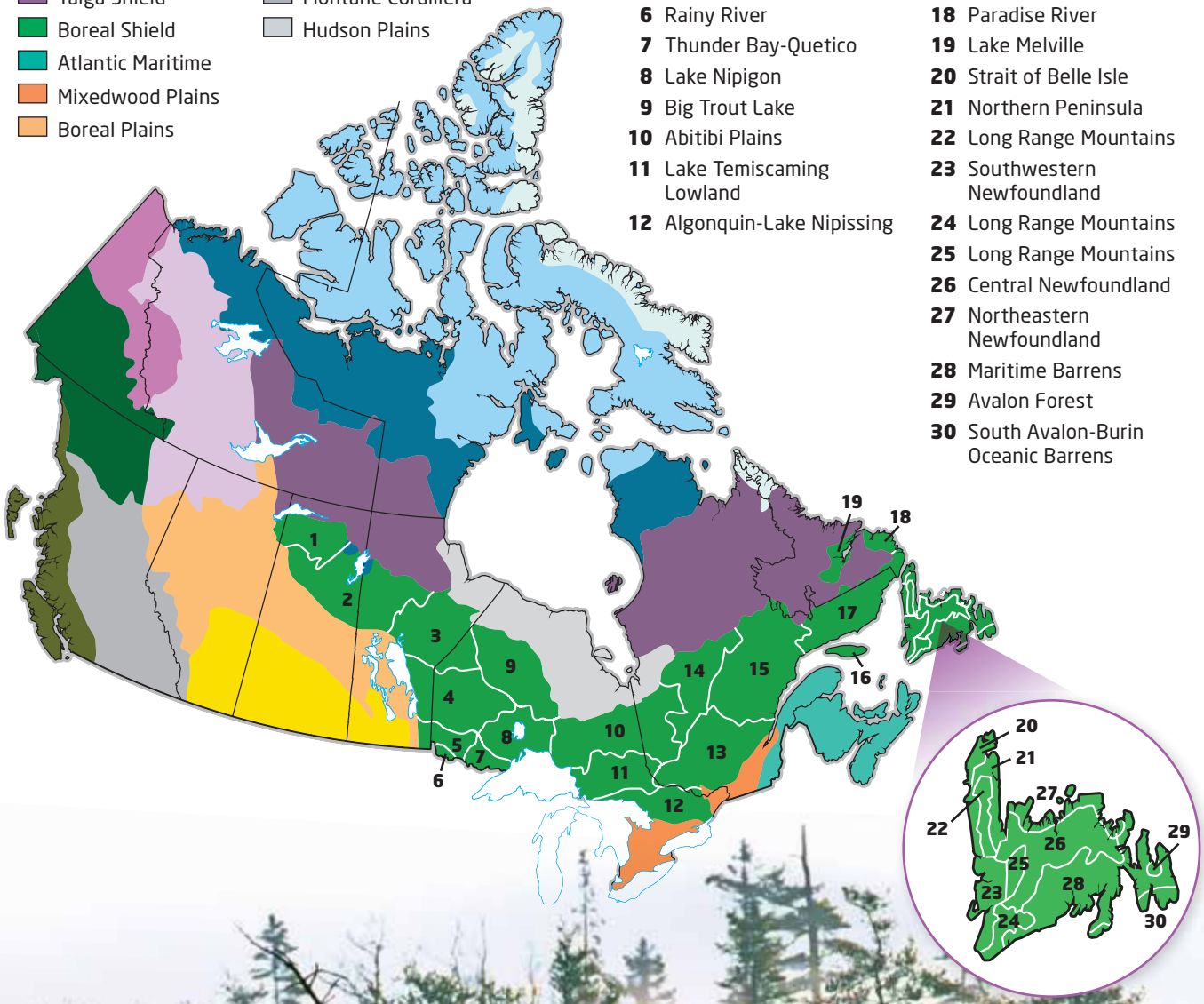

Figure 7.18 The boreal forest ecozone of Canada can be subdivided into many ecoregions. The forest shown here is located in northern Ontario.

Changing Climate, Changing Landscapes

Suggested Investigation

Data Analysis Investigation 7-C, Comparing the Effects of Climate Change on Vegetation in Canada, on page 304

Climate classification systems allow scientists to organize large amounts of information into smaller, simpler patterns. These patterns help scientists understand how and why climates vary around the world, and how climates affect other parts of the environment, such as plants and animals. Scientists can use this information to predict what effects climate change might have on society and the economy.

For example, some human activities, such as farming, depend on climate—especially on patterns of precipitation. With climate change, some regions will receive more precipitation than they do today and some will receive less. Changes in temperature also affect crop growth. Studies show that photosynthesis slows down as temperatures rise above optimum levels.

Today, wheat is grown in 12 regions around the world. One of the most productive regions is on the plains bordering the Ganges River in India, where the climate is ideal for producing high yields of wheat. However, models of climate change predict that this area will become much drier by 2050. This change in climate will reduce yields and affect the lives of hundreds of millions of people. There is little that farmers can do if the climate changes, other than switch to growing different crops that can survive in the altered environment.

