SECTION
3.3

Studying Organisms in Ecosystems

Section Outcomes

In this section, you will
- **identify** abiotic and biotic characteristics, and **explain** how they affect ecosystems
- **explain** how ecosystems support a diversity of organisms because of a variety of niches and habitats
- **explain** how limiting factors can affect the distribution and size of a population of organisms
- **design** an investigation to study a local ecosystem
- **research** the impacts of an introduced species in western Canada
- **explain** the use of sampling techniques, such as quadrats and transects
- **investigate** and **study** a local ecosystem

Key Terms

climate
biome
habitat
range
ecological niche
biodiversity
limiting factor
samples
transect
quadrat
density

Figure 3.14 How do you think the variety of life in the Badlands of Alberta compares with the variety of life in a tropical rainforest? Life is not uniformly distributed throughout the biosphere. Abiotic factors, such as temperature and the availability of water, can result in a "patchy" distribution of organisms.

At first glance, the Alberta Badlands seem to be an inhospitable environment (see Figure 3.14). What could possibly live there? Yet this environment is home to many populations, including eagles, hawks, ground squirrels, rattlesnakes, scorpions, and hardy plants, such as cactus, that can thrive in the dry conditions and the extremes in temperature from hot, dry days to cold, clear nights. The diversity of life in the Badlands differs from the diversity in nearby river valleys and from the diversity in northern Alberta spruce forests.

Life on Earth is not evenly distributed. As noted in Section 3.1, the patterns of distribution of life are, in large part, due to abiotic factors. Most organisms either directly or indirectly obtain their energy from sunlight. As well, each requires certain levels of abiotic conditions such as temperature, humidity, salinity (saltiness), and moisture. Organisms can tolerate fluctuations in these levels but only within a range, and there is always a level that is best for the organism. It is the abiotic factors that affect the distribution of Earth's organisms.

Climate and Biomes

You learned in your previous science courses that **climate** refers to the average weather conditions in a particular region over a period of time, usually 30 years or more. Climate is determined by temperature and rainfall, which, in turn, result from the unequal heating of Earth and other factors, such as local geography, snow and ice cover, and the proximity of large bodies of water.

You may recall that the unequal heating of Earth's atmosphere, shown in Figure 3.15, causes Earth's major climate zones from the tropics near the equator, through the temperate zones, to the cold

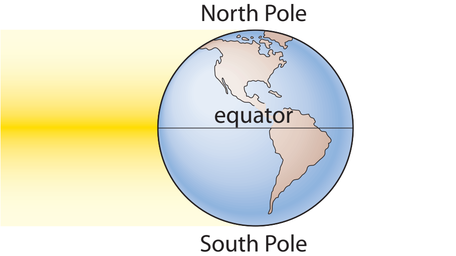


Figure 3.15 Because Earth is spherical, sunlight strikes it unevenly. The most intense rays strike near the equator. The sunlight that reaches the Poles is spread over a wider area (and, thus, is more diffuse).

Terrestrial Biomes According to Temperature and Precipitation

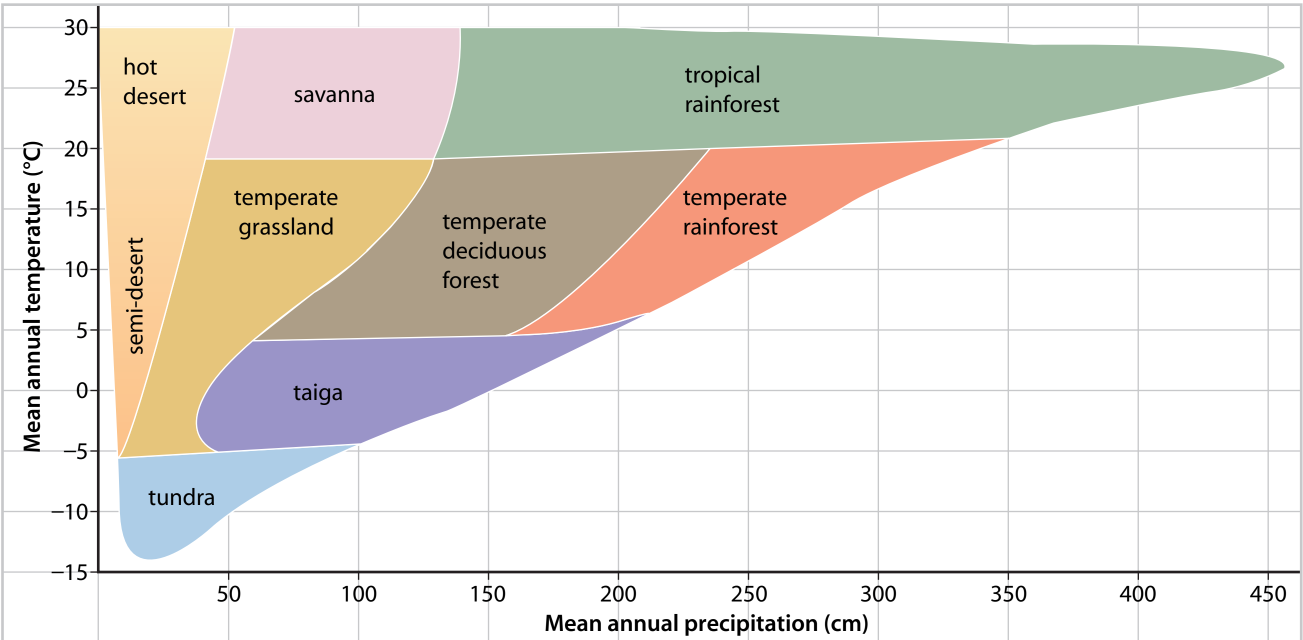


Figure 3.16 Distinctive patterns become apparent when terrestrial biomes are plotted according to mean annual temperature and precipitation. How could you use this graph to predict the distribution of Earth's biomes?

regions near the North and South Poles. The unequal heating of the atmosphere sets up conditions that produce global air and water movements (trade winds and ocean currents) that interact with physical features (mountains, islands, and lakes) to produce various patterns of rainfall. As a result, some areas of the world are quite dry, while others are very wet.

The pattern of precipitation influences the type of soil that forms in different regions. These two factors in combination with other factors, such as topography, altitude, latitude, and temperature, determine the types and abundance of plants and other photosynthetic organisms that can survive. The photosynthetic organisms, in turn, determine the variety and population sizes of animals, fungi, and other non-photosynthetic species that inhabit the area.

It is possible to identify some very general types of large ecosystems, or groups of ecosystems, called **biomes** in specific regions on Earth. A biome, as you may recall from previous studies, has a particular mix of plants, animals, and other organisms that are adapted to living under certain environmental conditions.

When terrestrial biomes are plotted according to their mean annual temperature and mean annual precipitation, as in Figure 3.16, you can

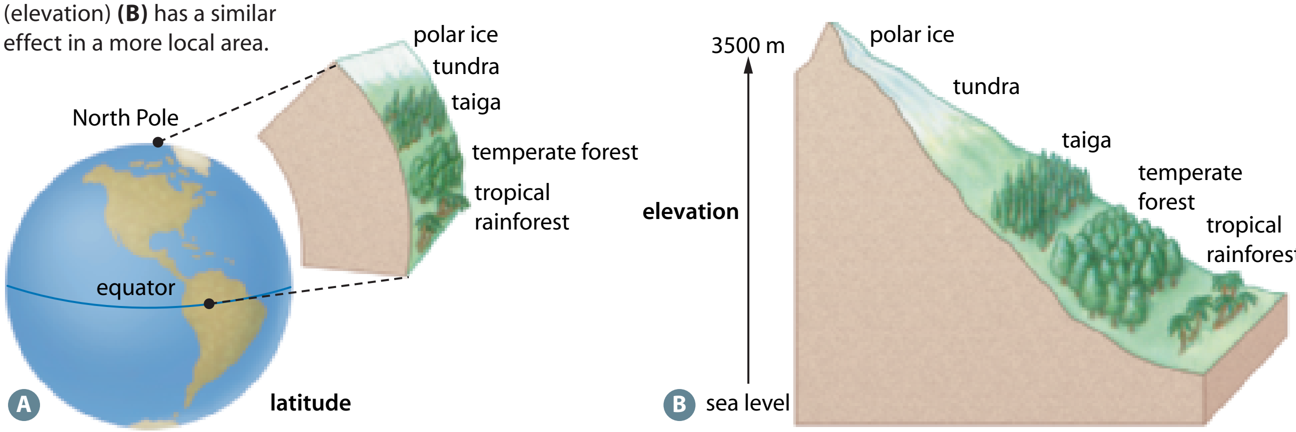


Figure 3.17 Latitude **(A)** affects the distribution of biomes on Earth. Altitude (elevation) **(B)** has a similar effect in a more local area.

see that particular patterns result. Most notably, the abundance of terrestrial life increases as the temperature and amount of precipitation increase. An increase in temperature *or* precipitation will usually also result in increased abundance of organisms but not to the same degree as an increase in both factors (and not when it becomes too hot). Thus, the distribution of organisms is directly related to abiotic conditions in the biome.

