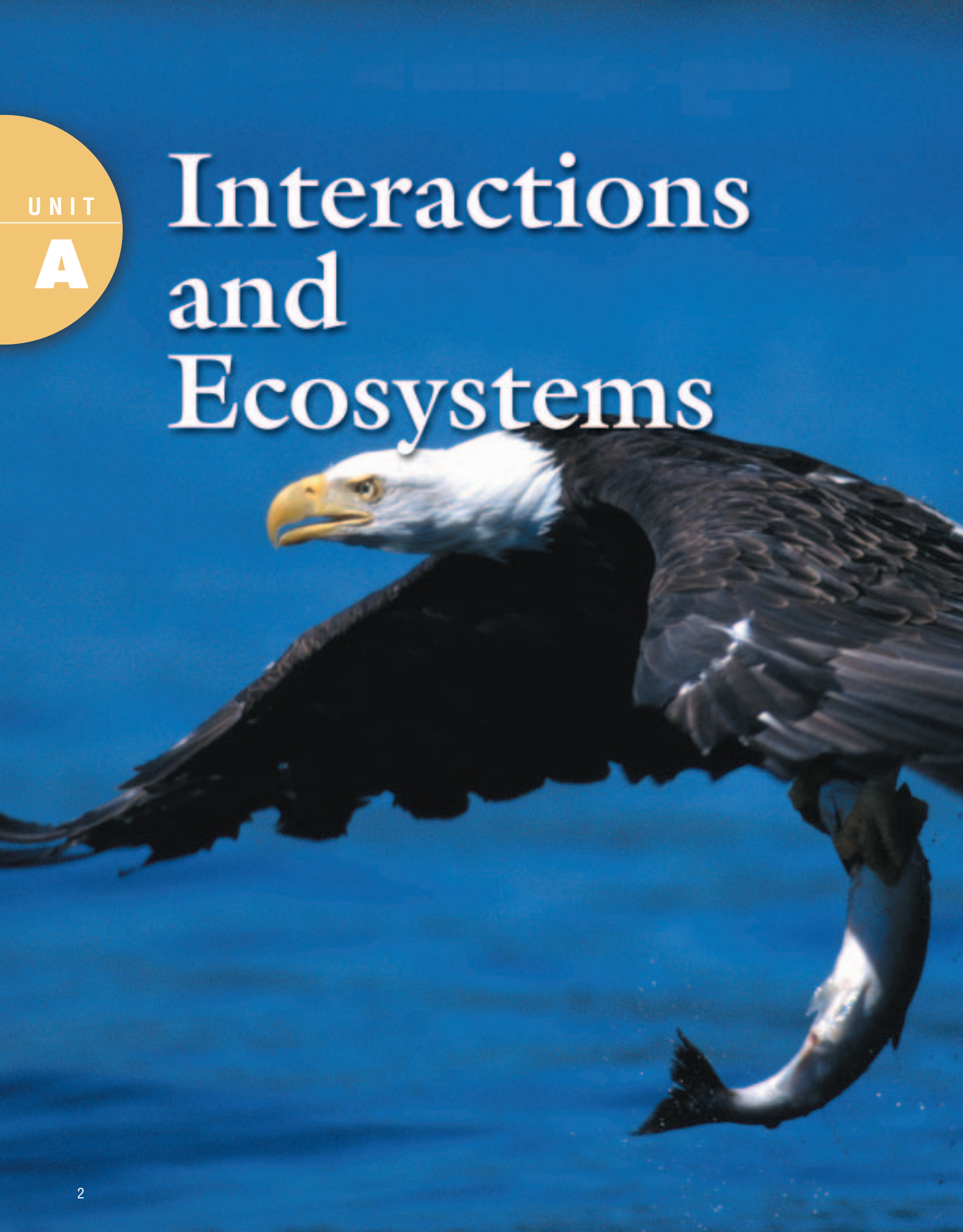
UNIT

A

Interactions and Ecosystems



In this unit, you will cover the following sections:

1.0 **Relationships exist between living things and their environments.**

- **1.1** Defining an Ecosystem and Learning about Basic Needs
- **1.2** Interactions among Living Things
- **1.3** Human Impacts on Ecosystems

2.0 **The flow of energy and the cycling of matter can be traced and interpreted in ecosystems.**

- **2.1** Ecosystems Have Interactions among Producers, Consumers, and Decomposers
- **2.2** Food Chains Demonstrate the Flow of Energy in Ecosystems
- **2.3** Food Webs
- **2.4** Matter Cycles in Ecosystems

3.0 **Changes can be observed and monitored in ecosystems.**

- **3.1** Investigating the Distribution of Living Things in an Environment
- **3.2** Interactions and Changes Occur in Ecosystems
- **3.3** Succession: How Ecosystems Change over Time

4.0 **Maintaining sustainable environments requires knowledge, decisions, and actions.**

- **4.1** There Are Intended and Unintended Consequences of Human Activities within Ecosystems
- **4.2** Information from Scientific Investigations Can Assist Environmental Decision-Making
- **4.3** There Are Limitations to Scientific and Technological Knowledge
- **4.4** Using Evidence from Many Sources Can Help Analyze a Local Environmental Problem

Exploring

Imagine you are out on a winter camping trip in northern Alberta. You see a wolf chasing a rabbit among the snow-covered trees. At that moment, you all have something in common. You are all part of an ecosystem. An **ecosystem** is an area where living things interact with other living and non-living things.

In this unit, you will find out how all living things are related and depend on each other. You will learn how ecosystems work and are maintained and why that is important for the well-being of Earth. You will discover how human actions can impact Earth in both positive and negative ways. In Alberta, a new wetland was created thanks to many concerned organizations and individuals.

Saving Frank Lake

Just east of the town of High River, in south-central Alberta, a wetland has been created. It is called Frank Lake. Thanks to Ducks Unlimited, a national non-profit conservation organization, what was once a shallow lake that disappeared in dry summers, is now a wetland which will have water all year.

Ducks Unlimited works to restore, improve, and/or preserve habitats that are critical for ducks and other migrating waterfowl. Alberta is home to 20% of all the ducks surveyed each spring in North America. The Frank Lake project is an important one since its location is a stopover spot for birds like ducks, geese, and shorebirds as they make their way north in spring and south in fall. It is also a breeding ground for many of these birds.

Frank Lake before it became a wetland

What human actions were needed to make Frank Lake a wetland? Finding a source of water was the key factor. This happened through a unique partnership between Ducks Unlimited and a local meat-packing plant.

Waste water from the meat-packing plant is treated and cleaned. The water is then piped from the town of High River to Frank Lake. Water levels and water quality are continually monitored at Frank Lake. During dry, hot years, more water can be piped into the lake. If there is a wet period, less water is required.

Now the water flows all year in Frank Lake, providing a habitat for amphibians, fish, and plants as well as rare birds like the peregrine falcon and trumpeter swan. It also provides a grazing area for the cattle of local farmers, and a rich wildlife viewing area for local naturalists. According to Jerry Brunen, an area manager for Ducks Unlimited, "Frank Lake is once again the most important wetland in southwestern Alberta."

Frank Lake, the new wetland

Give it a **TRY** **Activity**

Creating a Plan

Think about a natural area in your community that you enjoy. Work with a partner or small group to brainstorm ways that people might have a negative impact on this area. For example, too much litter in a park or too many people in an area can damage plants. Once you have identified three to five negative impacts, suggest some possible ways to reduce these impacts. Your suggestions can be creative, but make sure they can be done in a reasonable amount of time at a reasonable cost.

Select your best idea and be prepared to share it with the class.

Focus On

Social and Environmental Context

As you work through this unit, you will be asked to organize your thoughts about how society and environmental changes influence ecosystems. Many decisions regarding ecosystems involve a variety of perspectives. You will be asked to consider some of these perspectives as you perform certain activities and answer certain questions throughout this unit. As you work through this unit, think about the following questions:

1. **How do human activities affect ecosystems?**
2. **What methods can we use to observe and monitor changes in ecosystems?**
3. **How can we assess the impact of our actions on ecosystems?**

The answers to these and other questions about ecosystems will help you understand the role that science and technology has in monitoring and maintaining ecosystems, as well as the intended and unintended consequences of human activity, and the need for responsible decision-making and action. The project at the end of the unit allows you to apply your knowledge of how to balance the needs for human growth and development with the needs of an ecosystem.

1.0

Relationships exist between living things and their environments.

Key Concepts

In this section, you will learn about the following key concepts:

- interactions and interdependencies
- environmental monitoring
- environmental impacts
- environmental management

Learning Outcomes

When you have completed this section, you will be able to:

- define an ecosystem
- identify abiotic and biotic factors
- explain how basic needs are met in an ecosystem
- describe interactions among living things
- identify human impacts on ecosystems
- recognize that in order to make an informed decision about an environmental issue, scientific knowledge and exploration are involved

Imagine sitting quietly in a natural setting such as a field or on the side of a mountain. What sensations would you have? There certainly would be a wide variety of plants to look at. Would there be rocks, sand piles, and soil, too? Would you see animals moving around? What would you smell: flowers, pine needles, wet grass? Would you hear bird calls, the buzz of insects, rustling in the grass or bushes? The environment in which we live is composed of a wide variety of living and non-living things. In fact, your life—all life—depends on and is connected with other living things.

For Web links relating to 1.0, visit **www.pearsoned.ca/scienceinaction**

1.1 Defining an Ecosystem and Learning about Basic Needs

Any place on Earth where living things interact with other living and non-living things is called an **ecosystem**. The living things are called the **biotic** factors, or parts, of the ecosystem; the non-living things are called the **abiotic** factors. The "bio" part of the word comes from a Greek word that means *life*, and the "a" part means *not*, so biotic means living, and abiotic means not living.

Figure 1.1 A rotting log ecosystem

Ecosystems may be large, such as an ocean or desert. They may also be small, such as a puddle or a rotting log.

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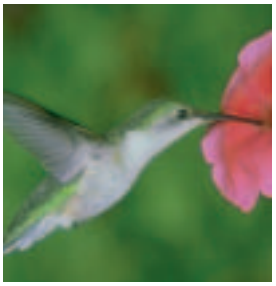
An Ecosystem?



Is this an example of an ecosystem?

Give it a **TRY** ACTIVITY

BIOTIC AND ABIOTIC FACTORS IN THE CLASSROOM

Look around your classroom. Try to find as many biotic (living) and abiotic (non-living) factors as possible. Work with a partner to make a table.

Compare your table with those of other pairs. Did you have similar tables? Add any missing factors to your table.

Your Schoolyard

Is your school located in the heart of a major city? Is it in the suburbs, or in a smaller city or town, or in the countryside? Regardless of where your school is located, it's probably surrounded by plants, soil, animals, rocks, and other living and non-living things including you and the people that go to your school. Some things may be big enough for you to notice easily. Others may be small enough for you to have missed. Until now.

Take a moment. Consider what living and non-living things make your schoolyard their home. Make a list of them. Now think about the relationships between the abiotic and biotic factors on your list. Describe the interactions among them.

Figure 1.2 Interactions between biotic and abiotic factors

Figure 1.3 What biotic and abiotic factors can you see in this photo?

The World within an Ecosystem

Earth contains many ecosystems. Each ecosystem contains a variety of different **species**. Living things of the same species are able to reproduce and have young that are also able to reproduce. The young usually look very similar to the parents. When a number of individuals from the same species live together in the same area, the group is called a **population**. All the populations of different species that live and interact in the same place form a **community**. An ecosystem could be considered the area where all the living and non-living things within a community interact.

Figure 1.4a) This ant is a member of one of many species of ants.

Figure 1.4b) All the ants of this species living together in one area form a population. Ants of the same species living in another area would form a separate population.

Figure 1.4c) This tree is a member of the species *Picea glauca.*

Figure 1.4d) All the trees of this species that grow in the same area form one population.

Figure 1.4e) All the populations of various living things that live together in an area—including trees and ants—form a community. How many different populations can you see in this community?

The Needs of Living Things

Some living things are able to live in your schoolyard while other living things just visit or pass through your schoolyard. You are an example of a living thing that just visits your schoolyard. This is because all of your **basic needs** cannot be met in the schoolyard ecosystem. An ecosystem must meet the needs of the living things that are present in it. What do living things need in order to survive?

Figure 1.5 A tiger meeting its basic need of water

Living Things Need Water

About three-quarters of our planet's surface is covered with water. Water not only makes up the majority of Earth's surface, but also makes up the majority of all living things. For example, about two-thirds of your body is made up of water. About nine-tenths (or more) of a head of lettuce is water! Life cannot exist without water.

Figure 1.6 Students getting the nutrients they need

Living Things Need Food

You need food for the **nutrients** it provides. Nutrients include substances such as carbohydrates, fats, proteins, vitamins, and minerals. All these substances supply your body with energy and materials that you need to move, grow, and to repair and maintain the health of the billions of cells in your body. Most other living things need nutrients for the same reason.

Figure 1.7 An athlete using energy to win a race

Living Things Need Energy

You need energy to walk, run, breathe, eat, digest what you eat, and grow. You need energy even when you're sitting still and relaxing. Energy keeps your heart beating, air moving in and out of your lungs, and the rest of your organs working properly. So you need energy even when you're asleep!

- Where do you get the energy you need to survive?
- Where does this energy source come from?

Living Things Need Oxygen

When you eat, chemical reactions take place inside your body. These reactions use oxygen to break down the food to provide you with energy. With only a few exceptions, all living things need oxygen to provide the energy they need to survive. This includes animals, plants, fungi such as mushrooms, and microscopic life forms such as bacteria.

- Where do you get the oxygen you need to survive?
- Where do living things in water get their oxygen?

Figure 1.8 This backpacker uses oxygen when hiking.

Living Things Need Suitable Living Conditions

Life can exist in harsh conditions. For example, certain kinds of microscopic bacteria and algae thrive in hot springs that can reach temperatures of up to 85°C. Other kinds of life exist in the Antarctic, where temperatures can reach as low as –90°C. However, most living things live best in a more moderate range of temperatures. They often build shelters to provide safety and comfort.

- What kinds of shelters do people build?
- What kinds of shelters do other animals build?

Figure 1.9 Two shelters in very different climates

Decision Making Activity

Buried Alive

The Issue

For publicity, magician David Blaine wanted to convince people of his skills as a magician and illusionist. He was buried in a coffin for seven days with only a few tablespoons of water every day. How long can humans survive without being able to meet their needs?

Background Information

On April 5, 1999, at 10:00 a.m., magician David Blaine was lowered into a 1.83-m-deep hole in a clear Plexiglas coffin at a New York City construction site. A water-filled tank was placed atop his coffin, and gravel was poured around him. To prepare for this event, Blaine fasted for six days prior to it to clean out his body. He also spent four days a week living in a coffin in his living room to help him get used to living in a small space. A plastic container, funnel, and tube was used to eliminate the urine from the three to four tablespoons of water he consumed each day.

Figure 1.10 David Blaine, seconds before emerging from his coffin

Fresh air was pumped into the coffin, a tent was raised over the water tank if the sun got too hot, around-the-clock medical personnel were on hand, as was a crane to remove the water tank, and a panic button. When Blaine came out of the coffin seven days later, he was quite weak, but otherwise healthy.

Support Your Opinion

Could David Blaine have survived for a longer period of time? If so, would some needs become more important than others in the next few days? Why do you think that? How did Blaine meet his basic needs of

- water?
- food?
- energy?
- oxygen?
- suitable living conditions?

Meeting Your Basic Needs

An ecosystem must meet the needs of the organisms living in it. Think about your basic needs for survival. Illustrate with a labelled picture how basic needs for survival are met in your own life. Identify three things in your life that you could do without and still meet your basic needs.