In Canada, a warmer climate will have a different impact. It could open up areas for agriculture that are now unsuitable for growing crops. **Figure 7.19** shows one estimate of where wheat might be grown in Canada by 2050. A large amount of the area that could become farmland is currently covered by forest. A change from forest to farmland would affect Canada's economy and culture in many ways.

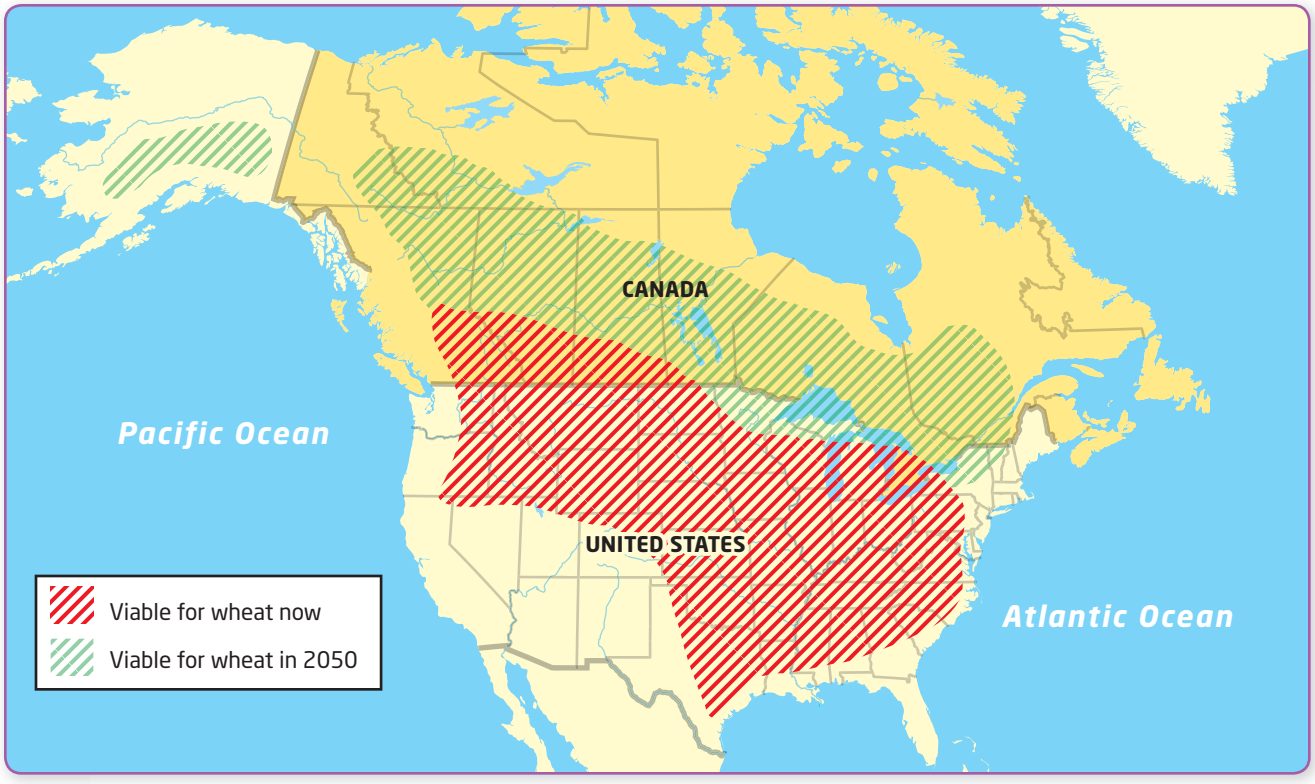

Figure 7.19 This map illustrates the projected change in the boundaries of a wheat-growing climate in North America.

Section 7.2 Review

Section Summary

- Climate zones can be classified based on latitude or on weather factors such as precipitation rates and temperature ranges.
- Climatographs are useful tools for studying and comparing climates.
- Climate classification systems categorize the abiotic and biotic components of a region and allow scientists to compare different parts of the world easily.
- Biomes are large regions that have similar types of organisms. Each biome is associated with a particular climate.
- Ecozones and ecoregions are subdivisions of biomes that can be used to compare the climate conditions in nearby or distant locations.
- Some human activities, such as farming, depend on climate. Changes in climate may cause people living in different parts of the world to change their lifestyles.

Review Questions

K/U **1.** Into what three climate zones did ancient scientists divide Earth's surface?

K/U **2.** What two benefits do climatographs have for scientists studying climate?

K/U **3.** Why do scientists classify and compare climates?

C **4.** Create a table similar to the one below that identifies five different ways to classify climates. In your table, include columns that describe the factors used to define categories and that identify advantages and disadvantages of each tool or system.

Advantages and Disadvantages of Climate Classification Systems

Tool/System	Description	Advantages	Disadvantages
Climatographs			
Köppen climate classification system			

K/U **5.** What criticism have scientists had about the Köppen climate classification system?

A **6.** If you were given only information about the monthly average temperature and monthly average precipitation of a region, what tools or systems could you use to identify and classify the climate of the region?

K/U **7.** Use the maps in **Figure 7.17** and **Figure 7.18** to explain how the boreal forest biome is different from the boreal forest ecoregion.

T/I **8.** If climate in Canada gets warmer, what will happen to the growing season of crops, and what effect could that change have on food supplies in Canada?