Since changes in temperature vary not only with latitude but also with altitude (elevation), you might anticipate distinctive regional biome patterns similar to those in Figure 3.17A. However, because precipitation, which can be affected by a mountain, plays such a vital role in determining the characteristics of an area, you often find a grassland region at the base of a mountain, rather than a forest as shown in Figure 3.17B.

Figure 3.18 shows the distribution of Earth's terrestrial biomes by latitude and includes some finer distinctions than those shown in Figure 3.16. Each terrestrial biome is characterized by communities of species with similar adaptations to that particular combination of physical conditions. There are also aquatic biomes, which include lakes, rivers, estuaries (where rivers flow into an ocean), coral reefs, intertidal zones (where an ocean meets the land), open ocean, and deep sea. It is important to note that at the edges of biomes, there is a gradual transition from one biome to the next. So, for example, where the taiga meets the tundra in northern Canada, there is a gradual change in the composition of plants and animals, not an abrupt change.

Q 7 On the map in Figure 3.18, identify the biome(s) found in Alberta. What are the limitations of dividing Earth into broad biomes?

Habitats

Within a biome, there can be a tremendous amount of variation. For example, the taiga biome (also referred

BiologyFile

Web Link
Choose one biome to investigate further. What are the distinctive features of its climate, geography, and soil? Which plants and animals are present in this biome that would be absent from other biomes? Why?

www.albertabiology.ca
www

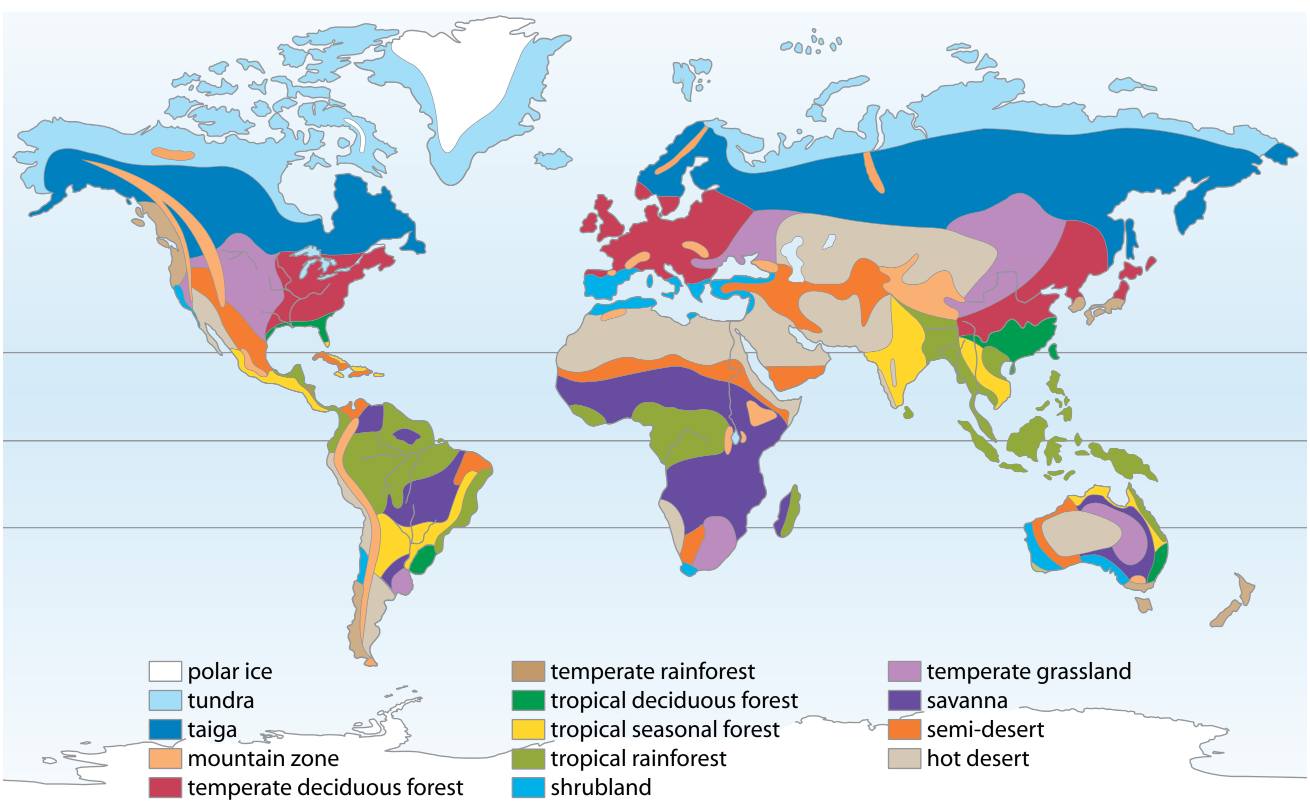


Figure 3.18 The distribution of Earth's major biomes. The same type of biome can occur in different regions in the world, but usually at similar latitudes.

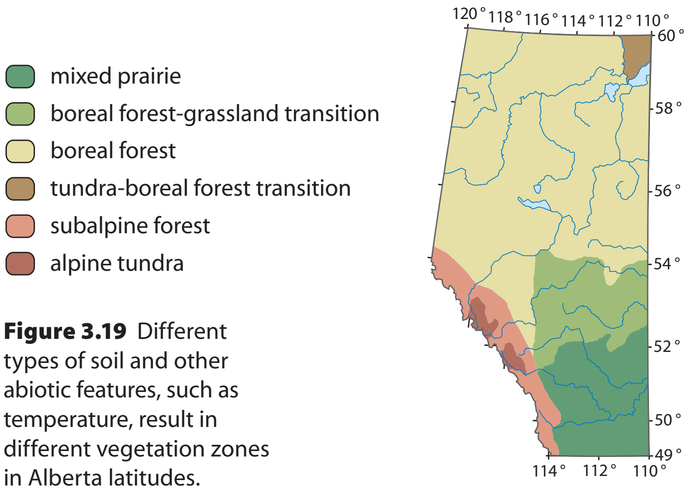


Figure 3.19 Different types of soil and other abiotic features, such as temperature, result in different vegetation zones in Alberta latitudes.

to as the northern coniferous forest or the boreal forest) covers a major part of central and northern Canada, Europe, and Asia. The taiga can vary widely, however, from north to south and from east to west. So, even though these areas are all considered to be part of the taiga, the density of the forests and the types of trees within these forests can vary. Figure 3.19, for example, shows the vegetation zones within Alberta. Even though most of the province is broadly identified as taiga in Figure 3.18, vegetation zones in the province may be further classified into the zones shown in Figure 3.19.

Within biomes and vegetation zones are different habitats, each with its own set of organisms and abiotic conditions. A **habitat** is a place or area with a particular set of characteristics, both biotic and abiotic. Each species is found in the specific habitat that its physical, physiological, and behavioural adaptations equip it to survive and reproduce in.

Sometimes, all members of a species live in the same general type of habitat. The habitat may be spread over a single large area or be found in a number of separate locations. Hoary marmots (see Figure 3.20), for example, live in the alpine and subalpine areas of mountains in western Canada. There may be groups of marmots separated by large distances, but all members of this species live in similar habitats.

The **range** of a population or species is defined as the geographical area where the population or species is found. The limit of a species' range is generally determined by its habitat requirements. The species will only be found where its habitat is present. This is determined by environmental variables, including both abiotic factors (such as temperature and rainfall) and biotic factors (such as type of food). The range of the hoary marmot is shown in Figure 3.21. Note that the hoary marmot does not live *throughout* this range, but only in its particular habitat *within* this range.

Q 8 Distinguish between a species' habitat and range.

Figure 3.20 The habitat of the hoary marmot (*Marmota caligata*) is the alpine and subalpine areas of northwestern North America. Its diet includes grasses, wildflowers, and other plants found in high-altitude meadows.

Figure 3.21 The range of the hoary marmot: Identify three reasons why the hoary marmot is not found outside this range.