Check and Reflect

1. Which living things probably live full time in your schoolyard? What is it about your schoolyard that makes it a good place for these living things to live?
2. What other living things just visit or pass through your schoolyard? Where do you think they live? Why would they live there and not in your schoolyard?
3. Select an area near your school that has both abiotic and biotic factors. List at least three of each. Illustrate possible interactions between the different factors that you listed.
4. In your notebook, classify the items in the list below into one of the following three categories: species, population, community.

   flock of birds
   grizzly bear
   school of fish
   pond
   ant
   pack of wolves
   dragonfly
   herd of elk
   moose
   prairies
   grasshopper

5. In your own words define an ecosystem. Use your definition to explain whether you think the following statement is true or false: A schoolyard is an ecosystem.
6. Identify which of the following statements are false. Reword these false statements to make them true.
   a) Ecosystems can only be large.
   b) Ecosystems contain both biotic and abiotic factors.
   c) Only the stones and sand in a puddle are needed to make up an ecosystem.
   d) Your schoolyard is an ecosystem.
   e) Ecosystems do not need water.

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Learning about Dinosaurs

Scientists often have to learn about living things, or **organisms**, from evidence rather than from observing the real thing. Dinosaurs are an example of this. Research what scientists have learned about dinosaurs.

1.2 Interactions among Living Things

Interactions exist between living things. You probably can list many ways that living things interact with each other. Clown fish live unharmed among the stinging tentacles of sea anemones, where the fish are protected from predators. You eating a green salad is another example! Interactions are important for the survival of most organisms.

Symbiotic Relationships

Living things sometimes interact with other living things in very surprising ways. For example, some plants grow best in soil that has a particular type of fungus present there. And certain species of birds are often found on the backs of cattle and other large grazing animals. The birds eat the insects off the backs of the cattle. As the cattle walk and stir up more insects, the birds have an easy food source. Whenever different living things live closely together where the relationship may benefit one or both living things, this relationship is called **symbiosis**. There are three major types of symbiotic relationships: **commensalism**, **mutualism**, and **parasitism**.

Commensalism

This is a relationship in which one species in the relationship benefits while the other neither benefits nor is harmed. An example of this relationship is that between trees and a species of flower called an orchid. Orchids live by attaching themselves to the branches of a tree. The tree neither benefits nor is harmed, while the orchid benefits because it receives access to sunlight.

Figure 1.11 An orchid attached to a tree

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Microscopic Interactions

Interactions occur everywhere. These dust mites live in your bedroom! They eat the dust that comes from your hair, flakes of skin, and clothes.

Mutualism

This is a relationship in which both species in the relationship benefit. An example of this is the relationship between the goby fish and snapping shrimp. The shrimp builds a sand burrow and allows the goby fish to share the burrow. The shrimp is almost blind, so it always has a feeler on the goby. The goby warns the shrimp when danger is approaching by a flick of its fins, and both retreat into their burrow.

Figure 1.12 A goby fish and a snapping shrimp helping each other

Parasitism

This is a relationship in which one species in the relationship benefits while the other species is harmed. If you have ever been bitten by a mosquito, then you have experienced parasitism! The mosquito sucks blood from you so it can make its eggs. It leaves you with an itchy lump.

Figure 1.13 A mosquito biting a human

Inquiry Activity

Ecosystem in a Jar

The Question

What types of living and non-living things can you put in a sealed jar to make a self-sustaining mini-ecosystem?

Materials & Equipment

- glass jar with lid
- gravel or rocks
- pond water
- tap water
- pond snails
- aquatic plants such as duckweed or elodea
- duct tape

Procedure

1. Make sure your jar is clean and the label is removed. Put your name and today's date on the lid.
2. Look at the materials your teacher has made available for this activity. Make a list of the ones you will use in your mini-ecosystem jar. Remember: You want to make sure that whatever you put in allows the snails and plants to stay alive in the sealed jar.
3. Show your list to your teacher for approval. After your teacher checks it, assemble your mini-ecosystem in your jar.
4. Predict what you think the jar will look like in three weeks. Draw a picture to record your prediction. After three weeks, examine how your mini-ecosystem jar is working.

Figure 1.14 An ecosystem in a jar

Collecting Data

5. Record the final number of each type of living and non-living thing that you put into the jar.
6. Create a table that will allow you to monitor and record any changes to the living and non-living things in your jar over the next three weeks.

Analyzing and Interpreting

7. Is your mini-ecosystem jar a totally closed system? Explain your answer.
8. Identify all the living and non-living things in your mini-ecosystem jar.
9. Suggest some possible interactions between the things in your mini-ecosystem jar.

Forming Conclusions

10. Describe what your mini-ecosystem looked like after three weeks. Explain any changes that happened since you first put it together.

Adapting to the Environment

Living things meet their needs in many different ways. Each organism in an ecosystem has certain unique characteristics. **Adaptation** is how organisms respond to their environment. Only those species that are best suited to their environment will survive and produce offspring. Over many generations, the offspring that inherit their parents' successful characteristics continue to reproduce, whereas the species that are not well suited to their environment are less likely to survive and produce offspring. So, over time, the successful characteristics will be more common in the population. These changes in the behaviour and physical characteristics of species make them better adapted to their environment.

It is important to understand that living things cannot choose how they will change. They do not decide to develop characteristics that will allow them to live successfully in their environment. However, living things have changed in many ways to meet the challenges of their environment.

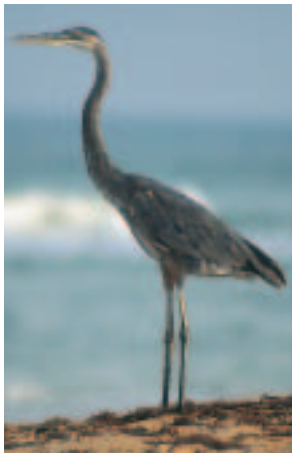

Figure 1.15 The great blue heron's sharp beak, long neck, and long legs are its adaptations for catching fish.

Check and Reflect

1. Draw a labelled diagram to demonstrate your understanding of how humans interact with other living and non-living things in their environment.
2. Describe an example of a symbiotic relationship between two living things, and the adaptations involved.
3. Look at the examples below and decide whether the relationship is commensalism, mutualism, or parasitism.

Figure 1.16 The sea lamprey attaches itself to other fishes by suction. Some of the lamprey's victims may die, while others live but have a scar where the lamprey had attached itself.

Figure 1.17 Barnacles, unable to move on their own, attach themselves to whales to increase their chance of finding food. Whales are not affected by the barnacles.

Figure 1.18 As the butterfly feeds, pollen sticks to its body. The butterfly carries the pollen to the next flower it feeds from. Most flowers need this pollen to produce seeds.

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Plant Uses

Many Aboriginal peoples have a close relationship with the animals and plants in their ecosystem. They have used plants like bearberry for soap, and willow as a painkiller. Research some other uses of plants in the Aboriginal culture.

1.3 Human Impacts on Ecosystems

Ecosystems are impacted by human actions. Even if our intentions are good, the impact may have unintended consequences as in the case of the beaver population in Yoho National Park.

Declining Beaver Population

Many times, humans think that they are trying to help the ecosystem, but their help has unintended consequences. For example, biologists have recently been studying the dramatic decline in the beaver population in Yoho National Park after noting that the population is significantly lower than it was 100 years ago.

Fire management practices have changed since Yoho became a national park. While forest fires were a relatively frequent occurrence in Yoho before it became a park, they are almost non-existent now since the development of efficient fire-monitoring and fire-fighting teams. The decision to put out all fires appeared to be in the best interests of wildlife, people, and the park. However, since there are no longer any fires, the trees in the park have grown larger. As a result, there is not enough light for the young aspen trees to grow. Since this tree is the preferred food and shelter for the beaver, beavers are no longer able to live in this area. So what was meant to be a deliberate attempt to manage the forest fires in this area has had an unintended impact on the beaver population.

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Toad Tunnels

In England, cars travelling on the highways have killed more than 100 000 toads each year. So, special toad tunnels have been built under the roads. The tunnels can fit about 200 toads per hour.

Give it a **TRY** **Activity**

Impacts on Ecosystems

Work with a group. Think about the following situations. Explain how the individual in each situation has an impact on his or her environment.

- a student throwing a candy wrapper on the ground
- a student riding a mountain bike on a thin trail through the forest
- a farmer plowing a field
- a person involved in a strip-mining operation
- a fisheries biologist adding trout to a lake
- a biologist cleaning oil off the wings of a duck

Can you think of one more impact an individual could make?

Figure 1.19 A garbage dump containing consumer waste

Dealing with Our Garbage

Humans have a bigger impact on ecosystems than any other living things. No other species inhabits as many different ecosystems. We also invent and use technology to alter the ecosystems in which we live. And technology has affected the amount and type of waste we produce.

As long as there have been people on the planet, they have produced waste material. Long ago, all waste material could be broken down to be returned to the environment. However, we now use a lot of materials, like plastic, that cannot be broken down, or produce so much of it that the natural cycles cannot keep up.

In the past, it was common for garbage to be poured into large pits. These pits were called "dumps" because people just dumped their garbage there. Dumps were smelly and looked unattractive. Sometimes they caught fire, polluting the air with sooty, foul smoke. Rainwater often washed dangerous chemicals and disease-causing bacteria from the dumps into local water systems. Think about the potential impact of waste products on the environment. How have our needs and wants affected the types of garbage we produce? What has been done to clean up our act?

Decision Making Activity

What Kind of Drink Container Would Lessen Our Impact on the Environment?

The Issue

Think about the impact that drink containers can have on the environment. What kind of drink container would lessen the impact on it?

Background Information

1 Brainstorm a list of all the different kinds of drink containers.

Figure 1.20 Students assessing drink containers

Drink Container Features		
Drink Container	**+**	**–**
can		

2 Compare the different kinds by making a plus/minus chart like the one shown above. In the "plus" column, list the positive features of each container. In the "minus" column, list the negative features of each one. When making your chart, think about safety, cost, waste, energy, and recycling.

3 Review your chart. Suggest any additional scientific information about environmental impacts that you might need to complete the chart.

4 Develop a fair test that you could perform to help you gather more information.

5 As a group, determine which container would be best. Explain your reasons for your choice.

Support Your Opinion

6 Present your findings to your classmates.

7 Did your findings agree with those of other groups in the class?

8 What other aspects would you want to consider when making this decision?

The Garbage Solutions

Some of the ways we have cleaned up our act include: recycling, composting, incinerating, household hazardous waste operations, and sanitary landfills.

Here are examples of how some of these methods work.

Recycling handles paper products as well as clear glass bottles, metal cans, aluminum foil containers, and some plastics. These materials are separated, sorted, crushed, compacted, and then bundled for transport to various industries for reprocessing.

Sanitary landfills are similar to landfills. The wastes from both types of landfills are spread across the ground and then compacted by bulldozers into layers 0.5 m thick. A layer of soil is spread over the compacted wastes to reduce odours and litter, and to discourage animal activity.

However, landfills will leak. Sanitary landfills are designed not to leak. Once the hole for the sanitary landfill is dug, a clay liner and system of pipes is put in place to prevent leakage.

Although both the landfill and sanitary landfill handle solid wastes from municipal, residential, and industrial sources, sanitary landfills are a more environmentally friendly way of dealing with our garbage problem.

Figure 1.21 A recycling depot

Figure 1.22 A sanitary landfill

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Dealing with Waste

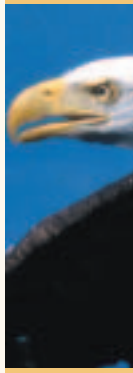
Find out how your community deals with household waste. What happens to it? Where does it go?

Check and Reflect

1. Draw a mind map or flowchart to show how discarding the pop can holder in Figure 1.23 could have an impact on the ecosystem.

Figure 1.23 Question 1

2. How does an answer to a question as simple as "What kind of drink container will I take to school?" have both intended and unintended consequences for the ecosystem?
3. How have humans had an impact on the Yoho National Park ecosystem? Was the impact positive or negative? Explain your answer.
4. What do you think can be done to lessen the "unintended consequences" that humans create for the ecosystem? Provide a specific example to illustrate your thoughts.
5. Create a web to demonstrate your understanding of all the things that must be considered when making an informed decision about an environmental issue.
6. Your school wants to start a recycling program. What kind of information would you need to know in order to determine if this is a good idea? Design a survey as a first step in investigating the issue.



Assess Your Learning

1. List three basic needs of living things and explain their importance.
2. a) Name four abiotic factors on our planet.
   b) Name four biotic factors on our planet.
   c) Choose one abiotic factor and one biotic factor that interact.
   d) Choose two biotic factors that interact.
   e) For parts c) and d), use words, pictures, or both to explain how they are connected to each other. Identify the type of interaction present.
3. Draw a picture to illustrate how the following biotic and abiotic factors together could make up one ecosystem.
   a) trees
   b) lake
   c) birds
   d) mosquitoes
   e) mushrooms
   f) soil
   g) campground
4. Imagine you were out for a walk along a river bank. You notice a large pile of household garbage on the other side of the river. What impact could this garbage have on the local ecosystem?
5. Identify an example of human impact on an ecosystem not mentioned in this section. Was the impact positive or negative? Were the consequences of the impact intended or unintended? Explain your answers.

Focus On — Social and Environmental Context

Science and technology are designed to meet human needs and expand human capability. Think about what you learned in this section.

1. What are the needs of all living things?
2. How can science and technology help humans balance their needs with the needs of the other organisms present in the ecosystem?
3. How can science and technology be used to lessen the unintended impacts that humans have on ecosystems? How would this expand human capabilities?

2.0

The flow of energy and the cycling of matter can be traced and interpreted in ecosystems.

Key Concepts

In this section, you will learn about the following key concepts:

- interactions and interdependencies
- producers, consumers, and decomposers
- nutrient cycles and energy flow
- environmental impacts

Learning Outcomes

When you have completed this section, you will be able to:

- identify the relationship between producers, consumers, and decomposers in ecosystems
- describe how energy and nutrients are stored in plants and animals
- describe how food chains and food webs demonstrate the flow of energy in ecosystems
- describe how matter is recycled in ecosystems
- predict changes to any part of a food web
- describe the cycles of matter of water and carbon in ecosystems

What would you say to getting rid of the biting insects that attack you each spring and summer? You would probably say "yes." But studies of ecosystems suggest that there is no easy way of eliminating certain species without harming the environment.

At first, it would be great to have no mosquitoes, horseflies, or blackflies. In a couple of years, however, you would notice some important changes. Insects are a main food source for some birds and fish. Without a steady food source, what would happen to those animals? How about the animals that feed on those fish and birds—what would happen to them? Insects also pollinate many flowers, and without them, many plants would not produce fruits and seeds. The animals that eat these fruits and seeds would suffer. Some insects also have an important role in the breaking down of dead and decaying organisms.

As you can see, the elements in an ecosystem are interdependent. It's important to understand these relationships to see how an ecosystem works.

For Web links relating to 2.0, visit **www.pearsoned.ca/scienceinaction**

2.1 Ecosystems Have Interactions among Producers, Consumers, and Decomposers

By the time you have reached grade 7, your body mass has probably increased 10 times since you were a baby. Your body has gone through many changes. It needed energy to "fuel" all these changes. And it needed matter to supply what your body needed to increase in size and mass. The energy and matter that your body needed came from food. Your body broke down the food into a form that it could use. Choosing the right foods, then, is important, because no one food can supply your body with everything it needs.

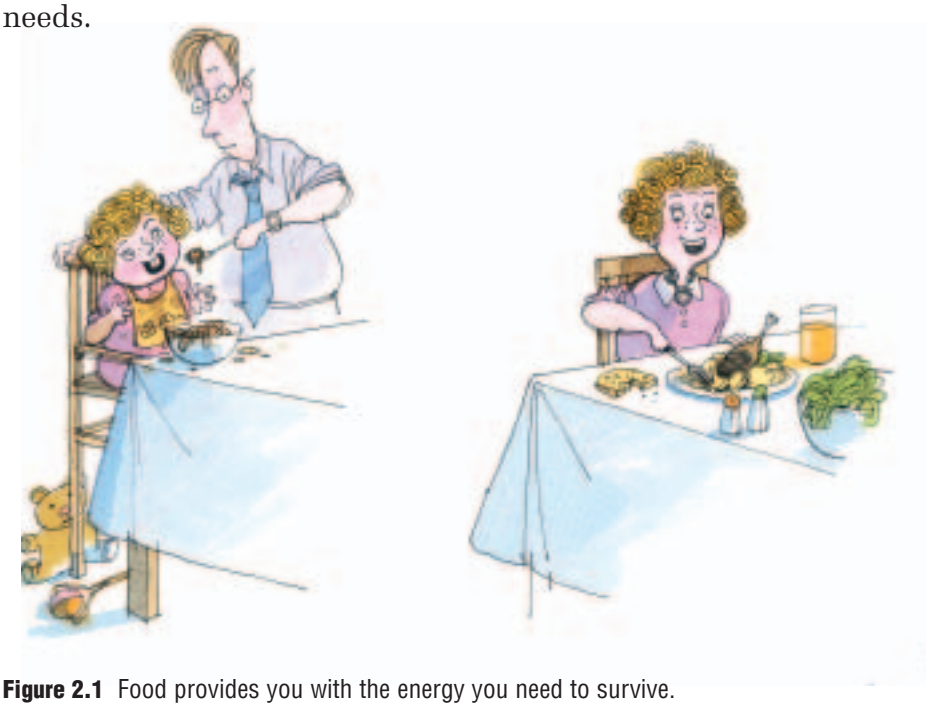


Figure 2.1 Food provides you with the energy you need to survive.

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Hyenas

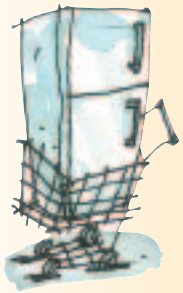
For a long time, scientists believed that hyenas were exclusively scavengers. That's because people saw hyenas scavenging during the day. Now, scientists have a different view. Researchers discovered that hyenas do hunt for their food, but only at night. In fact, hyenas are skilful, cunning hunters. But they're always ready and willing to scavenge if they have the opportunity.

Give it a **TRY** ACTIVITY

Creating a Food List

Take a moment. Think back to the foods you've eaten over the past two days. Design a chart to list them. Include the foods you ate for breakfast, lunch, and dinner, as well as any snacks you had.

Think back to subsection 1.1. Which needs have been met by the foods that you have consumed? Add these needs to your chart.



You and Other Animals Are Food Consumers

Store owners and advertisers often call people consumers. That's because we buy and use goods and services produced by companies or other people. This is the common-language meaning of the word consumer. In science, the word consumer has another meaning. A **consumer** is any organism that has to seek out and eat, or consume, other living things for food. According to this definition, you are certainly a consumer. So is a raccoon, a cat, a moose, a bear, a hyena, a grasshopper, a seal, an elephant, and a praying mantis. In fact, all animals are food consumers.

Scientists often find it helpful to classify consumers based on the kinds of food they eat. Animals like cats, hyenas, seals, and praying mantises, which consume mainly animal food, are called **carnivores**. Animals like moose, elephants, and grasshoppers, which consume mainly plants and plant-like living things, are called **herbivores**. Animals like humans, bears, and raccoons, which consume other animals as well as plants, are called **omnivores**.

Food Consumers Depend on Food Producers

Plants and plant-like living things play a vital role in nearly all ecosystems on Earth. That's because plants can do something that you and other food consumers cannot.

Animals must find food to eat to get the matter and energy they need to survive. Green plants can nourish themselves. Such organisms are known as **producers**. They can make their own food to supply the matter and energy they need to survive.

Figure 2.2 A snake consuming a frog

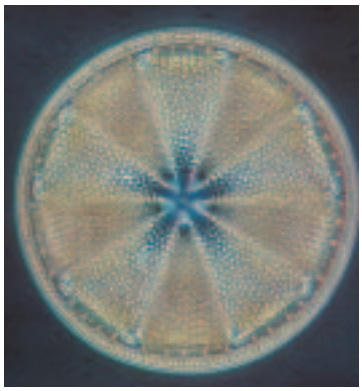


Figure 2.3a) Diatom

Figure 2.3b) Flowering cactus

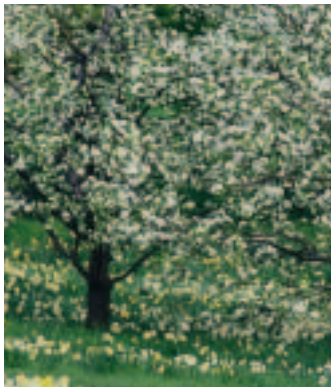


Figure 2.3c) Apple blossom

Figures 2.3a) – c) All these living things are producers. Which do you think are important for land-based ecosystems? Which are important for water-based ecosystems?

The Process of Photosynthesis

Plants need two raw materials to make their food. Raw materials are materials in their natural state. They have not been manufactured, treated, or prepared. The two raw materials that plants need are water and carbon dioxide. Water comes from the soil, and carbon dioxide comes from the air. However, plants also need energy to make their food. Their energy source is the sun.

Plants absorb the sun's energy through their leaves. Inside the leaves, this energy is used to rearrange the particles that make up water and carbon dioxide. Two products result from this rearrangement: food and oxygen. The food is in the form of sugars and starches. These nutrients allow the plant to grow. The oxygen is released back into the air. This food-making process is called **photosynthesis**. Figure 2.4 shows the steps in photosynthesis.

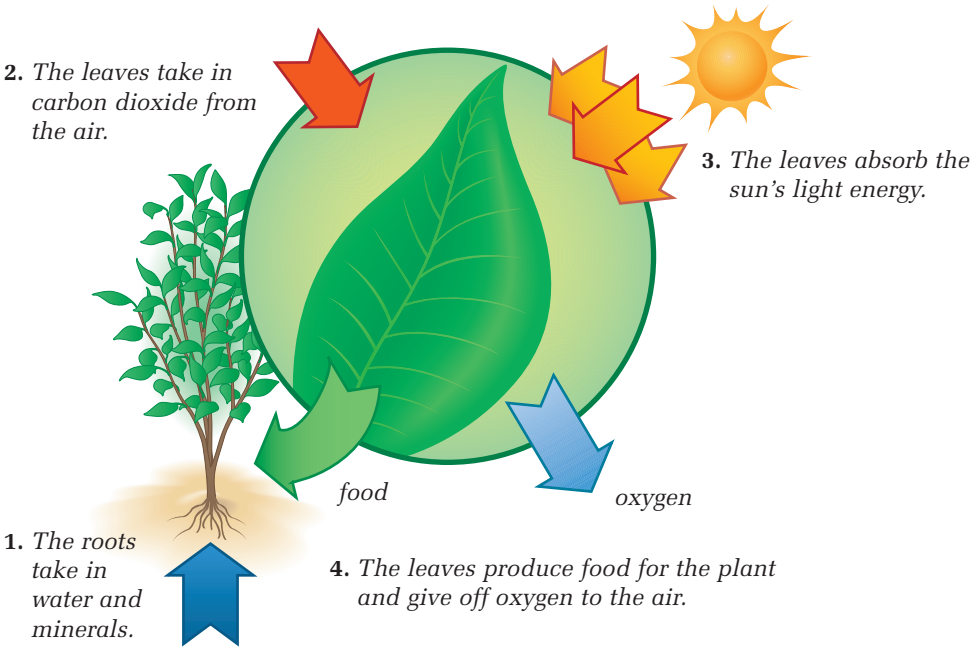


Figure 2.4 The process of photosynthesis

The Importance of Photosynthesis

The process of photosynthesis can also be written as a word equation as shown in Figure 2.5.

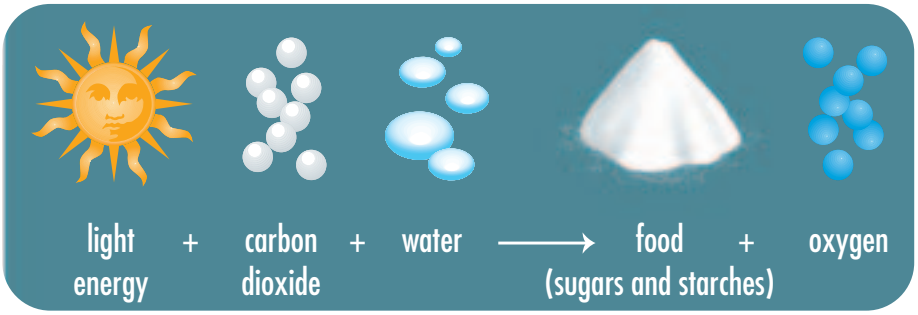


Figure 2.5 Word equation for photosynthesis

This process is important to your life for two main reasons:

- Photosynthesis converts the sun's energy into chemical energy in plants and stores it in the form of sugars and starches. Your body can use this stored energy when you eat plants, plant-based products (e.g., bread), or plant-eating animals.
- Photosynthesis provides the oxygen in the air you breathe.

Photosynthesis also plays an important role in ecosystems. It is the only process that allows other living things in an ecosystem to use the sun's energy. Through photosynthesis, plants produce the food and oxygen that all food consumers need to survive. That's why scientists call plants and plant-like living things *producers*.

Oxygen Is for More Than Just Breathing

You have learned that photosynthesis is important for making food in plants and for producing oxygen. Food is the source of matter and energy that animals and plants need to survive. Both animals and plants need oxygen. That's right—plants need oxygen too.

Nearly all living things need oxygen to release the energy that is stored in their food. **Cellular respiration** is the process responsible for this release of energy. Cellular respiration is a chemical reaction that occurs within the cells of all living things. It combines food and oxygen to produce carbon dioxide, water, and energy. The food is in the form of the sugar glucose. The energy and water are used to carry out life functions. The carbon dioxide is given off (in plants) and exhaled during breathing (in animals). Figure 2.6 shows the word equation for cellular respiration.

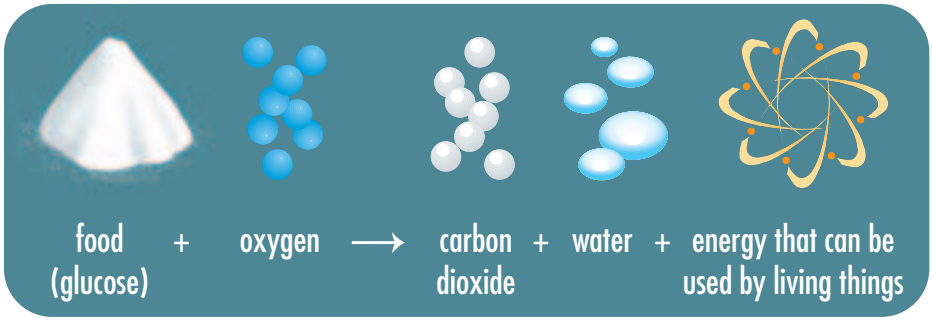


Figure 2.6 Word equation for cellular respiration

A Vital Interaction

You may have noticed a vital interaction that occurs between photosynthesis and cellular respiration. In photosynthesis, plants take in carbon dioxide and water, and produce food and oxygen. In cellular respiration, plants and animals use food and oxygen to produce carbon dioxide and water. The products of one chemical reaction are used by the other. For example, we exhale carbon dioxide when we breathe. We also give off water when we exhale and when we perspire. Plants use this carbon dioxide and water to produce oxygen that we breathe and food that we eat.

A Special Group of Consumers: Scavengers and Decomposers

All living things eventually die. As well, all consumers generate waste materials from the food they eat. Our planet would be littered with dead bodies and waste materials if not for a special group of consumers. These consumers get the matter and energy they need from wastes and dead plants and animals. Some of these consumers are **scavengers**. Others are **decomposers**.

Scavengers are consumers that don't usually kill for their own food. Instead, they feed off the remains of living things that are killed by other consumers. Crows, ravens, and housefly larvae (maggots) are examples of scavengers. Can you name two more? Decomposers are consumers that break down (decompose) dead plants and animals. They also break down animal waste materials. Fungi such as mushrooms and the mould you see growing on bread, fruits, and vegetables are decomposers. So are many kinds of bacteria.

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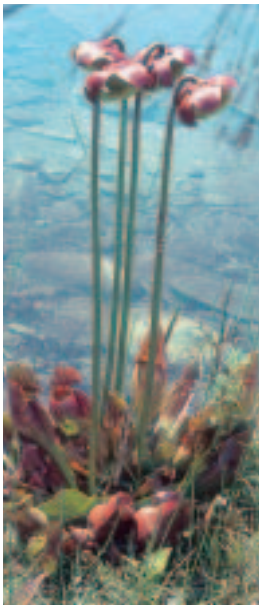
A Carnivorous Plant!
The pitcher plant eats insects such as grasshoppers and snails. Find out where it lives and how it "eats" its prey.



Decomposers Can Be Helpful or Harmful

Helpful or harmful? Baker's yeast—single-celled decomposers. They feed on sugars that are naturally present in foods such as grains and fruits. The carbon dioxide that they emit, or give off, is a by-product that bakers count on to make breads and pastries rise.

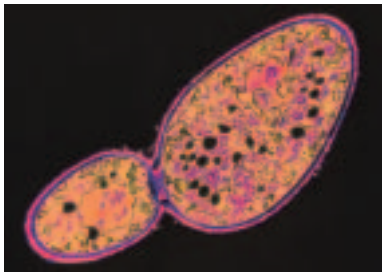


Figure 2.7a) Baker's yeast

Figure 2.7b) *E. coli*

Helpful or harmful? *E. coli* (short for *Escherichia coli*—bacteria found in your large intestine. They break down nutrients in the food you eat for their own food. In the process, they manufacture several vitamins that your body needs to stay healthy.

Helpful or harmful? *Candida albicans*—a kind of yeast found in the moist mucus or mucus-producing areas of your body, such as your throat and mouth. When the body's immune system is weak, these decomposers can grow and reproduce rapidly. This results in a disease called thrush. It is characterized by raised white spots, usually on the tongue or inner cheeks of the mouth.

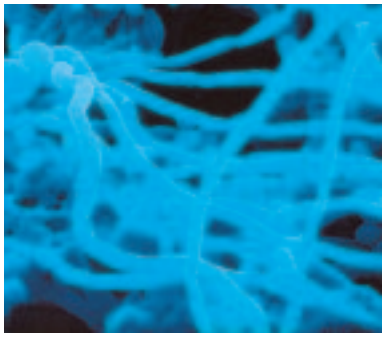


Figure 2.7c) *Candida albicans*

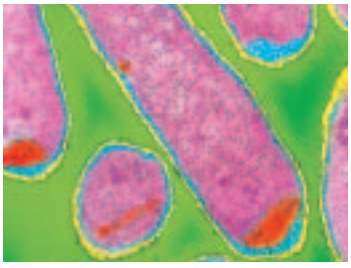


Figure 2.7d) *E. coli bacteria 0157:H7*

Helpful or harmful? *E. coli bacteria 0157:H7*—a form of *E. coli* sometimes found in common food products such as ground beef, milk, and apple juice. When these decomposers break down food, they produce highly toxic chemicals that can cause food poisoning.