Ecological Niche

Members of different species can share the same range and even the same habitat, or at least show considerable overlap in the types of habitats they prefer. This is possible because they have different ecological niches. The **ecological niche** of a species is the role that its members play in a community and the total range of biotic and abiotic requirements that its members need in order to survive. For example, the ecological niche of the northern long-eared bat shown in Figure 3.22 includes the temperature range it tolerates, the type of boreal forest trees on which it roosts, and the size and type of insects it eats.

You could think of a population's habitat as its street address, and its ecological niche as its job in the community. Two species can share the same habitat because they have different ecological niches. The bat in question, or even two species of warbler, for instance, can co-exist within a habitat because they may nest in different types of trees or feed on different insects. Trouble arises, as in the case of a mountain pine beetle infestation, when one species' niche affects (in this case, destroys) the habitat of others.

Q 9 Assume that a species of animal has a very restricted diet; it eats only two species of plants. Using the word "niche" in your answer, explain why this species may have a higher probability of becoming endangered than a species that eats ten species of plants.

Habitats and Niches within Ecosystems

Within an ecosystem, differing biotic and abiotic characteristics result in a variety of habitats and niches. In an aquatic ecosystem such as a lake, for example, there is vertical stratification, or layering, of water caused by different physical and chemical conditions, such as different amounts of light and nutrients. In the upper layers of a lake, there is sufficient light for photosynthesis. Water temperatures also vary within layers of a lake. Generally, the upper layers are warmer due to solar radiation, while the deeper layers are colder.

Figure 3.22 The range of the northern long-eared bat (*Myotis septentrionalis*) extends across much of Canada. Alberta's populations of this species are found mainly in boreal forest, from Edmonton to Wood Buffalo National Park in the extreme north of the province.

Each species in a lake occupies a niche that it requires for its survival. The individuals that photosynthesize and absorb nutrients from the water, as some algae do, inhabit the warmer, brighter surface water, as do the organisms that consume them. Other photosynthetic aquatic species may need to be rooted into the bottom sediments in the zone that is closest to the shore. Animals may swim through the water or crawl along the bottom sediments. Figure 3.23 on the next page shows the different zones in a lake, and how they differ depending on the depth of water (thus, light penetration and temperature) and their distance from shore (thus, habitat for organisms that can float or swim and those that are bottom-dwellers).

A similar diversity of habitat and niches occurs in terrestrial communities. In a forest, for example, soils with differing mineral and moisture content support different plants. These plants, in turn, provide food and habitat for different animals. The variety of habitats and niches, and thus the variety, or

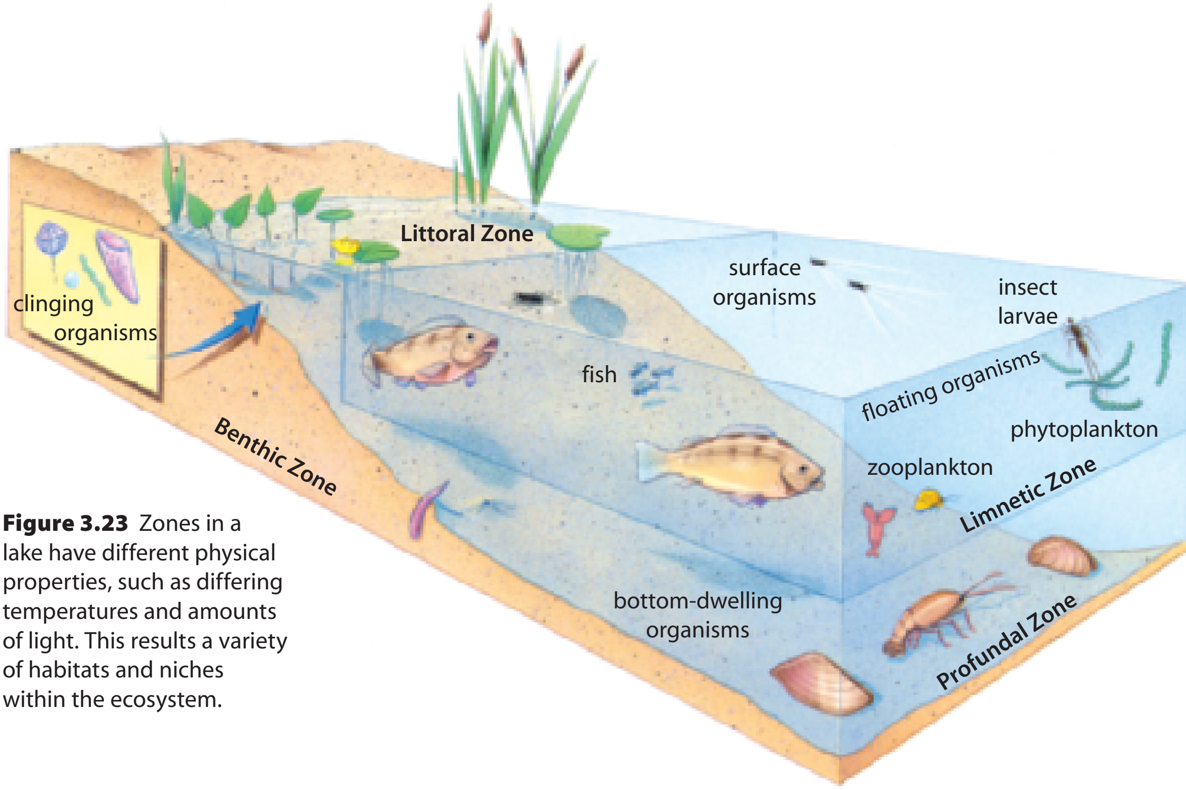


Figure 3.23 Zones in a lake have different physical properties, such as differing temperatures and amounts of light. This results a variety of habitats and niches within the ecosystem.

Biology File

Web Link
Alberta has been divided into *ecoregions*, which are determined by abiotic and biotic components, such as climate, geography, vegetation, soil type, and fauna. In which ecoregion do you live? What are its main abiotic and biotic characteristics?

www.albertabiology.ca
WWW

biodiversity, of species, can vary widely in different areas depending on the specific abiotic and biotic components. Examine the photographs in Figure 3.24. Figure 3.24A shows a forest that has been harvested and replanted with only one species of tree, the white spruce (*Picea glauca*). Figure 3.24B is a mixed forest, with a greater diversity of tree species. The diversity of species results in a diversity of habitats and niches as well. In the Thought Lab opposite, you will analyze data that compare the diversity of bird species in a forest dominated by one tree species with a mixed forest.

Factors Limiting Growth in Ecosystems

Trembling aspen, such as those in Figure 3.25, are fast growing. Their range includes much of Canada, yet they do not live everywhere. There are places with large stands of trembling aspen, places where trembling aspen grow more sparsely, interspersed with other plants, and places where trembling aspen are absent. The bacteria in Figure 3.26 on page 100 could, in theory, reproduce exponentially without limits. If this were possible, after 20 hours there would be

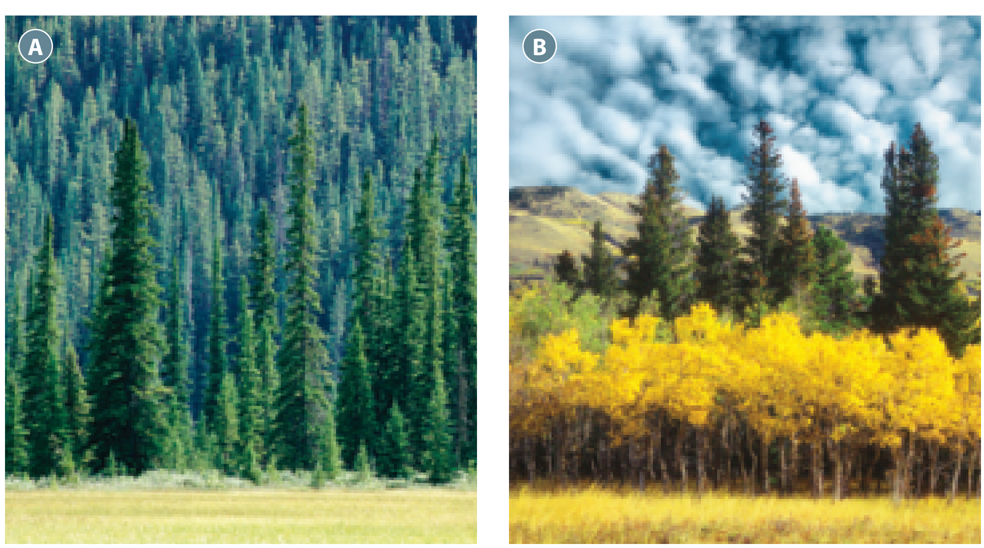


Figure 3.24 How would the variety of habitats and niches differ between a forest that has been harvested and replanted with a single species of tree, known as a monoculture **(A)**, and a forest with a variety of tree species **(B)**?