Helpful or harmful? Nitrogen-fixing nodules—round swellings on the roots of some plants that are home to millions of bacteria. The bacteria make nitrogen available to the plant, and in return, the bacteria get their nutrients from the plant.

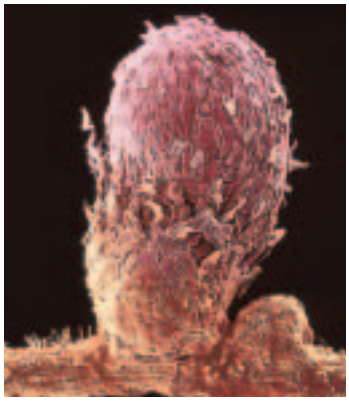


Figure 2.7e) Nitrogen-fixing nodules

Decomposers Are Essential to All Ecosystems

Decomposers keep us and other living things from being buried in dead bodies, dead plant parts, feces, and urine. It's funny to think about it that way, but it's true! However, decomposers are more than just nature's "clean-up crew." Their actions mean that plants always have a supply of nutrients available to them. In fact, decomposers act like a bridge that connects the biotic factors of ecosystems to the abiotic factors.

Check and Reflect

1. Compare the role of producers and consumers in ecosystems. How are they related? How are they different?
2. Plants can make their own food through photosynthesis to supply the matter and energy they need to survive.
   a) What are the raw materials for photosynthesis?
   b) What are the products of photosynthesis?
   c) Name a process in plants that uses oxygen. Compare the raw materials and products of this process with those of photosynthesis.
3. Write a poem or descriptive paragraph describing producers or what producers do in ecosystems.
4. Create a Venn diagram to show helpful and harmful decomposers.

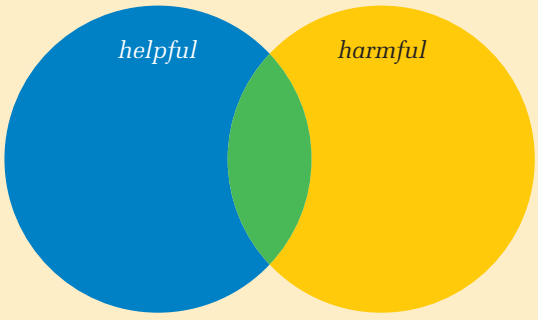


Figure 2.8 A Venn diagram

List the decomposers in the appropriate parts of your diagram. Decomposers that are both helpful and harmful should go in the overlapping section of the circles.

Continued on next page →

Check and Reflect

5. Which of the organisms shown below are scavengers and which are decomposers? Explain your choice for each organism.

Figure 2.9a) Millipede

Figure 2.9b) *Russula rosacea* mushroom

Figure 2.9c) Turkey vulture

Figure 2.9d) Wolverine

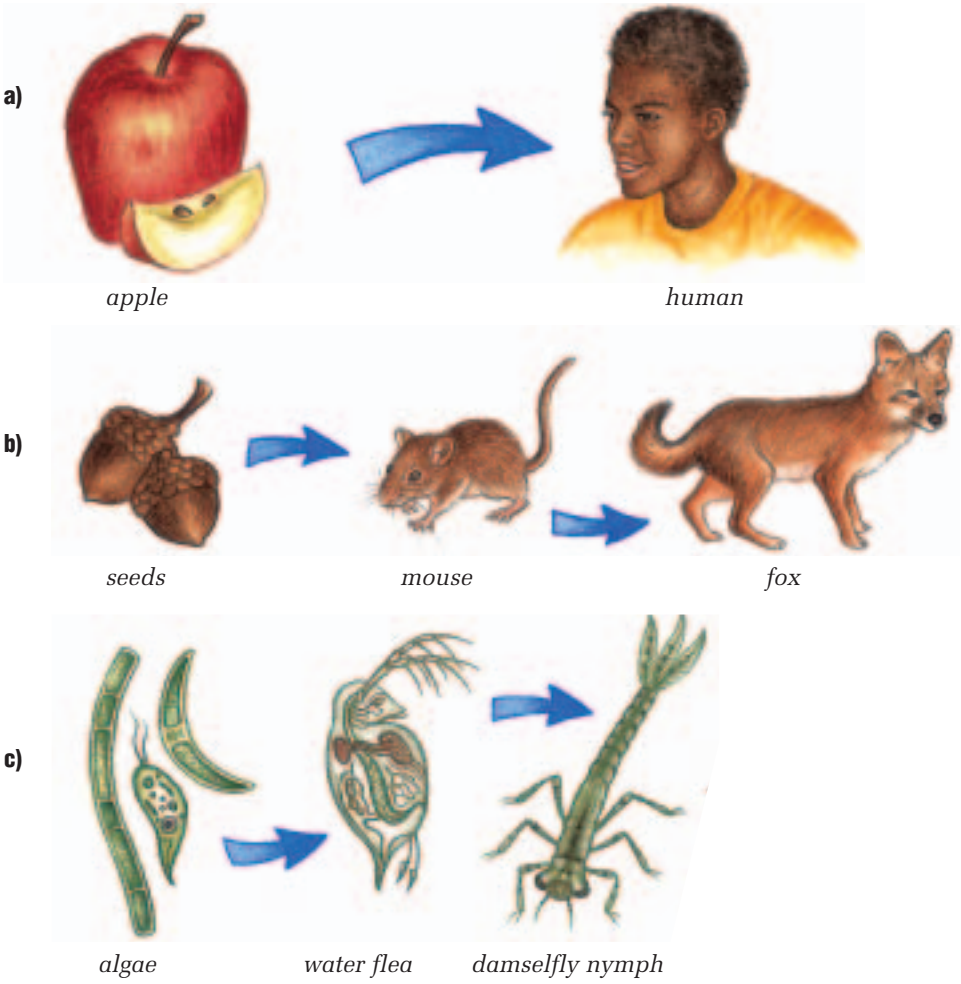
Figure 2.9e) Earthworm

Figure 2.9f) Cinnabar red polypore fungus

6. What similarities do you notice about the word equations for photosynthesis and cellular respiration? What are the differences? Make a table comparing the two.

2.2 Food Chains Demonstrate the Flow of Energy in Ecosystems

In general, food and energy in an ecosystem flow from the producers to the consumers. A **food chain** is a convenient way to show how energy moves among living things in an ecosystem. Here are a few examples of food chains.



Figures 2.10a)–c)
Three food chains

A food chain starts with the original food source: a producer. Then an arrow points to a consumer that eats that producer. In many cases, a primary consumer may, in turn, point to other secondary consumers. An example of a primary consumer is a herbivore, and an example of a secondary consumer is a carnivore that feeds on a herbivore, but not another carnivore. Notice that some food chains can be quite short, while others are longer. In Figure 2.10a)–c) above, which is the primary consumer? Which is the secondary consumer?

Give it a **TRY** **Activity**

Where Did That Food Come From?

Think of something you ate in the past day. Write it down near the right edge of a sheet of paper. Draw an arrow pointing to this food.

Decide what living thing was used to make or feed the food you ate. For example, if you had a piece of cheese, the source of the cheese might have been milk from a cow. Write this food source to the left of the arrow, as shown here.

→ cow → cheese

Draw another arrow pointing to this source. In this example, you could put grass to show that the cow ate grass to produce the milk. Keep adding arrows until you are not sure what the next step in the flowchart might be.

Repeat this process for five other food items.

When you have finished, review your flowcharts and look for similarities or patterns. Using this information, answer this question: What food sources do I seem to depend on for all the foods I eat?

Energy Flow in Ecosystems

Most ecosystems on Earth get their energy from the sun. Through photosynthesis, plants provide a way for other organisms in an ecosystem to use the sun's energy. This makes plants essential to almost all ecosystems. Plants play such an important role as producers that there are usually many more plants in an ecosystem than there are consumers. Within the consumers, there are usually more herbivores than carnivores in an ecosystem.

Figure 2.11 is an example of what happens to energy in an ecosystem. Light energy from the sun is used by plants in photosynthesis to make food. The food contains chemical energy that plants use for their life functions. A plant uses as much as 90% of the energy it gets from its food to support its life functions. The rest—or only about 10%—is stored as nutrients in the plant's roots, leaves, and other parts. So only about 10% of the plant's energy is available to the herbivore that eats the plant. The herbivore then uses as much as 90% of the energy from its food to support its life functions. A large part of this energy is given off as body heat. This leaves 10% as stored energy for a carnivore to eat.

Figure 2.11a) Plants use sunlight to make food to store and use for their life functions.

Figure 2.11b) A rabbit eats the plants and stores the food in its body. The rabbit's body changes some of the food into energy for its life functions.

Figure 2.11c) The predator eats the rabbit and uses the energy gained to carry out its life functions.

You can see that much of the energy doesn't get passed from one living thing to another. The largest percentage of energy is used for body heat, which just escapes into the environment. Other plants and animals cannot use this energy. The energy is not "used up"—it still exists. But it is now in a form that other plants and animals can't use.

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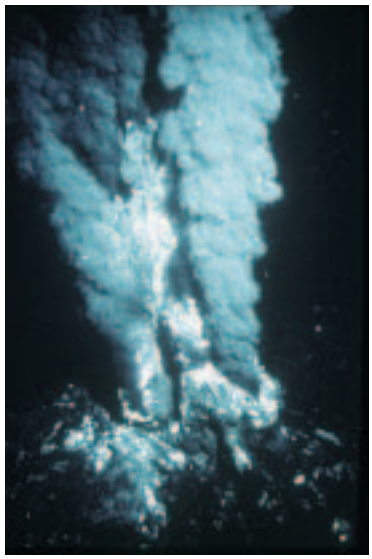
Deep-Ocean Community

Scientists once thought that all life on Earth depended on the sun's energy. Then, in 1977, a crew of scientists on board a deep-sea submarine made a discovery in the Pacific Ocean. They found an ecosystem 2.5 km below the water's surface in cracks along the ocean's floor, where the sun's rays cannot reach. Heat energy from inside Earth creates warm areas in the normally frigid water. Bacteria live in these waters. They are the producers for food chains that include unusual aquatic herbivores and carnivores.



Black smokers

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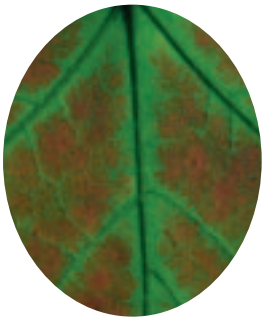
Why Do Autumn Leaves Turn Colour?



What happens to the green-coloured chlorophyll in plants in autumn? Why do leaves change colour before they fall off a tree? Research what happens to leaves every autumn. Write a paragraph explaining what you have learned.

Energy, therefore, is not recycled in an ecosystem. It follows a one-way path. In each ecosystem, producers depend on a constant supply of energy from the sun to survive. Herbivores depend on plants, and carnivores depend on herbivores for their energy. Finally, scavengers and decomposers depend on everyone else for the energy they need. Figure 2.12 is another way of representing the flow of energy through an ecosystem.

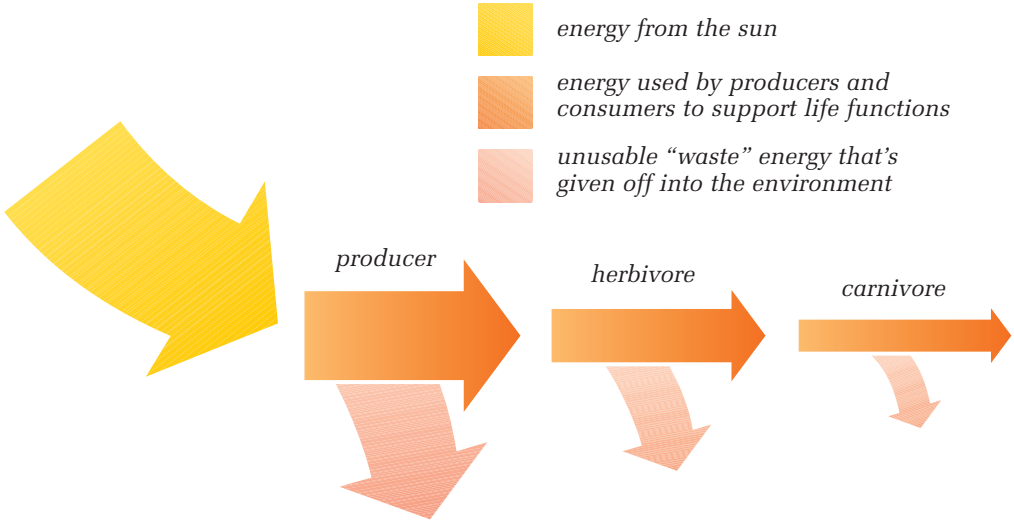


Figure 2.12 A plant uses much of the energy it gets from its food to support its life functions. The rest is stored as nutrients in its roots, leaves, and other plant parts. That leaves very little energy available to a herbivore that eats the plant. The herbivore also uses much of the energy from its plant food to support its life functions. What do you think that means for a carnivore that eats the herbivore?

Check and Reflect

1. What is the difference between the energy used in photosynthesis and the energy used in cellular respiration?
2. What happens to the energy in cellular respiration not used to support life functions?
3. In terms of the flow of energy through an ecosystem, which is the correct order for each of the following situations?
   a) rabbit, sun, rose, wolf, earthworm
   b) seaweed, sea urchin, otter, sun, bacteria
4. Provide an example of how a plant or animal stores nutrients.

2.3 Food Webs

You have been using food chains to help you understand how all living things are connected with one another. However, food chains are simplified ways of showing these interactions.

In real ecosystems, there are usually many carnivores, many more herbivores, and many, many more producers—and there are countless decomposers. In real ecosystems, there can be dozens, hundreds, or even thousands of different food chains. Each living thing is a part of many food chains. Many of these food chains are linked. If you link food chains in an ecosystem, you get a **food web**.

Food Webs and Ecosystems

Changes in either the abiotic or biotic factors affect the members of the food web. These changes can have a great effect on living things in an ecosystem.

infoBIT

Size and the Food Chain

Larger animals are not necessarily higher on the food chain. For example, herbivores, which are primary consumers, include small animals such as grasshoppers, and large animals such as elephants.

Give it a TRY **Activity**

Disappearing Organisms

Food webs are made up of a wide variety of living things. If you were to count the number of organisms in a typical food web and graph the results, this is what the graph might look like.

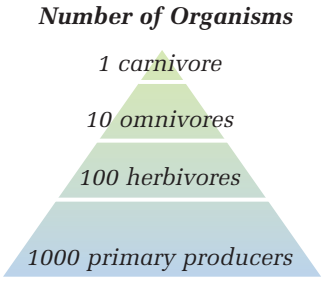


Figure 2.13 A food web pyramid

Suppose that one type of living thing were to disappear from an ecosystem. Which type do you think would have the greatest impact on the other living things? the least impact?

Write a paragraph or create a table identifying what would happen if one of the groups of organisms were removed.

Inquiry Activity

Food Web Chain Reaction

The Question

How do abiotic and biotic factors in the forest ecosystem affect the complete food web of the forest?

Materials & Equipment

- 30–40-m length of strong string or yarn, or light rope
- "forest identity" cards

Figure 2.14 The forest ecosystem

Procedure

Part 1 Modelling a Forest Ecosystem

1. In this activity, you will be creating a model of some interactions that can occur in a forest ecosystem. Using this model, you will investigate the impact of various situations on the ecosystem.
2. Your teacher will hand out a forest identity card to everyone in your group. When you get your card, quietly think about your new identity and how you fit into a forest ecosystem. Think of the role you play in the forest. Think of a part of the forest (biotic or abiotic) that depends on you. Think of a part of the forest that you depend on or use. One person in the group will be assigned the task of recorder.
3. Your teacher will give someone in your group a ball of string. That person may be you. While holding onto one end of the string, you will pass the ball to another person who has a role in the forest that depends on or uses you.
4. As this person receives the ball, he or she explains the relationship to you. The recorder sketches the connection between the two factors (you and the other person).
5. Repeat steps 3 and 4 until all members of your group are connected by the string. Some members may be connected more than once. You now have a model of some of the interactions that occur in a forest ecosystem.

Part 2 Impacts on the Forest Ecosystem

6. Once everyone is connected, find the person who is water. Pretend that there's a drought this year, so there's very little water for the forest. The water person should tug gently on the string. Do you feel the tug? Does anyone else in the circle feel the tug?
7. Repeat the process followed in step 6 for each of the following situations:
   a) Disease has killed the foxes.
   b) Too many trees have been cut down.
   c) The air has become heavily polluted.
8. If you wish, make up some of your own situations to test. When you've finished, answer the following questions.

Analyzing and Interpreting

9 When the water person tugged on the string, how many people felt it? Did this surprise you? Why or why not?

10 In the other situations, how many people felt the tug? Again, did this surprise you? Why or why not?

11 a) Make a sketch of the forest ecosystem that you were part of in this activity. (See the partially completed diagram, Figure 2.15.) You might want to use different colours for some of the connections. If you like, add any other living things that you want to include.

b) Label all the biotic and abiotic factors. Then draw lines to connect all biotic parts of the ecosystem into a food web.

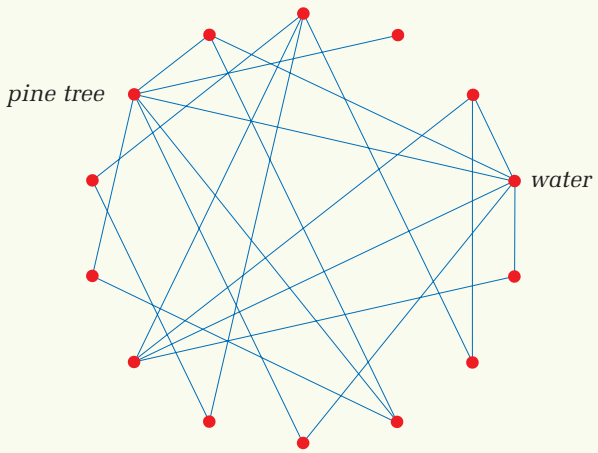


Figure 2.15 A sketch of the forest ecosystem, partially completed

Forming Conclusions

12 Summarize this activity by answering the following:

a) What do you think are the most important things about food webs?

b) What did you learn about food webs that you didn't know before?

c) What is one thing about food webs you would like to know more about?

Applying and Connecting

In late February 2000, floods devastated much of southeastern Africa. Mozambique was one of the places hit the hardest. Floods destroyed much of the crops and left hundreds of thousands homeless. Research what is presently happening in Mozambique. How did the Mozambicans recover from the flood?

Meadow Food Web

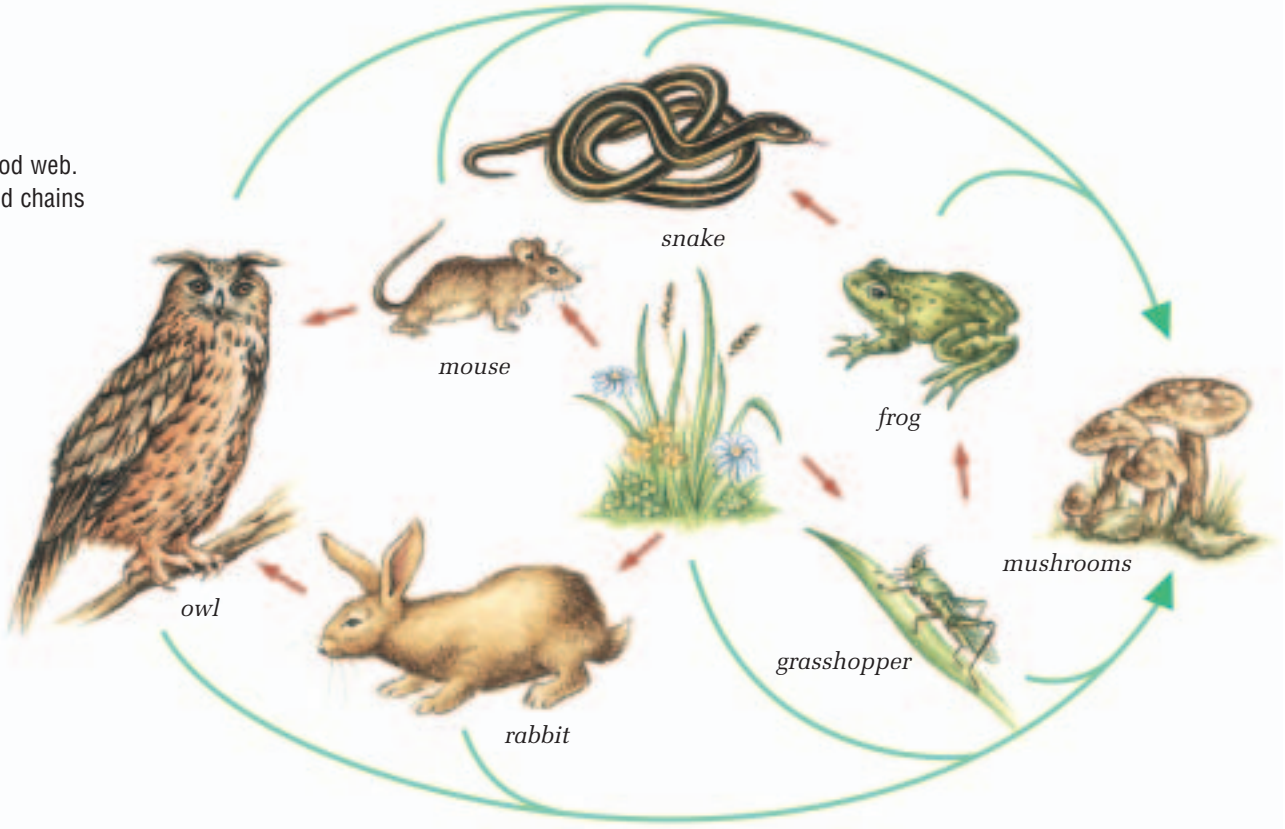


Figure 2.16 A food web. Describe two food chains in this web.

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Earthworms and Ecosystems

Earthworms are an important part of many ecosystems. Use print or electronic resources to find out why. What would happen if all the earthworms in a lawn or field disappeared? Write a report, design a poster, or prepare a multimedia presentation to share your discoveries.

Study this food web of a meadow community. The dark-coloured arrows show the direction in which energy and nutrients are being passed in the food chain. You can find the food chains that make up this food web by starting with the plants and grasses in the middle of the picture. Then, follow the dark-coloured arrows until they end. When any of the organisms in the food web die, the decomposers will break them down, and the cycle will start again. The light-coloured arrows show how energy and nutrients are being passed to the decomposers.

But what would happen if the number of grasshoppers changed? If the number increased, then more grass and plants would be eaten. This would mean less grass and plants would be available for the mice and rabbits. With the increase in the number of grasshoppers available, the number of frogs might increase. However, when the number of grasshoppers decreases again, the frogs would not have enough food, and some would starve. As you can see, each part of the food web depends on the other parts. If one part changes, the rest of the web also changes in some way.

Check and Reflect

1. Think of a food web in a forest that contains trees, foxes, rabbits, mushrooms, and ferns.
   a) Create a food web that would use all of the above organisms.
   b) Add yourself to this web and redraw the food chains to include you.
2. Think about a forest food web and a desert food web. List three differences and three similarities between the food webs.
3. Compare a forest food web with a food web in any other ecosystem of your choice. How are they different? How are they similar?
4. a) Think of a park or other green space. Name two producers, two herbivorous consumers, and two carnivorous consumers that you would find in this ecosystem.
   b) Explain how these living things are related to one another.
   c) Would you expect to find scavengers and decomposers in a park ecosystem? Why or why not?
5. Here are components of a Northern food web. Draw a food web using each component.

Figure 2.17a) Mink

Figure 2.17b) Sandhill crane

Figure 2.17c) Wood frog

Figure 2.17d) Pike

Figure 2.17e) Shiners

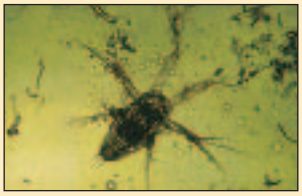


Figure 2.17f) Plankton

Figure 2.17g) Mayfly larva

Figure 2.17h) Mallard

2.4 Matter Cycles in Ecosystems

You have learned that energy flows in ecosystems, and can show that energy flows through food chains and food webs. Both matter and energy are abiotic factors. Both are required for ecosystems. Together they influence all areas of the ecosystem. Now you will investigate how water and carbon cycle through ecosystems. Study the pictures and read the captions on this page. What does the information presented say about what happens to matter in ecosystems? Write a paragraph that summarizes what you think these pictures are telling you.

Figure 2.18a) Sunlight, soil, and water from the abiotic environment provide plants with what they need to grow and live their lives.

Figure 2.18b) Plants serve as food for herbivores. The herbivores can sometimes serve as food for other consumers.

Figure 2.18c) Plants and animals grow, reproduce, produce wastes, and in time, die.

Figure 2.18d) Scavengers and decomposers feed on the wastes and remains. This process breaks down once-living matter into smaller, simpler particles. In time, even solid skeletons are broken down.

Figure 2.18e) Skeletons are made up of chemicals such as calcium, phosphorus, and carbon. These chemicals (minerals) are nutrients that other living things (such as plants) need to survive. Mineral nutrients are non-living, so they are part of the abiotic environment.

Water and Carbon Cycles

You are made up of matter. So are all living things and non-living things. The matter that makes up all living and non-living things on Earth has been here for several billion years. On occasion, a meteorite or a comet has struck our planet. When this happens, matter from outer space is added to our planet. For the most part, though, all the matter that exists here today has been here for a long, long time.

So where does the matter that living things need come from? Matter continually moves from the abiotic environment (non-living things) to the biotic environment (living things) and back to the abiotic environment. This over-and-over-again movement of matter is referred to as a **cycle**.

There are many cycles of matter in nature. In each of these cycles, matter is used by living things and then returned to the abiotic environment to be used again by living things. The diagrams below and on the next page show two important cycles of matter: the **water cycle** and the **carbon cycle**.

*info*BIT

Raindrops Keep Falling on My Head

Scientists, using high-speed cameras, have discovered that raindrops are not tear-shaped. They actually look like the shape of a small hamburger bun.

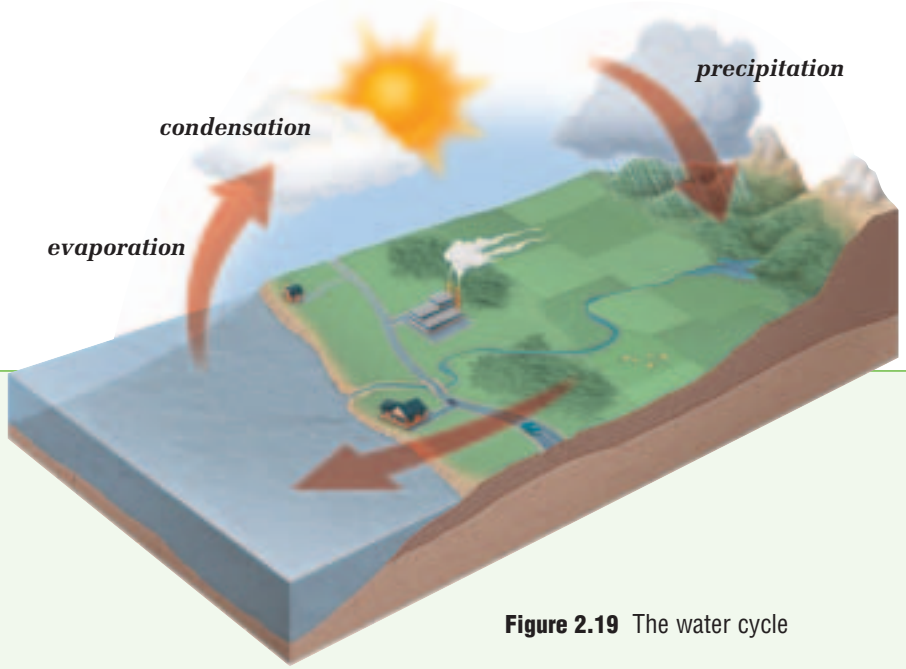


Figure 2.19 The water cycle

Three main processes are responsible for the water cycle: evaporation, condensation, and precipitation.

- According to this diagram, what sources add water vapour to the atmosphere?
- What happens to the water that falls back to Earth?

Heat from the sun causes water in bodies such as oceans, rivers, and lakes to evaporate (change from liquid water to water vapour). Water vapour condenses into clouds. It returns to Earth in the form of precipitation (rain, hail, and snow).

Fuel-burning factories and motor vehicles add water vapour (steam) to the atmosphere. People and other animals drink water. They give off water vapour into the atmosphere whenever they exhale or perspire. Plants take in water from the soil through their roots. They give off water vapour.

RESEARCH

Cycles of Matter

There are cycles of matter for other substances living things need, such as nitrogen, phosphorus, and sulphur. Choose one of these substances to investigate further. Find out why the substance is important for living things and how it is cycled in nature. Present your findings in the form of a diagram similar to the water cycle or carbon cycle diagrams.

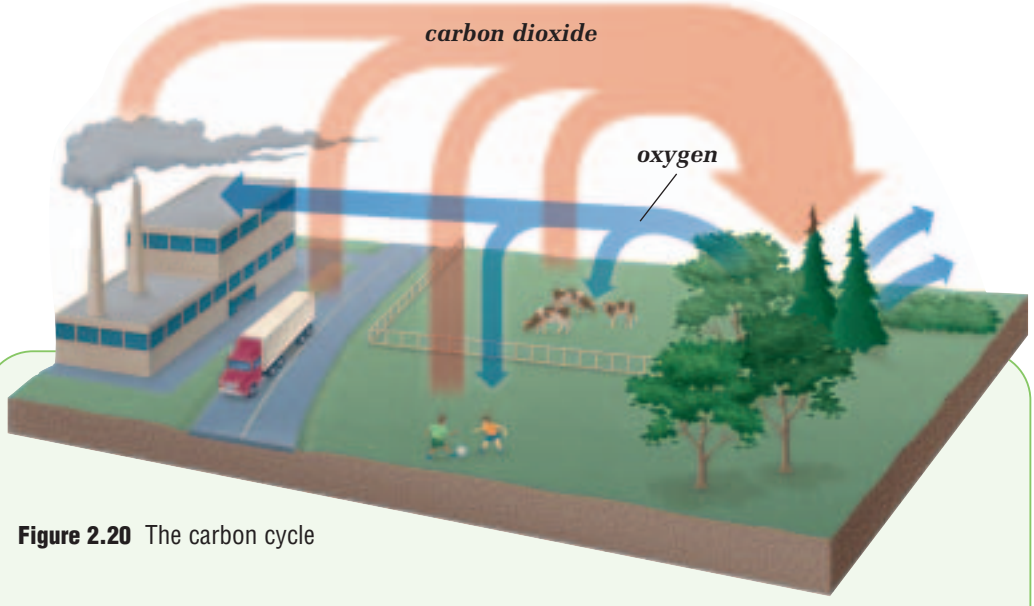


Figure 2.20 The carbon cycle

The carbon substances may, over millions of years, change to become fuels such as coal, oil, and natural gas.