1.1×10^{12} individuals. Within four days, the mass of the bacterial population would be greater than the mass of Earth! Clearly this does not happen. There are no bacterial populations that large on Earth, despite the fact that both the growth rate and the generation time in this example are plausible. Populations cannot grow in an unlimited fashion for a sustained period of time. (Some can for a shorter period of time, however.) The growth, survival, and distribution of

Figure 3.25 Trembling aspen (*Populus tremuloides*) reproduce fairly quickly through a process called vegetative reproduction. The shoots that spread widely from the trees' roots produce new trees that are essentially clones of the parent tree. If these plants are so fast-growing, why are they not everywhere in Alberta? What conditions limit their growth?

Thought Lab 3.2 Forest Habitat and Bird Biodiversity

Target Skills

Analyzing data to look for patterns between and among variables

Evaluating the impact of human activities on the biodiversity of an ecosystem

How will communities of birds vary between a forest dominated by one tree species (a pure stand) and a forest with a variety of tree species (a mixed stand)? This is a question that two biologists—Erin Bayne from the University of Alberta and Keith Hobson from the University of Saskatchewan—examined in a study in Saskatchewan. What they learned can be used to predict how future changes to boreal forests, particularly logging practices, might impact species of birds.

In their study, Bayne and Hobson set up "count stations" in stands of black spruce, jack pine, aspen, and white spruce. They had stations in pure stands and in mixed stands. For example, for black spruce, they had study areas where over 75% of the canopy (the "top" of the forest) was dominated by black spruce (pure stands) and study areas where more than 25% of the canopy was dominated by black spruce and one or two other tree species (mixed stands). They used the following protocols (procedural rules) in their study:

- All count stations were at least 250 m apart.
- All count stations were at least 100 m from the "edge" of the study area.
- All birds that were heard or seen during a 10 min early-morning count were recorded.
- Observers were tested beforehand to ensure that they had similar levels of expertise at identifying birds.
- Counts were taken twice, in early and late June.
- Observers counted at each station only once; for the second survey, a different observer was used.

In this Thought Lab, you will interpret some of Bayne and Hobson's results, given in the following table.

Procedure

Examine the data in the table. Compare species richness and abundance in the eight sample sites. *Species richness* is the number of species. *Abundance* is the actual number of individual birds.

Analysis

1. In this study, what did the researchers find out about the species richness and abundance of bird communities when they compared stands of trees with just a single tree species (pure stands) with stands with a variety of tree species (mixed stands)?
2. Based on your understanding of habitats and niches, explain the researchers' results.
3. Choose three of the protocols that the researchers used. Explain why each protocol resulted in a more accurate survey.
4. How might a study such as this be helpful when planning how and where to harvest trees and what to replant?
5. When fire burns through a forest on a regular basis, it burns in patches, rather than in a devastating way that destroys the entire forest. How does this type of periodic forest fire result in a diversity of habitats in a forest?

Comparing Species Richness and Abundance in Pure and Mixed Stands of Trees

Species of tree	black spruce		jack pine		trembling aspen		white spruce	
Type of stand	pure	mixed	pure	mixed	pure	mixed	pure	mixed
Species richness	13	15	11	18	18	24	20	23
Abundance	56	60	39	90	76	91	71	94

(Adapted from: Hobson and Bayne, 2000, Breeding Bird Communities in Boreal Forests of Western Canada) populations are controlled by **limiting factors**—abiotic and biotic conditions that limit the number of individuals in a population.

Figure 3.26 Populations of microscopic bacteria such as those shown in this micrograph grow very quickly. What finally causes a population to stop growing?

Abiotic Limiting Factors

The abiotic components of an ecosystem limit the distribution and size of the populations that live there. Plants, for example, have an optimum set of abiotic requirements, including soil type, moisture and humidity levels, and temperature range. Their populations are controlled by these abiotic requirements. Gardeners, farmers, and foresters must keep in mind the abiotic factors that limit plant growth. They must ensure that their plants have the proper soil conditions, as well as the appropriate temperature and moisture for optimum growth. If conditions change, resulting in severe hot or cold, drought or flood, or

INVESTIGATION 3.C

Target Skills

Defining and **delimiting** ideas to assist in planning a field study

Gathering and **recording** data and information

Preparing for Your Field Study

In this investigation, you will continue to prepare for your field study at the end of this chapter. You will determine some of the abiotic components of the ecosystems you chose for your field study. Your team will select the tools you will need for your field study. The group will also begin to assign tasks required to prepare for the field study.

Materials

Library resources or Internet access (optional)

Procedure

1. Using print or Internet resources, research some of the abiotic components of the ecosystems you will be investigating, such as climate, soil types, topography, hours of sunlight, and annual temperature and precipitation. ICT
2. As a group, brainstorm three abiotic features of your ecosystems and tools you might use to measure them. For example, what tools will you need to measure soil and air temperature, moisture content in soil, or the depth that light penetrates into a pond? What other tools might aid in your study? (**Hint:** How will the team identify the organisms found in your field study? How will the team record what you see and the data you obtain?)

Analysis

1. **a)** How do the tools you use to gather information about an ecosystem affect the accuracy or precision of your measurements? For example, how does gathering information on soil moisture content from an Internet database or map compare with completing the measurements yourself? (Refer to Appendix A to review the distinction between scientific accuracy and precision.)
   b) What are two advantages and two disadvantages of each tool?
2. Is it precise enough to measure an abiotic factor at only one location in an ecosystem? Explain your answer.
3. How will you obtain the tools you have selected? Which members of the team will be responsible for using the various tools?

Extension

4. Contact a field biologist at a local university or forestry department office to find out what tools they use when conducting a field study.

depletion of nutrients, then plant growth will be compromised.

Figure 3.27 shows cottonwoods that grow along the banks of the Oldman River in southwestern Alberta. Periodic flooding of the riverbanks is a natural feature of the cottonwood's environment. These trees are adapted to survive flooded conditions for one to two months. The increased moisture, timed with the growth of young cottonwood seedlings, is a critical part of the life cycle of this tree. Cottonwood populations are now suffering poor growth, and in some cases no growth, because of changes in water levels and flow patterns in rivers that have been dammed.

> **Q 10** Describe two abiotic limiting factors that could limit the growth of a greenhouse full of tomatoes.

Biotic Limiting Factors

A population may grow rapidly, then level off—it no longer increases in size but remains fairly constant. (Births roughly equal deaths in the population.) What factors cause the growth of a population to slow? Several biotic factors, including competition for resources, predators, and parasites, play a role.

Competition Limits Populations

The size of a population can be limited by the availability of resources, such as food. For example, when a population reaches a point where there is no longer an abundance of food for each member of the population, the members must compete with each other for the limited food supply. At this point, the number of births decreases or the number of deaths increases (or both), and population growth slows. In this type of competition, called *intraspecific competition*, members of the same population compete with each other for the limited resource.

Figure 3.27 Periodic flooding is necessary to sustain cottonwood populations that grow on the banks of the Oldman River. Dams on the river have changed river levels and have interrupted the seasonal flooding, which is needed for the survival of cottonwood seedlings.

Members of a population may not only compete for food, however. They may also compete for other resources, including water, sunlight, soil nutrients, shelter, mates, and breeding sites. Regardless of the resource, the result of the competition is always the same—a reduction in the population's growth rate.

Competition can also occur between two or more populations. For example, two species with similar niches may compete with each other for food, water, or other resources found in the habitat. In some cases, one species will eventually out-compete the other, and the "losing" species will disappear from the area. A result like this may indicate that the interacting species had very similar ecological niches, although other factors are often involved. The bull trout (see Figure 3.28 on the next page) has been out-competed, throughout much of its range in Alberta, by other trout species, including brook and brown trout, which were introduced into habitats where they do not commonly occur. Learn more about the effects of introduced species in the next Thought Lab.

Sometimes, two species may have similar, but not completely overlapping, niches. Both species can live in a particular area, although the density of

BiologyFile

FYI

The loss of cottonwood forests affects abiotic and biotic parts of the riparian (riverside) habitat. Cottonwood trees moderate water temperatures and supply carbon and other nutrients to the river habitat as their leaves and branches decompose. They provide a habitat for a variety of insects, birds, and small mammals. As well, their roots anchor the soil and reduce erosion during floods. Fallen trees provide a river habitat for trout and food for aquatic insects. Even standing dead trees provide an important habitat. These snags, as the dead trees are called, are used by birds that nest in holes or cavities.

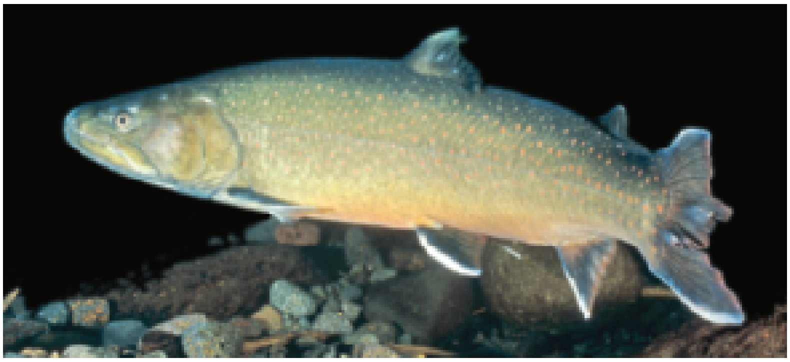


Figure 3.28 Native to much of Alberta and western North America, bull trout (*Salvelinus confluentus*) are actually a species of char, not trout. Competition with introduced species, such as brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*), for food and other resources has contributed to the decline of this species. Other significant limiting factors include habitat loss and overfishing.

one or more populations may be lowered by the presence of the other species. For example, the barnacles in Figure 3.29 have similar niches. If only one species were present on the rocky shore, it would likely inhabit the entire area that the two species share. Their differences are enough, however, for both to occupy the same habitat.

Predators Limit Populations

Predation is a biotic interaction that involves the consumption of one organism by another. In this type of interaction, the consumer organism is referred to as a predator and the consumed organism is called prey. This type of biotic interaction includes the grazing of grasses by a horse and other herbivores as much as it does the capturing and eating of a rabbit by a coyote and other carnivores.

The relationships between predators and their prey can have a significant

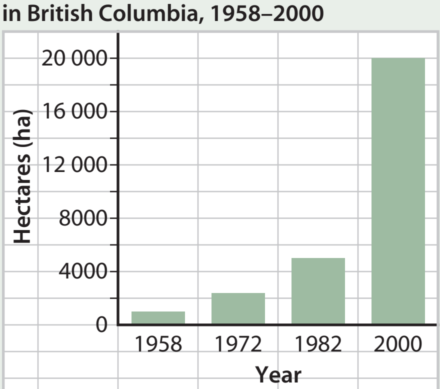
Thought Lab 3.3 Super Competitor: Knapweed

Target Skills

Assessing the environmental impact of an introduced species in established ecosystems

Many species have been introduced to North America, either intentionally or unintentionally. For example, most of the food crops grown in Canada are introduced species that were intentionally cultivated for human benefit. Some species that are introduced, usually accidentally, become invasive and have a serious impact on native ecosystems. One of these invaders, spotted knapweed (*Centaurea biebersteinii*), was introduced into North America from Europe in the late 1800s.

Hectares of spotted knapweed in British Columbia, 1958–2000

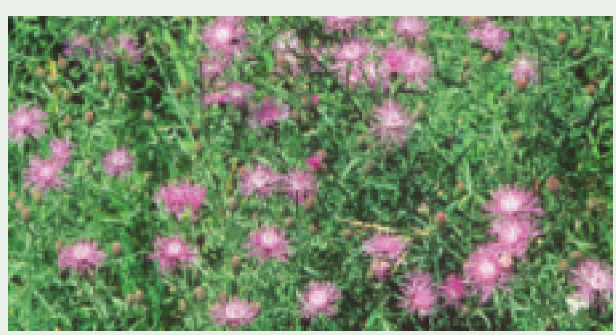


Procedure

Investigate the biology of spotted knapweed. Specifically, find out how it reproduces, what animals eat it, how it was introduced into North America, and how it is spread.

Analysis

1. Study the graph opposite.
   a) Describe what has happened to the population of spotted knapweed since its arrival in British Columbia.
   b) Predict the number of hectares that will be covered by spotted knapweed in 2020. Explain your prediction.
2. Explain why some introduced species can become so invasive and damaging to native species and ecosystems.
3. Why is spotted knapweed not a pest in its native habitat in Europe?
4. a) Populations of spotted knapweed are present in Alberta. How could spotted knapweed be spread throughout the province?
   b) Predict how this might affect:
      i) farming and ranching ii) native ecosystems



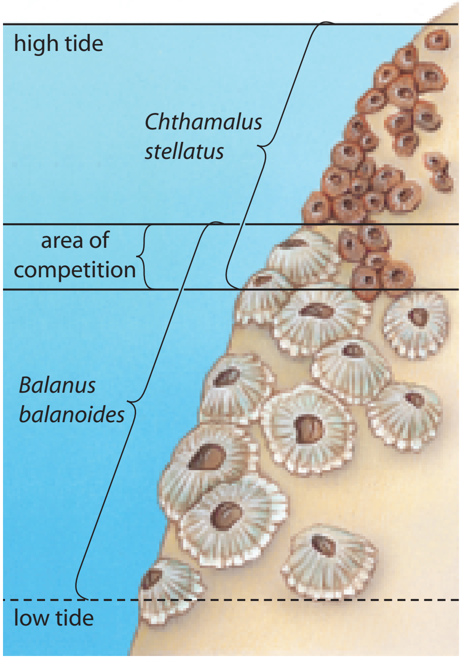


Figure 3.29 The two species of ocean barnacles, *Chthamalus stellatus* and *Balanus balanoides*, have similar niches. Although they compete for space and other resources, there are sufficient differences in their ecological niches for both to establish viable populations at different depths of the rocky shore.

impact on communities. A striking example occurred in the Aleutian Islands, a chain of volcanic islands west of Alaska. In the mid-1700s, fur traders introduced Arctic foxes to nearly 200 islands. (See Figure 3.30.) Native populations of seabirds, many of which nested on the ground, were easy targets for the invading predators. Within 50 years, Aleut (Aboriginal people of the Aleutians) hunters reported a noticeable decline in seabird populations. By the early 1900s, populations of the Aleutian Canada goose were so reduced that the bird was on the brink of extinction.

The ecological impact of the foxes, however, was not limited to this loss. Prior to the introduction of the foxes, the islands supported the growth of dense grasslands. Seabird droppings (guano) fertilized the otherwise nutrient-poor volcanic soils of the islands, allowing for this lush growth. As the numbers of birds dwindled, so did the supply of guano. By the early 1900s, fox-inhabited islands had become transformed from grassland to tundra. With the removal of foxes from many of the islands, which occurred during the latter-half of the twentieth century, seabird populations—including those of the Aleutian Canada goose—are recovering, as are their grassland habitats.

> **Q 11** Identify and explain the limiting effects of introducing Arctic foxes to the Aleutian islands.

Parasites Limit Populations

Parasitism is an interaction in which one organism (the *parasite*) derives its nourishment from another organism (the *host*), which is harmed in some way. Parasitism is similar to predation because one organism benefits from the interaction and the other organism does not. In parasitism, however, the host is not always permanently harmed or entirely consumed.

An increase in the density of the host population makes it possible for the parasites to increase in number. The increased number of parasites decreases the hosts' ability to survive or reproduce, and may lead to a decrease in the density of the host population. This can result in fluctuations of parasite and host, similar to the cycles of predator and prey.

BiologyFile

FYI
A University of Alberta ecologist hypothesizes that climate plays a role in predator-prey interactions. Dr. Stan Boutin has recorded data on the success of lynx predation under different snow conditions. Lynx sink in deep fluffy snow, while their prey, snowshoe hares, do not, enabling them to escape capture. With increasing periods of warm weather, which reduce the depth of the snow and increase its crusting, lynx are more successful in their predatory attempts.

Figure 3.30 Although Arctic foxes (*Alopex lagopus*) commonly inhabit northern Canada and regions of the Arctic Circle, their residence on the Aleutian islands near Alaska occurred as a result of human, rather than natural, action.

The Smeetons and the Swift Fox

Things were not looking good for the swift fox (*Vulpes velox*) in 1978. Once a common resident of the short- and mixed-grass prairie, ranging north to south from central Alberta to northern Texas, it had just been declared extirpated by the Canadian government. (An extirpated species is extinct in one geographical area but may be present elsewhere.) Habitat fragmentation, due to conversion of native prairie into agricultural land, had contributed to its decline. Luckily for North America's smallest canid, Miles and Beryl Smeeton were on its side.