- According to this diagram, what sources add carbon dioxide to the air, water, and soil?
- What happens to the carbon dioxide?

Animals use oxygen in combination with food to release the energy they need to survive. (This is called cellular respiration.) This process gives off carbon dioxide as a by-product. Animals on land add carbon dioxide mainly to air. Animals in bodies of water add carbon dioxide mainly to water. Plants take in carbon dioxide from the atmosphere and water from the soil. Photosynthesis transforms these substances into food and oxygen. Fuel-burning factories and motor vehicles add carbon dioxide to the atmosphere. Decomposers add other forms of carbon to the soil and to water.

CHECK AND REFLECT

1. The following statements have to do with the carbon cycle. Put them in order. Hint: Begin with carbon in the form of oil being found underground.
   a) A car fuel tank is filled up with gasoline.
   b) Plants die and are put in a composter.
   c) Driving the car burns the fuel; this creates exhaust gases including carbon dioxide.
   d) Decomposers in a composter add carbon to the soil.
   e) Oil is pumped from the ground and refined into gasoline.
   f) Plants combine carbon dioxide from the air with water to create food and oxygen.
2. Describe the cycle water goes through, from evaporating from a lake to returning to the lake. Your description should include the following words: evaporation, condensation, precipitation, clouds, plants, roots, animals, soil, and cars.

Careers and Profiles

Naturalists—Our Environmental Watchdogs

Do you want to know more about preserving and protecting the natural environment? If so, you can become a naturalist. These are people interested in protecting endangered species, preserving animal habitats, reducing pollutants that affect ecosystems, and other environmental issues. While many naturalists have a background in science, some are just concerned citizens. Here are two examples of people who didn't start out studying science but who had a great influence on the environment.

Figure 2.21 Jack Miner (1865–1944) was a farmer who became one of Canada's first naturalists. He set up bird sanctuaries and did research on bird migration.

Figure 2.22 Even though Jane Goodall (1934–) has no formal science training, she has become world famous for her research on chimpanzees. She later received a Ph.D. from Cambridge University in England without first having earned an undergraduate degree.

Ethnobotanists

Figure 2.23 The inner bark of the red-osier dogwood shrub is used to heal sores and swellings.

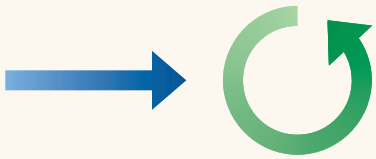
Figure 2.24 Canadian ethnobotanist Nancy Turner works with plant specialists like Mary Thomas, a Shuswap elder.

What do leukemia, high blood pressure, diabetes, multiple sclerosis, and cerebral palsy have in common? They've all been treated with drugs that have originally come from plants. In fact, about one-quarter of today's prescription drugs have been developed from plants.

There are probably even more treatments in ecosystems just waiting to be discovered. Unfortunately, finding them is very difficult and costly. That's where an ethnobotanist comes in. Ethnobotanists study Aboriginal cultures to find out how their people use plants. They work closely with plant specialists and elders of Aboriginal communities.

1. Why do ethnobotanists work with Aboriginal peoples? Why do you think this is a good idea?
2. Why is it important to preserve and protect the natural environment?
3. How could you start a naturalist club in your school? What people outside the school would you like to contact to help you get started?

Assess Your Learning



1. a) Which of the arrows at right describes the path that energy moves in ecosystems?

b) Which describes the path that matter moves in ecosystems?

c) Give reasons to explain your answers to a) and b).

2. Figure 2.25 shows a typical food web.

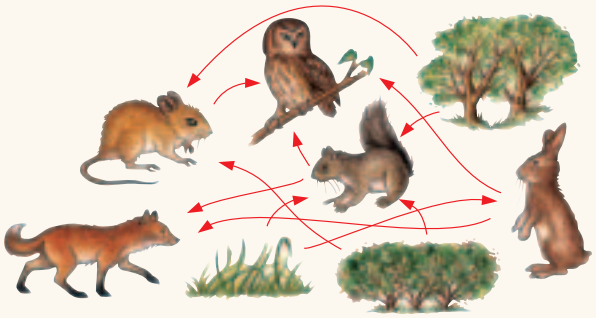


Figure 2.25 Question 2

a) Name an ecosystem in which you would find a food web like this.

b) Identify at least three food chains in this food web.

c) Why does a food web give a more realistic picture of the interactions in an ecosystem?

d) How is energy supplied to and through this food web?

3. Describe a change in an ecosystem that would affect plants and animals living there. What are the positive and negative effects of this change?

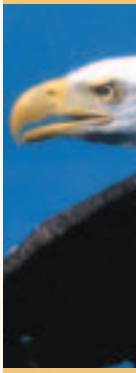
4. What would happen if matter in the abiotic environment wasn't recycled? How do you know?

5. What would happen if an ecosystem's supply of sunlight was removed? How do you know?

6. Compare and contrast two similarities and two differences of carbon and energy in ecosystems.

7. The list below shows typical producers and consumers you would find in a pond ecosystem.

algae
bladderwort
bullrush
deer
dragonfly
duckweed
fish
fox
frog
heron
mosquito
reed sweet grass
roundworm
spider
toad
water flea
water horsetail
water lily
wolf



a) The list is in alphabetical order. Reorganize it to make two lists: one showing all the producers and the other, all the consumers. (If you aren't sure what some of these living things are, make an inference, or look them up in a reference such as an encyclopedia.)
b) Construct as many food webs as you can using the living things in your lists.
c) Choose two of your food webs. Explain how energy flows through them. How is matter recycled in these food webs?

8. How do you think the number of producers in an ecosystem usually compares with the number of herbivores? (In other words, are there more producers than herbivores, or fewer?) How do you think the number of carnivores compares with the number of herbivores? Give reasons to support your answers.

Focus On — Social and Environmental Context

Consider how science and technology provide opportunities for many diverse careers, hobbies, and interests, and for meeting personal needs. Think about how this relates to the work done in this section and your project at the end of this unit.

1. Why do you think information on energy flows in ecosystems might convince a city to have more parks?

2. What personal needs and environmental concerns should be considered when designing a land use plan?

3. How might understanding the cycling of water and carbon be important in developing a land use plan?

4. What types of careers are related to the water and carbon cycles?

5. Use the following examples to demonstrate how people can affect energy flow and the cycling of matter in an ecosystem:
a) A developer fills in a wetland to build houses.
b) A farmer plows a natural grassland to plant a crop.
c) A town changes the drainage system in an ecosystem to reduce flooding.
d) A logging company cuts down trees over a large area.
e) A city builds roads.

3.0

Changes can be observed and monitored in ecosystems.

Key Concepts

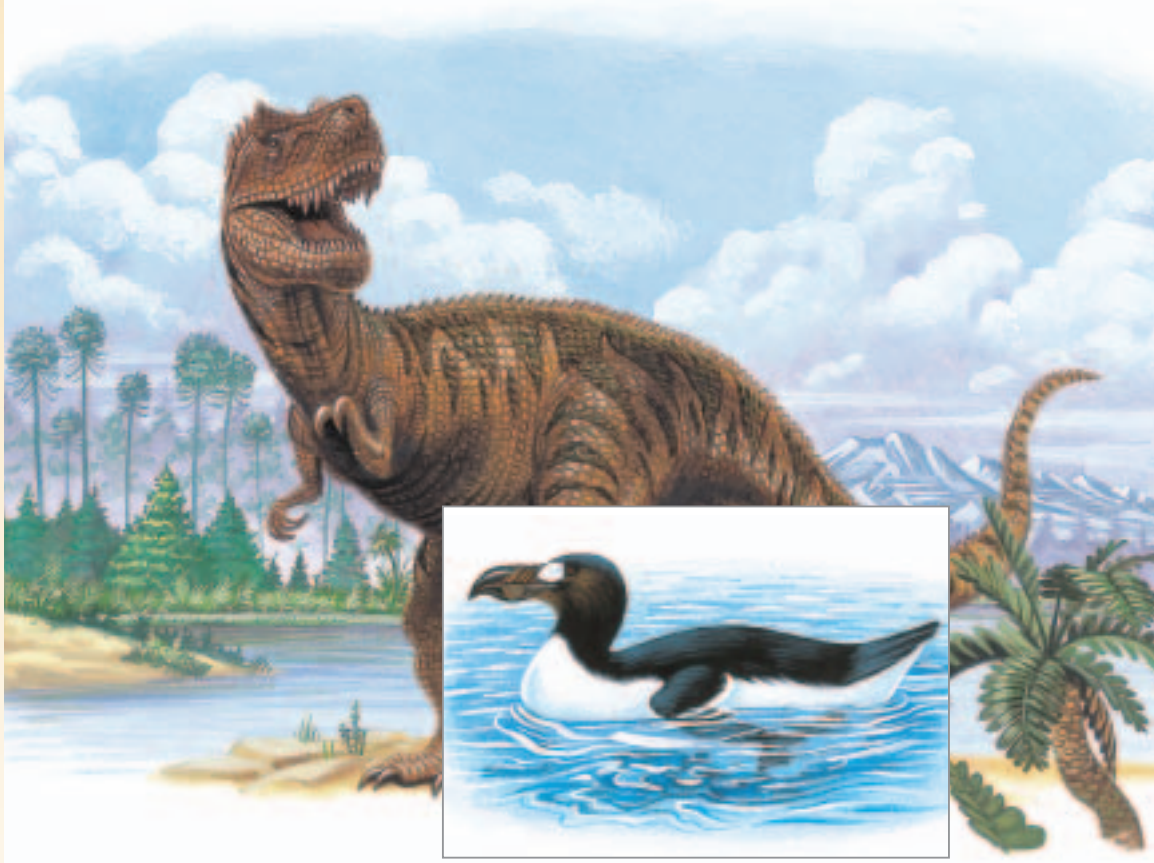
In this section, you will learn about the following key concepts:

- interactions and interdependencies
- environmental monitoring
- environmental impacts
- species distribution
- succession

Learning Outcomes

When you have completed this section, you will be able to:

- recognize the distribution of living things in an environment
- recognize interactions and changes in ecosystems
- identify succession in ecosystems



These two animals once roamed our planet. Now they're both gone. The last *Tyrannosaurus rex* died about 65 million years ago. A dramatic, natural change in its ecosystem may have led to its death. The last great auk died around the year 1844. Its ecosystem changed forever with the arrival of Europeans. Overhunting by humans led to its death. Ecosystems are always changing. Sometimes these changes are natural. Drought or floods can cause massive, long-term changes to ecosystems. Sometimes these changes are the result of human activity. Building dams and clearing forests can cause great, long-term changes to ecosystems. What kinds of changes do you think drought, floods, dams, and forest-clearing cause? How do these changes affect living things? How do you think these changes can be measured and monitored?

For Web links relating to 3.0, visit **www.pearsoned.ca/scienceinaction**

3.1 Investigating the Distribution of Living Things in an Environment

Think about your schoolyard or a local park for a moment. Changes continue to happen in both these areas. They may not be as dramatic as the extinction of the dinosaurs or dealing with the after-effects of a flood or drought, but they are still changes. Have you noticed any changes in your schoolyard or local park? How do you know that changes have occurred?

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Help with Counting

One way that scientists estimate the distribution of living things in an area is by a technique called sampling. Sampling is used when it is too difficult to count each living thing.

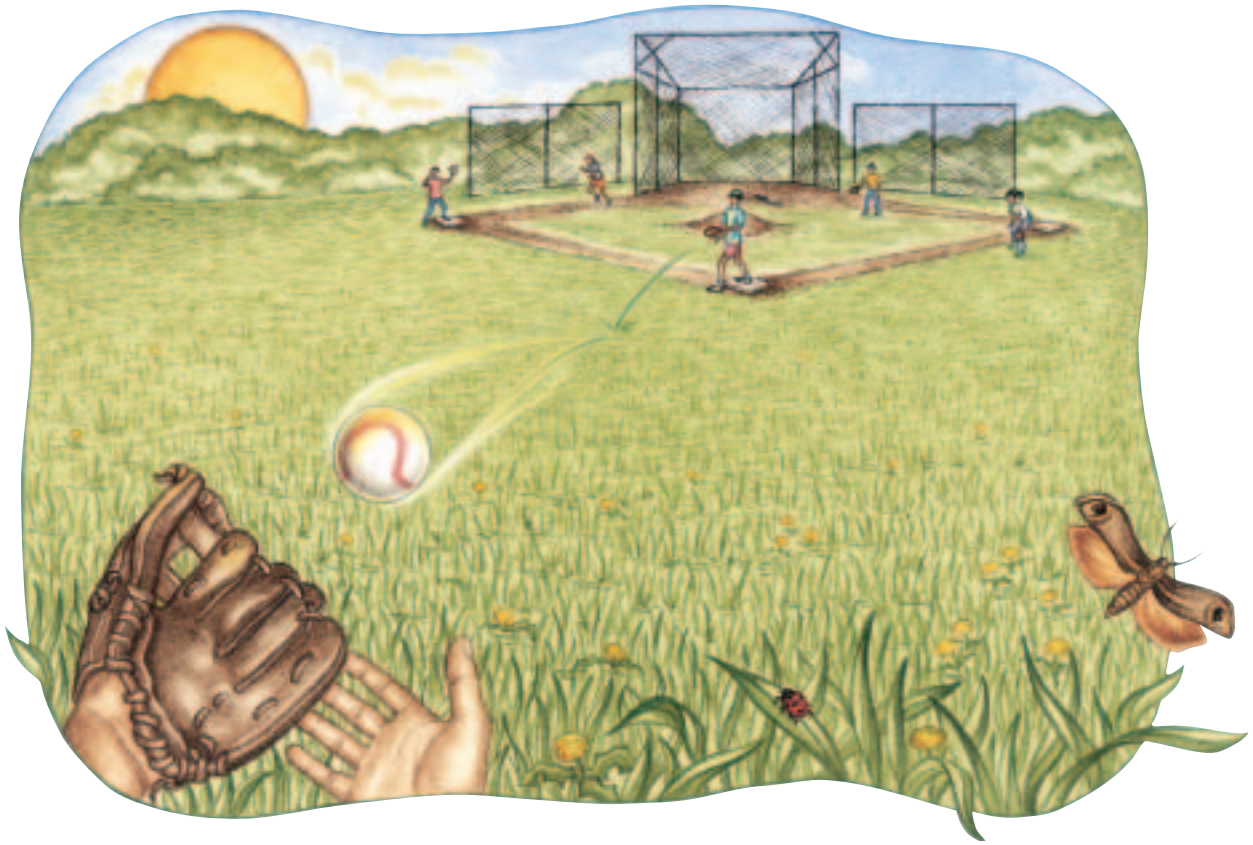

Figure 3.1 The distribution of living things in a park

Distribution of Living Things

If you look closely at your schoolyard or a local park, you are likely to see differences even within this small area. Perhaps there are more dandelions, grass, or daisies in one section, or perhaps there are more ants in another section. The distribution of living things may be different from one area to another. Think about why this is true.

Inquiry Activity

Human Impact in the Schoolyard

The Question

Has human impact affected the distribution of living things in the schoolyard ecosystem?

Materials & Equipment

- 8 metal or plastic tent pegs
- 2 pieces of string, each about 4 m long
- tape measure or metre-stick
- thermometer
- anemometer
- classification key for local plants and animals

Caution!
Do not remove the organisms or disturb the environment. Leave it as you found it.

The Hypothesis

Restate the above question in the form of a hypothesis. (See Toolbox 2 if you need help with this.)