A Not-So-Swift but Steady Recovery

In 1971, Miles and Beryl Smeeton, renowned outdoor adventurers and authors, founded the Wildlife Reserve of Western Canada, now the Cochrane Ecological Institute (CEI). A year later, they established the world's first and only captive breeding colony of swift fox, bred solely for re-introduction into their historic range in Canada. After starting out with six pairs of foxes imported from the United States, the Smeetons signed an agreement with the University of Calgary to develop and initiate a re-introduction program. The Smeetons were promised help, as well, from the Canadian Wildlife Service and the Calgary Zoo.

The first captive-reared foxes were released in southern Alberta in 1983. Initially, the "soft release" method was used: pairs of foxes were penned and fed over the winter, allowing them to become oriented to their release area, and then released in the spring. Later, the "hard" method was also used: foxes were dispersed directly into the wild with minimal holding time. Between 1983 and 1997, over 800 captive-bred foxes were re-introduced in Alberta and Saskatchewan.

Despite continued threats of coyote predation and habitat fragmentation, researchers now estimate the population of swift fox in Alberta and Saskatchewan to be about 656 foxes, based on a census taken in 2000–2001. This is almost triple the estimate since the last census taken in 1996–1997, and a sign that a self-sustaining wild population has gained a foothold. In 1998, the swift fox was downlisted from extirpated to endangered in Canada.

The Return of the Senopah

In 1998, with a proven record in swift fox re-introduction, the CEI embarked on a five-year partnership with the Blackfeet Nation in Montana to re-introduce the swift fox, or "Senopah" as it is known to the Blackfeet. The Senopah has great spiritual significance for the Blackfeet, but it had been declared extirpated in Montana in 1969.

The CEI, now run by Miles and Beryl's daughter Clio, provided the foxes for the re-introduction. The Blackfeet Tribal Fish and Wildlife Department provided the land and assisted with the re-introduction, along with help from the conservation group Defenders of Wildlife.

In the first year, 30 captive-bred juveniles were released, with annual translocations to follow. By 2002, 10 dens with kits had been documented, and the population has continued toward the goal of self-sustainability. A similar re-introduction of swift foxes onto Blood (Kainai) tribal lands in southwestern Alberta began in 2005.

• • •

1. Evaluate the following point of view: "Why should we worry about preserving endangered species? After all, extinction is natural—species have been dying out for millions of years."
2. In addition to the swift fox, Alberta's Wildlife Act lists 12 other species as being threatened or endangered in Alberta. What are the species? What are the penalties for hunting, trapping, or trafficking in endangered species?

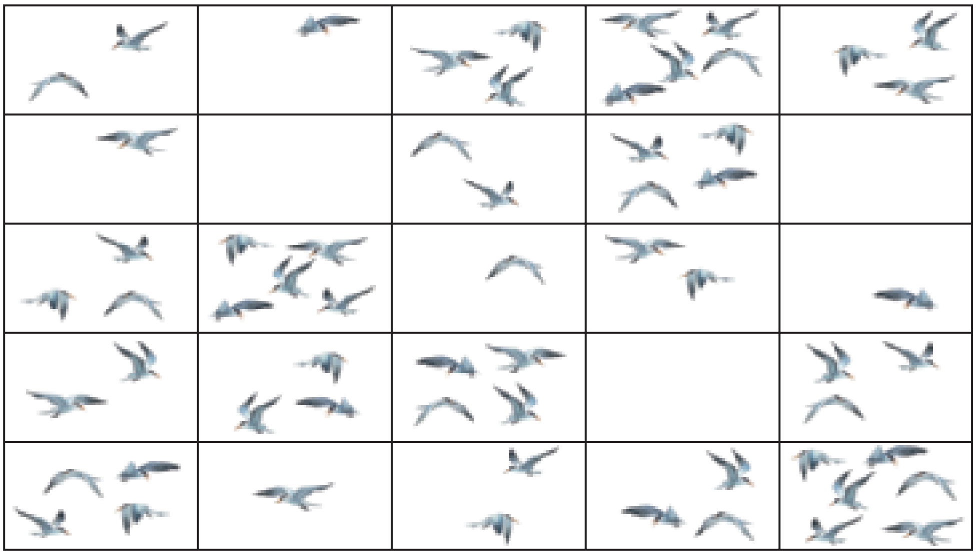


Figure 3.31 Examine a random sample of five of these 25 quadrats. Based on your sample, what is the average number of birds per quadrat? How many birds do you estimate are in this flock?

Sampling Populations in Ecosystems

If you were asked to sample a population of insects, or plants, or salamanders in an ecosystem in order to determine population size, how would you go about it? Some populations may be small enough for you to count every individual. This technique is not easy and it is not commonly done, although governments regularly conduct a count, or census, of their human populations.

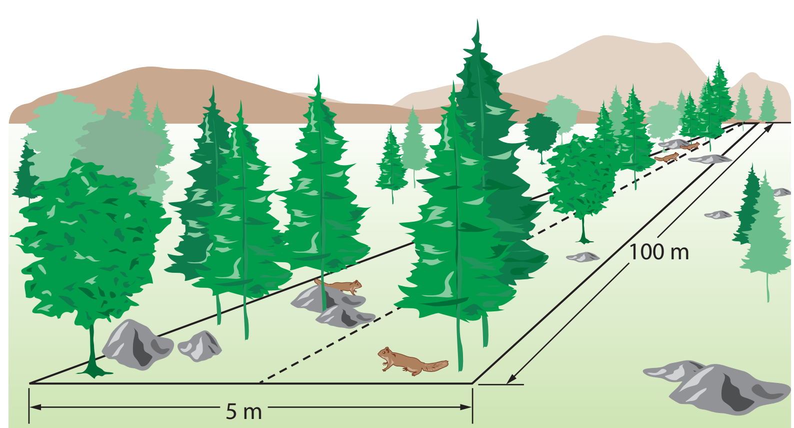
Usually, however, a census is too time-consuming, expensive, or impractical to conduct. Instead, ecologists estimate the size of a population. There are a variety of ways to do this. The most common way is to count or estimate the number of individuals in a number of **samples** (small portions or subsets of the entire population) and then calculate the average. The results are then applied, or extrapolated, to the entire area occupied by the population, as shown in Figure 3.31.

Estimating Numbers Using Transects or Quadrats

In some sample areas, organisms are sampled along a **transect**, which is a very long rectangle. In transect sampling, a starting point and direction are randomly chosen, and a line of a certain length (for example, 100 m) is marked out. The occurrence of any individual within a certain distance of the line is recorded. The distance from the line might be 1 m if plants are being sampled, or perhaps 50 m if mobile organisms (such as birds or mammals) are being studied. A sample transect is shown in Figure 3.32.

For plants and other organisms that tend to stay in one spot all their lives (such as marine life growing on a rocky shoreline), ecologists generally use **quadrats** to sample a given population. First, several locations are randomly chosen within the study area, and at every location a quadrat of the same size (for example, 1 m^2) is marked out. Next, the number of individuals of a species within the quadrat is counted, or the number of individuals of each of several species is counted if more than one population is being studied.

Figure 3.32 In this study area, you would count individuals of one species within 5 m of a 100 m long transect.



The **density** (the number of individuals per unit of volume or area) of the population is determined by calculating the average number of individuals per quadrat, and then dividing by the size of the quadrat. The size of the population can then be estimated by extrapolating from the density (for example, 2.5 individuals per m^2) to the entire study area. For example, if the study area is 1000 m^2, then the population size is roughly 2500 individuals.

This kind of information is collected by groups such as the staff at the Canadian Forest Services, who record data about species in particular areas. Information includes where and when the species are found and how they interact with the rest of the habitat and is used to identify areas that could be unique, as well as to monitor change in ecosystems over time.

Similar methods are used in studies of aquatic ecosystems to estimate the sizes of various populations. Often, water columns, samples of a known volume of water, are collected. The water is then passed through a net or sieve, and the number of organisms in each sample is counted. As with quadrats, the average density (number of individuals per unit volume) can be used to estimate the size of the population contained in the entire body of water.

When using any sampling technique, it is important to take *random* samples—that is, samples in which all of the individuals in the population have an equal chance of being represented. In Investigation 3.D, you will try one, or both, of these techniques to sample populations in your ecosystem field study.

INVESTIGATION 3.D

Target Skills

Performing a field study to observe and measure abiotic and biotic characteristics of ecosystems

Applying classification and binomial nomenclature in a practical context

Analyzing the interactions and connections of abiotic and biotic characteristics within investigated ecosystems

Evaluating the accuracy and reliability of measuring instruments used, and identifying the degree of error they introduce

Working cooperatively to collect and share data and ideas

An Ecosystem Field Study

You have been preparing for your field study throughout this chapter. In this investigation, you will sample and compare study sites from the two similar ecosystems you chose in Thought Lab 3.1. You will use the tools you chose in Investigation 3.C to help you gather information about the biotic and abiotic components of these ecosystems.

Question

How can you determine, qualitatively and quantitatively, the interrelationships between the abiotic and biotic components of ecosystems?

Safety Precautions

- Wear gloves if you are handling soil or water samples.
- Wash your hands thoroughly after your field study.

- Minimize your impact on organisms and their habitat as much as possible. Collect representative sample specimens of plants and animals only if absolutely necessary for identification. Use sketches or digital photos, if possible.
- If you disturb a habitat (by digging a hole, for example), return the habitat as close as possible to its original condition.

Materials

- tent pegs
- string
- Hula Hoops™ (optional)
- selected tools and materials approved by your teacher
- field guides

Experimental Plan

1. With your group, and using the suggested materials as a starting point, develop a plan for investigating the two study sites you chose in Thought Lab 3.1. Half of your group should study one site, and the other half should study the second site. You want to be able to compare the diversity of life in the two sites. Use the string and tent pegs (or Hula Hoops™) for transects or quadrats. In your study, you must:
   - include information about the abiotic features of your study site
   - determine the two or three dominant plant(s) of your study site
   - provide an overview of the species present in your study site, including an estimation of the number of species and their populations. (If necessary, in order to identify the species of each organism, plan to draw a sketch or take a photo of Plant 1, Plant 2, Animal 1, Animal 2, and so on, and use library or Internet resources to identify them when you come back from the field.) ICT
   - use classification systems and naming systems
   - take a sample (or samples) to estimate the populations of the organisms in your study site
2. Develop a data table that you will use to collect data at your study site.
3. Develop a plan to ensure the safety of your group as well as the safety of the organisms in your study area.
4. Have your plan approved by your teacher.

Data and Observations

Conduct your field study and record your results.

Analysis

1. Prepare a report detailing the abiotic and biotic components of your ecosystem. Include the following information:
   - location and size of your study area
   - the history of the area (for example, how long it has remained undisturbed or how recently it was developed)
   - the methods and tools you used in your field study
   - the abiotic components of your study area, including both qualitative and quantitative observations
   - the biotic components of your study area, including plant and animal species (common and scientific names) and, for at least two species, a description of their ecological niche in this ecosystem

Conclusions

2. Why was it important to choose sample areas randomly?
3. Why was it important to sample more than one area in your field study?
4. What are some limiting factors that might affect species in your study site?
5. **a)** Write a description comparing the diversity and abundance of species in the two study sites.
   b) Describe how the ecosystems of the two study sites are similar.
   c) Describe how they are different.
6. How have humans changed either of the ecosystems of the sites you studied?
7. Describe the tools and materials your team chose in terms of usefulness, accuracy, and reliability.
8. What are some ways you could improve your investigation techniques in future field studies?

Section 3.3 Summary

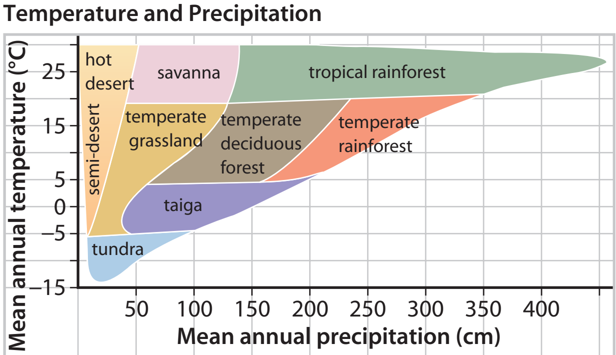
- Organisms are not distributed evenly across Earth. Patterns of distribution of life are largely due to abiotic factors such as climate, latitude, and elevation, and the ability of organisms to tolerate ranges of temperature, humidity, salinity, moisture, and light.
- A habitat is a place or area, within a biome or ecosystem, with a particular set of abiotic and biotic characteristics.
- An organism's range is the geographical area where the organism is found.
- The ecological niche of a population is the role that its members play in an ecosystem.
- The variety of niches and habitats within an ecosystem allow it to support a diversity of organisms.
- A limiting factor is any abiotic or biotic factor that controls the number of individuals in a population. Biotic limiting factors include competition, predation, and parasites.
- Organisms can be sampled using transects or quadrats, situated randomly in a study area. From these samples, the density of a population can be extrapolated.

Section 3.3 Review

1. Use an example to help you explain how the concept of niche differs from the concept of habitat.

Use the following information to answer the next question.

Terrestrial Biomes According to Temperature and Precipitation



Distinctive patterns become apparent when terrestrial biomes are plotted according to mean annual temperature and precipitation.

2. Explain how you could use this graph to predict why much of southern Alberta is in the grassland biome while much of northern Alberta is in the taiga (boreal forest) biome.

3. Identify the abiotic conditions that might affect the size of a population of mosquitoes in Alberta throughout the year.

Use the following information to answer the next question.

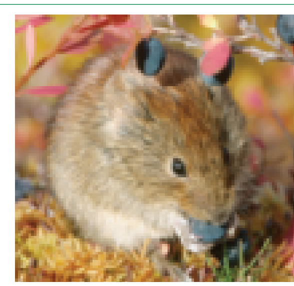
Boreal Forest

In Alberta, the boreal is located in the northern half of the province and is characterized by mixed wood forests comprised of both coniferous (spruce and pine) and deciduous (poplar and birch) tree species.

4. Describe how these species of trees would compete for the same resources.

Use the following information to answer the next question.

Red-backed Voles (*Clethrionomys rutilus*)



Populations of red-backed voles, found throughout much of Canada's boreal forest, fluctuate in cycles. Populations peak every two to five years and then decline sharply before building up again. In one study, researchers measured a density of 398 voles per hectare, which later fell to a density of 27 voles per hectare. Red-backed voles live in a variety of habitats but prefer moist, dense grassland with high soil moisture. They feed on fungi, lichens, seeds, berries, bark, flowers, and other parts of plants. Their predators include owls, hawks, and mammals such as coyotes.

5. Identify the factors that might lead to regular population cycles of the red-backed voles and explain how each factor can limit the population of this mammal.

Chapter 3 SUMMARY

An individual organism's environment includes biotic and abiotic components. Individual organisms affect and are affected by the biotic and abiotic components in the environment as they interact with them. Organisms are part of a population, a community, ecosystem(s), and Earth's biosphere. The distribution of an organism is determined by the abiotic components of environments in the biosphere.

In order to study organisms, biologists had to develop systems for logically organizing and naming them. They use a hierarchical system to group organisms in increasingly specific categories. The broadest categories are domain and kingdom, through phylum, class, order, family, genus, to the most specific category, species. The categories have often been revised to accommodate new discoveries. It is a universal, Latin-based system, and individual organisms are identified by a two-word system of naming, called binomial nomenclature. An organism's scientific name is its genus and species names.