Procedure

1. Go into the schoolyard. Look for two places: one that appears to be affected by human impact, and one that appears not to have been affected by human impact. Areas that appear to be affected by human impact might include an area on the soccer or baseball field, or in the playground. Make sure the places you choose are the same size and have similar abiotic conditions of light intensity and soil type.
2. Use the metre-stick to measure an area of 1 m by 1 m in a place of little or no human impact. Tie a length of string around the pegs to outline the square.
3. Draw a sketch of all the living (biotic) and non-living (abiotic) things inside the square. Count all of the individual plants that are growing inside the square. Count the animals that you see as well. Plants that are right under the string only count if more than half of the plant is inside the square. Do any of the abiotic or biotic factors cover a large area of your square? Estimate and record the percentage of your square covered by the factor(s).
4. Use your classification key to identify anything you do not recognize.
5. Repeat the procedure in another place with similar abiotic factors, but one where it appears that there has been human impact.

math Link

This staked-out area is known as a **quadrat**. Quadrats can be square, rectangular, or circular in shape. Studying the area in a quadrat is called quadrat analysis.

Collecting Data

6 Use the following table to record the data that you have gathered during your investigation.

Schoolyard Observations		
	Place with Little or No Human Impact	**Place with Human Impact**
date and time		
temperature		
wind speed		
light intensity (bright, shady)		
soil condition (dry, wet)		
number and type of plants observed		
number and type of animals observed		

Analyzing and Interpreting

7 Why did you try to choose two places that had the same abiotic factors, except human impact?

8 What type of graph would best display the biotic factors found in each place? Use it to graph each place.

9 What differences did you see in the biotic factors present in each place that you identified?

10 Did human use impact the biotic factors in this investigation? Why or why not?

Forming Conclusions

11 Think about the places that are most frequently used in the schoolyard. Does your data prove that human use has affected the number and distribution of living things in your schoolyard? Why or why not? What information would you gather to determine how much each place is impacted by humans?

Applying and Connecting

Ecologists use quadrat analysis to gather data about the location of plants and animals and their living conditions. Quadrat analysis can also be used to advise how a given area can be maintained or improved.

Extending

The ideal size of a quadrat is the smallest size that contains the same number of species as would be contained in a larger one. Determine the area of your schoolyard. Estimate the percentage of dandelions in your schoolyard by using quadrat analysis. How accurate do you think this number is? Explain your answer.

Check and Reflect

1. Describe two different things humans could do to have an impact on living things in your schoolyard.
2. Why is it important to investigate the distribution of living things in your schoolyard?
3. In many national and provincial parks, there are both wetland and dry-land areas for living things. Why do you think it is important to have both areas?
4. Figure 3.2 shows wetland and dry-land areas in a park. Create a chart with the headings "wetland" and "dry land" to list all the living things you see in each place. Why do you think park naturalists might want to know the distribution of each of these living things in the park?

*re*SEARCH

One, Two, Three ...
Research how scientists determine the populations of migrating birds.

Figure 3.2 Question 4

3.2 Interactions and Changes Occur in Ecosystems

In any ecosystem, living things need to interact with non-living things. As you have learned in previous sections, if there is an imbalance within an ecosystem, problems may occur. In some ecosystems, human activity has caused an imbalance.

An example of this is wetland ecosystems. At one time, wetlands were not considered to be important. In many countries, wetlands were drained to be replaced by farmland and housing. Others were destroyed by pollution. By destroying the wetlands, humans destroyed many plants and animals that lived in that ecosystem. Now, wetland ecosystems are recognized for their importance. Many steps have been taken to protect and preserve wetlands.

Give it a **TRY** ACTIVITY

To Change or Not to Change

Forest ecosystems have also undergone changes. Look at Figure 3.3. A forest once stood here. That was before the thunderstorm. Lightning pierced the sky, striking and igniting one of the taller trees. The fire jumped from treetop to treetop until the entire forest was burning. The photo shows all that's left.

Figure 3.3 A forest after a fire caused by lightning

Imagine what the forest scene in the photo looked like before the fire. Make a sketch to show what you're imagining. What kinds of living things populated this scene? What abiotic and biotic factors of the forest ecosystem supported them? Where are the living things now? Don't forget about human involvement in the area.

How do you think this scene will look a few years from now? Will it be any different? What could make it different? Use a sketch to record your impressions. Add labels to clarify your ideas. How will this scene look 20 years from now? 50 years from now? 100 years or more from now?

Do you think it ever burned before? Does the fire do any good?

Share your ideas with a group. Do they have the same ideas as you? Add one new idea to your sketch.

*info*BIT

Disappearing Dragonflies

Dragonflies, which live in wetlands, are an early warning sign for pollution. If the dragonflies at a pond disappear, then other pond plants and animals will soon follow if the pond isn't cleaned up.

All Things Change

Everything changes. You may not notice it, but you are not exactly the same as you were one day ago. Tomorrow, you will be different again. Change is always happening, everywhere inside you and around you. All things change, including ecosystems. Some of the ways that changes can occur are through **bioinvasion**, **competition**, **predation**, and weather.

Bioinvasion

Many of the plants and animals that you may think are common to Canada actually have come from somewhere else. European settlers introduced plants and animals from their home countries. Some well-meaning naturalists introduced other species, while still others were accidentally introduced.

Scientists call this species introduction bioinvasion. Because many of these new species were stronger than the native species or had no natural enemies, they quickly multiplied. Their effects on ecosystems and on other living things have been dramatic.

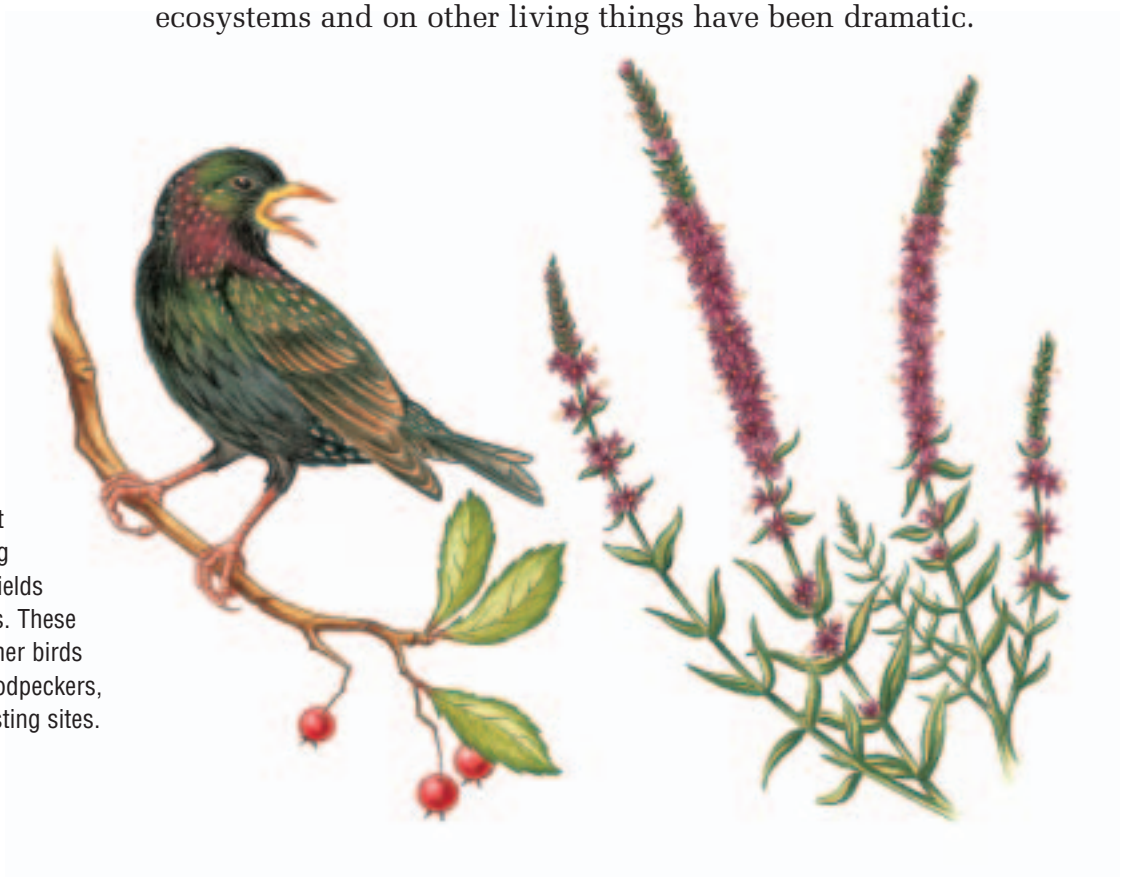

Figure 3.4a) In 1890, a hundred European starlings were released into New York's Central Park. Starlings have been very successful, and now number over 200 million throughout North America, causing problems in farmers' fields and hazards at airports. These birds compete with other birds such as bluebirds, woodpeckers, and flycatchers for nesting sites.

Figure 3.4b) The first wild plants of purple loosestrife in North America probably escaped from people's gardens. They originally came from Europe. The plant has spread so fast that it has pushed native species out of the way. This is especially true in wetland and marshy areas. Birds have a harder time making nests among purple loosestrife than among native species.

Figure 3.4c) Zebra mussels were first noticed in the Great Lakes in 1988. They probably travelled over here on a ship from Europe. By 1994, there were as many as 50 000 mussels/m^2 in some rivers near the Great Lakes.

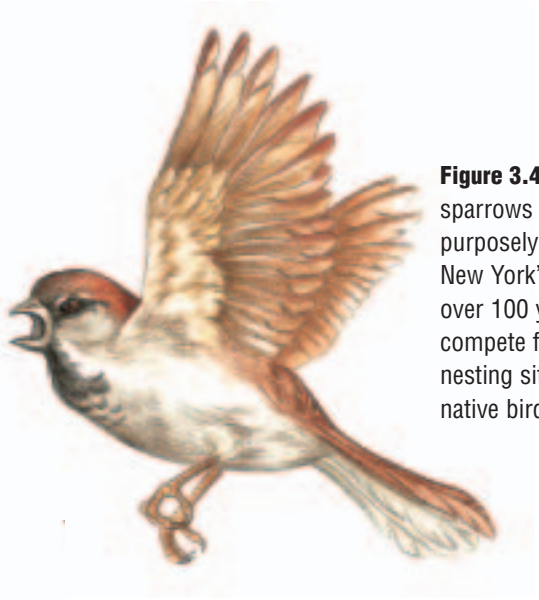

Figure 3.4d) House sparrows were also purposely released in New York's Central Park over 100 years ago. They compete for food and nesting sites with many native birds.

Figure 3.4e) More than one-quarter of Canada's plant species are not native.

Competition

Changes also occur in the population of species in ecosystems due to their interaction with other biotic and abiotic factors. One of these interactions is competition.

You probably have been involved in some type of competition. Whether it is running a race or designing a school logo, for humans, a competition involves more than one person trying to reach the same goal. All living things compete with all other living things in their community, but they compete for resources like food, water, and space to live. Because there is only so much of each resource, all living things are always trying to get enough of these resources to meet their needs.

Inquiry Activity

Survival in the Field

The Question

How does competition between two species affect their numbers and health?

Materials & Equipment

(for a group of 10 students)

- 4 plastic spoons
- 4 forks with centre tines removed
- 100 g sesame seeds
- 10 small Styrofoam balls
- 10 10-cm pieces of string
- 10 toothpicks
- a timing device

Figure 3.5 Lions chasing vultures off the lions' kill

The Hypothesis

Restate the above question in the form of a hypothesis. (See Toolbox 2 if you need help with this.)

Procedure

1. You are about to be part of a simulation of species competing for the same resource: food. There are two species, the forks and the spoons. In your group, assign four people to be spoons, four to be forks, and one person to be the recorder for each species.
2. The recorders randomly spread out the materials in an area 10 m by 10 m. This is the community.
3. The task for the members of the two species is to collect one food item from the community within 20 s. Members who cannot collect a food item and return to the recorder in this time period are considered to have died from starvation. Only members who collect one food item can go on to the next round. A food item is one pile of sesame seeds, one ball, one string, or one toothpick.
4. Begin Round 1 by having all the forks and spoons line up on one edge of the community. When your teacher tells you to start, go into the community and collect one food item. When you get your food item, come back to your recorder to have your item recorded. Any fork or spoon who is unable to collect food or who has collected too much cannot continue into the next round.
5. Repeat step 4 until no forks or spoons are left. Make sure each food item you collected is recorded at the end of each round.

Collecting Data

6 To record what each fork and spoon collected in each round, draw the following table on a clean sheet of paper.

Species	Round 1	Round 2	Round 3	Round 4	Round 5
Fork 1					
Fork 2					
Fork 3					
Fork 4					
Spoon 1					
Spoon 2					
Spoon 3					
Spoon 4					

Analyzing and Interpreting

7 Create a line graph that shows how many spoons and how many forks competed against each other in each round.

8 Using the graph, can you describe a trend that shows which species was more successful in the competition for food? What information can you use to support your conclusion?

9 Create a bar graph for forks and spoons that shows what type and how much food each species collected in each round.

10 Was there a preferred food at any time for each of the species?

11 Was there a food that you thought limited the survival of a species? Was there a food that only one species could use to survive?

Forming Conclusions

12 Use the data you collected from this activity. Describe how you think competition for food might affect the number and health of the forks and spoons in this activity.

Applying and Connecting

Look at the photo on the previous page of lions and vultures competing for resources. Work with a partner. Find examples of species in your community that compete for resources.

rESEARCH

Non-native Species

Research three common plants and animals that are not native to Canada. Choose ones not mentioned in this subsection.

Why are some of these alien species so successful in North America? Why are some a threat to our ecosystems?

Predation

Competition for resources is not the only factor that can affect a species' survival. Predation occurs when an animal hunts other animals for food. Organisms that are being hunted are the **prey**. An example of this is the lynx hunting snowshoe hares. The interactions of predators and their prey can affect an ecosystem. If there are too many predators, the prey population will decrease. This may increase competition for food among predator populations, so that one or more will either die out or move to a new location. If there are too few predators, then the prey population may increase. This would increase the competition for food among prey species, so that one or more will either die out or move to a new location.

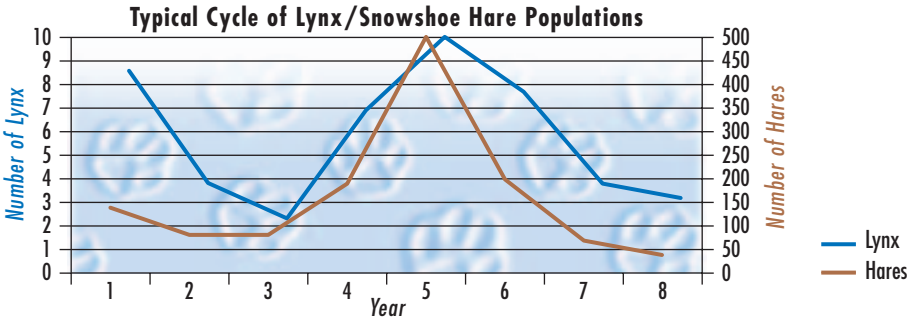

Figure 3.6 Typical cycle of Lynx/snowshoe hare populations over an eight-year period

Weather

Weather can also affect ecosystems. Many days of the right temperature and amount of rain can help plants grow. If the weather conditions are poor, the growth of plant populations may slow or stop. Natural disasters can also change ecosystems. Bad storms can damage plants. Floods can kill some plants and animals. Lightning can cause fires that destroy plants and kill animals.

Check and Reflect

1. How may the introduction of a non-native plant or animal species affect an ecosystem?
2. How do you think the following factors can affect populations and communities in ecosystems?
   a) the introduction of a new species
   b) the availability of food
3. Why do the populations shown in Figure 3.6 peak and crash at different times?