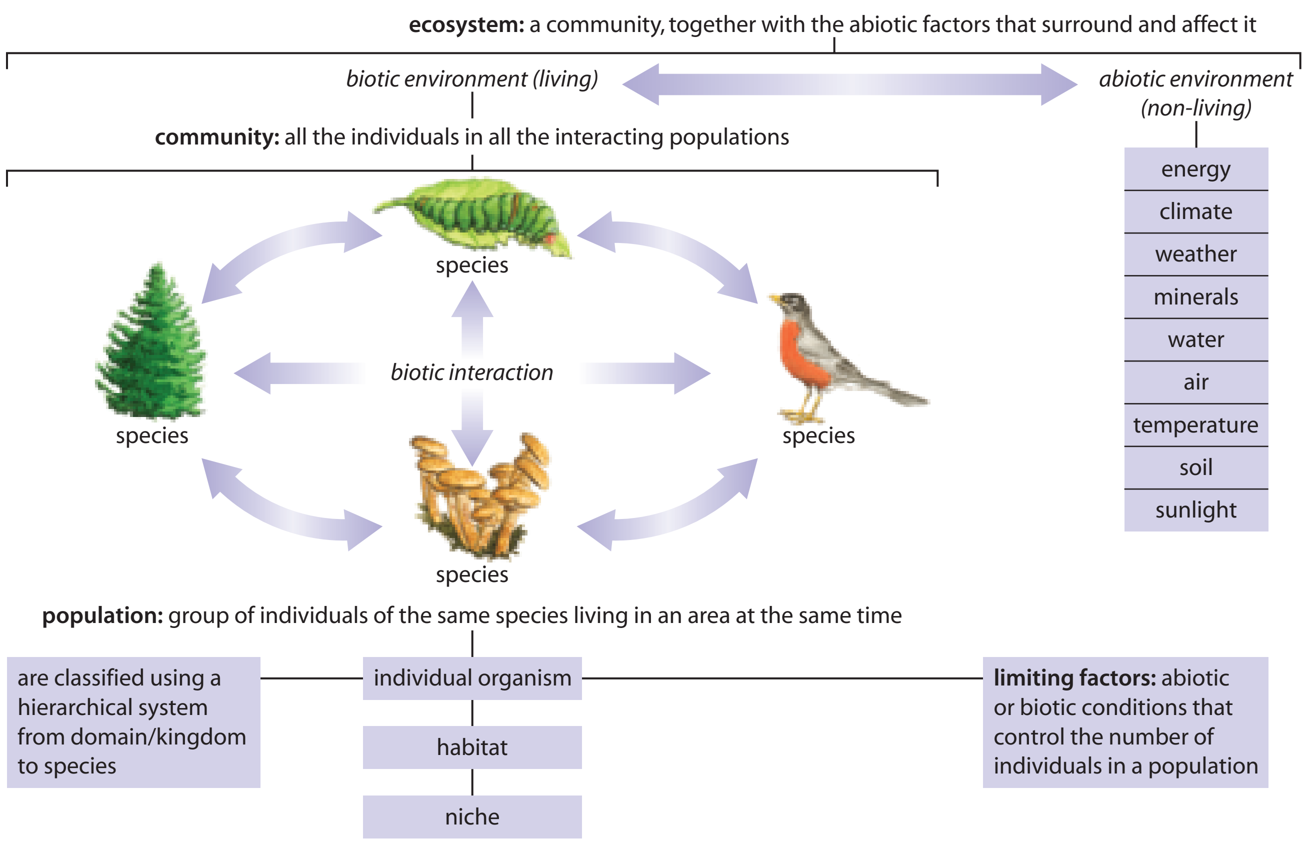
To identify organisms, biologists use dichotomous keys, which are arranged in steps. Each step has two statements, with answer choices as true or not true. Biologists work their way through each step until the species of the organism has been identified.

The unequal heating of Earth creates different climates in different parts of the world. This affects the organisms that live in particular places and results in distinct biomes, or groups of ecosystems, with similar abiotic conditions. Within biomes and ecosystems, there is a great deal of variation in habitats and niches.

The growth of a particular population in a particular habitat is limited by abiotic factors (such as climate and soil type) and biotic factors (such as competition for resources, predation, and parasitism).

Biologists use sampling techniques, such as transects and quadrats to sample populations in large ecosystems. Transects are often used to sample mobile populations over larger areas. Quadrats are often used to sample plants and other organisms that do not move. (Both methods can be used together.)

Chapter 3 Graphic Organizer

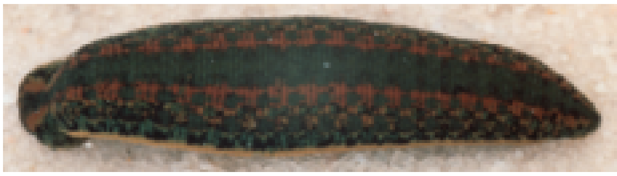


Chapter 3 REVIEW

Understanding Concepts

1. Predict five abiotic and five biotic factors in the ecosystem shown above.
2. Explain how an animal's habitat relates to its niche.

Use the following information to answer the next question.



The freshwater leech shown feeds on the blood of fish, frogs, turtles, and mammals.

3. Explain why the freshwater leech is an example of a parasite.
4. Compare an ecosystem to a biome.

Use the following information to answer the next question (5).

Coral reefs are considered to be ecosystems.

5. Explain how the physical nature of a coral reef provides habitats and niches for other organisms.
6. The tree swallow (*Iridioprocne bicolour*) and the little brown bat (*Myotis lucifugus*) breed in similar habitats. Both feed on insects they catch while in flight. Explain why these organisms do not occupy exactly the same ecological niche.
7. Use a forest fire as an example to explain how an ecosystem can change over time.
8. Explain how the trees in a coniferous forest might compete with each other.
9. Identify the kingdom in which you would place a single-celled, eukaryotic organism that makes its own food.
10. Identify three resources you could use to determine the scientific name of an organism.
11. Explain why an introduced species usually causes the population of a native species to decline.
12. The term "multidisciplinary" refers to a subject that requires understanding of many disciplines such as chemistry, geology, meteorology (weather), geography, archeology, and biology. Explain why ecology is a multidisciplinary subject.
13. List the three domains of life identified in this text, and provide an example of each domain.
14. **a)** Explain how interspecific competition, intraspecific competition, predation, and parasitism can control the size of a population.
    b) Explain, using examples, how abiotic factors can also limit the size of a population.

Applying Concepts

Use the following information to answer the next question.

Classifications for six species

Organism	house cat	dog	coyote	striped skunk	brown bat	praying mantis
Kingdom	Animalia	Animalia	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata	Chordata	Chordata	Arthropoda
Class	Mammalia	Mammalia	Mammalia	Mammalia	Mammalia	Insecta
Order	Carnivora	Carnivora	Carnivora	Carnivora	Chiroptera	Mantodea
Family	Felidae	Canidae	Canidae	Mephistidae	Vespertilionidae	Manitidae
Genus	*Felis*	*Canis*	*Canis*	*Mephitis*	*Myotis*	*Stagmomantis*
Species	*domesticus*	*familiaris*	*latrans*	*mephitis*	*lucifugus*	*carolina*

15. a) Identify the two animals in the table that are most closely related. Explain your answer.
b) Identify the animal that is not closely related to the other five animals. Explain your answer.
c) Use the scientific name of one of the animals in this chart to explain binomial nomenclature.
d) Predict the family of a wolf and a lion. Explain why you selected these names.
e) Infer why scientists would classify cats, dogs, coyotes, and skunks in the Order Carnivora.
f) Use graphics or word processing software to create a flow chart or concept map illustrating the relationship between the mammals in this chart. ICT

Use the following information to answer the next question.

Suppose that you have discovered an unknown organism while on a field trip. When you examine the organism under a microscope, you can see that it is multicellular and its cells have no chloroplasts to carry out photosynthesis.

16. a) Identify the kingdom that you would place this organism in.
b) Explain why there are other possibilities, as well.

17. Use graphics software to draw a diagram explaining why biodiversity will differ between a lawn that is regularly mowed with an adjacent lawn that has been left to go "wild." Write a short paragraph contrasting the abiotic conditions on both lawns. In addition, write a paragraph contrasting the habitats and niches in each lawn. ICT

Use the following information to answer the next questions.

Grizzly Bear

The scientific name of an organism often describes one or more characteristics of the organism. Take, for example, the grizzly bear. The scientific name of the grizzly bear is *Ursus arctos horribilis*. When taxonomists first encountered grizzlies during the 19th century, the bear's size and aggressiveness no doubt inspired this name. The common name *Ursus arctos* came later, when taxonomists recognized that grizzlies were the same as brown bears. *Ursus* is a genus in the family Ursidae (bears) that includes the widely distributed brown bears, black bears, and the polar bear.

Grizzly bears in the Central Rockies Ecosystem (CRE), the area in and near Banff National Park and Kananaskis Country, exist within a few hours drive of about 1 000 000 people. This is one of the most developed and used landscapes in North America where grizzly bears still survive. It is a critical link in the Yellowstone to Yukon landscape because here habitat available for large carnivores is relatively restricted.

18. a) Explain why scientists use Latin as the language of taxonomy.
b) Study the species name of the grizzly. Infer why taxonomists might have used the name "arctos" to describe brown bears.
c) Identify two so-called natural factors that may limit the population of grizzly bears in Alberta.
d) Describe how human activities have likely impacted the population of grizzly bears in Alberta.

19. Use graphics or word processing software to make a concept organizer that includes the following terms: cell, nucleus, no nucleus, eukaryote, prokaryote, plants, animals, archaebacteria, bacteria, fungi, Protista, Animalia, and Plantae. ICT

Making Connections

20. Identify a change in an ecosystem that has been caused by an action of people. Explain how you think this change might affect the diversity of the ecosystem.

21. Identify the things you do every day that can affect the ecosystem you live in.

Use the following information to answer the next question.

There is a growing concern worldwide about the numbers of species that are going extinct. Conservation organizations work to protect endangered species, but there may be disagreement about what exactly a "species" is.

22. a) Describe how naming an organism might influence our attitudes about the organism. For example, is a fish more likely to be protected if it is an endangered species or if it is newly discovered and different from all known species of fish?
b) Describe how naming an organism such as the grizzly bear (*Ursus arctos horribilis*) might influence our feelings about the organism.