Experiment ON YOUR OWN

Competition between Three or More Species

Before You Start ...

There may be hundreds or even thousands of populations in an ecosystem. In the experiment below, you will work with just a few populations to observe what happens when several species compete in an ecosystem.

The Question

How does competition affect the number of plant populations in an ecosystem?

Design and Conduct Your Experiment

TOOLBOX

You may wish to use Toolbox 2: The Inquiry Process of Science to help you plan your experiment.

1. Make a hypothesis to test how the populations of three or more species of plants will be affected when they compete with each other in a small area. (A hypothesis is a possible answer to a question or a possible explanation of a situation.)
2. Decide what materials you'll need to test your hypothesis. For example, you might consider the following questions:
   a) How many populations will you experiment with?
   b) Will you grow the plants from seeds or work with seedlings?
   c) How many containers will you need?
   d) How much soil will you need?
3. Plan your procedure. Ask yourself questions such as
   a) What evidence am I looking for to support my hypothesis?
   b) What steps will I follow to collect the data I need?
   c) Is the test I'm designing fair? How do I know?
   d) How will I record my results? For example, will I need a data chart? a graph? both? neither?
   e) How long will I run my experiment?
   f) How long do I have to complete my experiment?
4. Write up your procedure. Be sure to show it to your teacher before going any further.
5. Carry out your experiment.
6. Compare your results with your hypothesis. Did your results support it? If not, what possible reasons might there be?
7. Share and compare your experimental plan and findings with your classmates. Did anyone plan an experiment exactly like yours? similar to yours? completely different from yours? How do your results compare with theirs?

Figure 3.7

3.3 Succession: How Ecosystems Change over Time

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Taking Over

The pioneers of succession on bare rock are lichen. Lichen are actually two organisms (an alga and a fungus) living together in mutualism.

Have you ever noticed how bare patches on the ground don't often stay that way? Sooner or later, you will see new plants growing where there used to be just soil. Scientists call the first species that arrive **pioneer species**. Even though the abiotic conditions may be harsh, these pioneers find a way to live there. They also "pave the way" for populations of other species to enter the community and establish themselves. As time goes on, many of the pioneer species may get replaced by the new arrivals. These, in turn, may be replaced by other, newer arrivals.

This process of change can take a long time. It may take decades, centuries, even thousands of years. Scientists have been observing enough of these changes to notice a pattern. They can usually tell which species came first and which came later just by looking at an ecosystem.

This predictable pattern of change in ecosystems is called **succession**.

Give it a **TRY** ACTIVITY

Can You Identify the Pioneer Species?

Pioneer species are the first to arrive in an area. Look at Figures 3.8a)–c). Try to decide which one(s) are pioneer species. Explain your reasoning.

Figure 3.8a)

Figure 3.8b)

Figure 3.8c)

What Is Succession?

There are two types of succession to consider when observing communities.

Primary succession occurs in areas where no life exists due to an absence of soil. Common areas of primary succession include volcanic islands, lava flows, and rock left behind by retreating glaciers. In succession on rock or lava, usually one of the pioneer species to arrive is lichen. Each change that occurs helps prepare the way for another set of changes. Lichens are suited to grow in barren, rocky areas. Over time, they help to break down the rocks into soil. As the soil becomes more fertile, mosses, fungi, grasses, and herbs begin to appear. Grassy areas are replaced by trees with shallow roots. As more soil builds up, larger trees become established. Succession on sand dunes usually begins with grasses, followed by shrubs, and then trees.

In the process of succession, communities will grow and replace one another until a **climax community** forms. A climax community is a stable community of a diverse number of species that is not easily replaced by other communities. Unless disturbed by natural or human forces, a climax community can exist for many years. Even though a climax community may be fairly stable for a long time, change is a continuous process, and very little will stay exactly the same.

Secondary succession occurs when a community has been destroyed or disturbed by natural occurrences or human activities. Secondary succession is different from primary succession, because in secondary succession, these habitats previously supported life. A farmer's field, a vacant lot in the city, a newly forested area, even a strip mine, are examples of where this type of succession occurs. When a corn field is left alone, weeds are the first to grow.

Work with a group. Think about areas in your local community that have any of these stages of succession. Create a poster of the area. Make sure your poster includes pictures as well as a written description of the area.

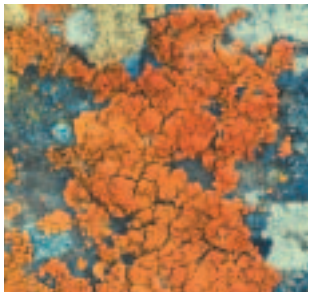

Figure 3.9a) Lichen

Figure 3.9b) Growing grass

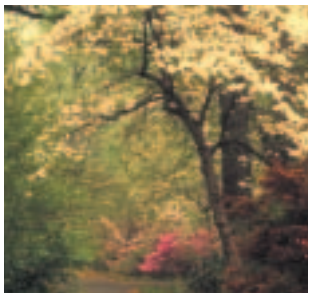

Figure 3.9c) Young forest

Figure 3.9d) Climax forest

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Surtsey

Surtsey, one of Earth's newest islands, is situated off the coast of Iceland. Research what pioneer species first inhabited Surtsey. What type of succession is present on Surtsey?

Check and Reflect

1. Which living things seem to be the pioneer species in all ecosystems? Suggest a reason to explain this.
2. Describe the key stages to the development of a climax community.
3. What is the difference between primary and secondary succession?
4. Give an example each of a pioneer species and a species of a climax community.
5. Over many years, the following plants and animals appeared in an area where a forest fire occurred. In what order do you think they appeared?
   - fireweed
   - birch tree
   - mouse
   - bear
   - grass
6. What examples of succession can you find in this scene of farmland that is no longer used for farming? Can you find a similar example in your community?

Year 1

Figure 3.10a)

Year 2

Figure 3.10b)

Year 10

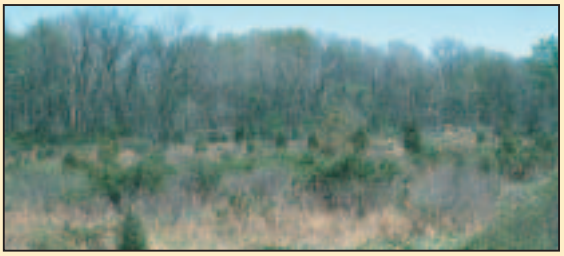
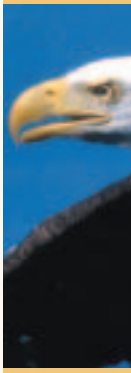


Figure 3.10c)

Year 20

Figure 3.10d)



Assess Your Learning

1. a) Whether they're started naturally or by people, forest fires change the ecosystem of a forest. Name at least three other natural changes that can affect ecosystems.
   b) Choose one of the above natural changes. Describe how it might affect an ecosystem.
2. Use words, pictures, or both to describe how primary succession takes place.
3. Describe how population fluctuations can change an ecosystem.
4. What interactions between living things can cause change in an ecosystem?
5. Give an example of an ecosystem where secondary succession can occur.
6. Imagine if all the bears (both grizzly and black) in Jasper National Park were removed from the park. Make a plan to investigate the changes that would take place in the ecosystem.

Focus On — Social and Environmental Context

In this section, you looked at changes that occur in ecosystems and the way that they can be assessed and monitored. Changes and interactions can have both intended and unintended consequences for humans and the environment. As you continue to gather information and ideas that will help you to design and develop your project, consider:

1. What types of changes and interactions need to be monitored?
2. What technology will need to be used to assist with the monitoring?
3. When should the monitoring be done?
4. How much importance should be given to impacts on the ecosystem compared with the needs of humans?

4.0

Maintaining sustainable environments requires knowledge, decisions, and actions.

Key Concepts

In this section, you will learn about the following key concepts:

- endangered species
- environmental monitoring
- environmental impacts
- extinction
- environmental management

Learning Outcomes

When you have completed this section, you will be able to:

- identify how some pollutants become concentrated in organisms
- identify intended and unintended consequences of human activities within ecosystems
- describe how information from scientific investigations can assist environmental decision-making
- describe examples of limitations of scientific and technological knowledge when making decisions about environments
- use evidence from many sources to help analyze a local environmental problem

Before a decision can be made, the situation must be studied, and the consequences of the actions must be analyzed. Some decisions may have the best intentions, as you saw in the case of Yoho National Park, with unfortunate results. In this section, you will look at the consequences of human activities within ecosystems, and how science investigations can help inform environmental decision-making. But science and technology are not always able to provide help with environmental issues, as you will learn. You will get the chance to analyze a local environmental problem and identify possible actions and consequences.

4.1 There Are Intended and Unintended Consequences of Human Activities within Ecosystems

The human population on Earth is very large, and continues to grow. This means we need more space to live, and more land to grow and raise living things for food. We need more energy sources such as coal and oil to fuel our technologies, and more raw materials such as wood, rocks, and minerals to build our homes, our industries, and our vehicles. Each human "need" has an impact on ecosystems and the living things that populate them—including ourselves.

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Rabbits Everywhere

In the summer of 1999, there was a population explosion of domestic rabbits living on the lawns of the Royal Victoria Hospital in Victoria, British Columbia. Hundreds of rabbits were seen every day feeding on the lawns. It is believed that these rabbits were released pets.

Figure 4.1 A human activity having a major impact on an ecosystem

Human Impact on Ecosystems: Chemical Use

Here's what can happen when humans interfere with an ecosystem they don't understand. In the early 1950s, malaria-carrying mosquitoes infected the Dyak people of Borneo. The World Health Organization was called to help. Their solution was to use a chemical pesticide called DDT to spray on the mosquitoes. As a result, the mosquitoes died off and the malaria diminished.

Unfortunately, there were problems. The DDT also killed a species of parasitic wasp. The wasps were helpful because they ate a species of caterpillar. This population of caterpillars ate the materials that the roofs of houses were made of. Now roofs were

falling on peoples' heads. The DDT also affected many species of small bugs that were eaten by geckos. The geckos began to suffer nerve damage and started moving more slowly. Cats, who normally ate rats, switched to the slow-moving geckos. The cats started dying from DDT poisoning. Not only had DDT worked its way up the food chain, but it had increased in concentration at each successive level of the food chain. When the cats died, the rats multiplied quickly. Fleas, piggybacking on the rats, carry a bacteria that causes typhus and sylvatic plague, which were much worse than the original malaria. The World Health Organization was called in again. This time their solution was to parachute live cats into Borneo. But this led to other problems. What do you think happened to the cats?

While DDT has now been banned in North America, there are other pesticides that threaten species. Migrating birds are very vulnerable because they visit so many localities. A recent example is the case of the Swainson's hawks. Many of these birds of prey summer in Saskatchewan and Alberta. They winter in Argentina and Brazil.

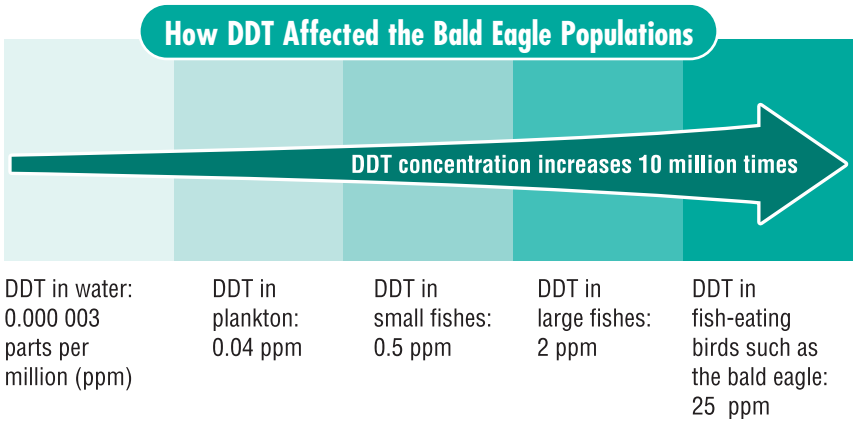

Figure 4.2 Look at how DDT became more concentrated as it moved up the food chain. By the time it reached the bald eagles, the DDT concentration was 10 million times the original concentration in water. DDT affected the eggshells of the bald eagles. Most eggs broke and therefore did not hatch. This resulted in a decline of the bald eagle populations.

Mysteriously, in just a few short years, between five and ten percent of the world's population of Swainson's hawks died. That translated into thousands of deaths to the 100 000 birds that summer in Canada. The reason is that Argentinian farmers used a pesticide to kill grasshoppers. What farmers didn't realize was that the hawks eat grasshoppers.

Now, thanks to environmentalists in North America and Argentina, and other concerned people, alternatives to using pesticides are being explored.

Human Impact on Ecosystems: Too Little Too Late?

Many species of plants and animals are in danger of being eliminated from the planet completely. Many others are already **extinct**. Extinction occurs when a species no longer exists anywhere on Earth. Extinction is a natural part of the planet's history. But in the past three hundred years or so, human activities such as hunting, bioinvasion, farming, building cities, and cutting down forests have greatly increased the rate of extinction. Human activities increase the rate of extinction because the environment is changed too quickly for organisms to adapt.

When their environment changes too quickly for them to adapt, organisms become rarer and rarer. Organisms that are so rare that they are in serious danger of becoming extinct, are considered **endangered**. **Threatened** species are species whose numbers are declining.

The chart outlines some of the 85 plants and animals in Canada that are extinct, endangered, or threatened.

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Grizzly Bears

Right now, there are about 20 000 grizzly bears in North America. Before the 1800s, there were more than 100 000. Research to find out what, if anything, is being done to protect the grizzly. Do you think it will be extinct in Canada someday?

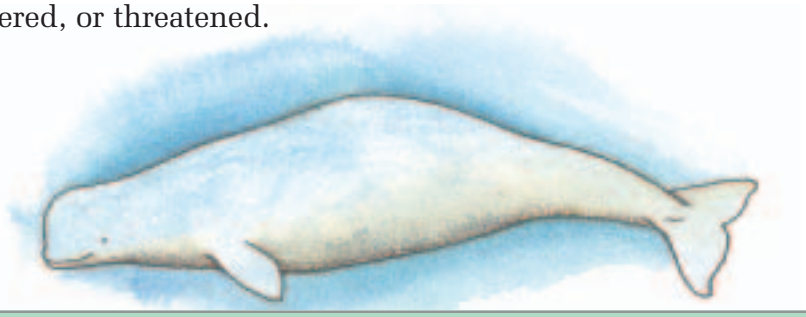


Figure 4.3a) Beluga whale

Extinct, Endangered, or Threatened Plants and Animals in Canada

Extinct	Endangered	Threatened
• Dawson's caribou • sea mink • great auk • Labrador duck • passenger pigeon	• eastern cougar • Oregon spotted frog • sea otter • beluga whale • whooping crane • eastern prickly pear cactus • Arcadian whitefish	• wood bison • pine martin • burrowing owl • eastern massasauga rattlesnake • ginseng

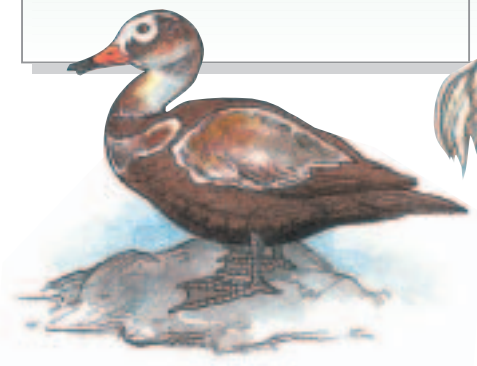


Figure 4.3b) Labrador duck

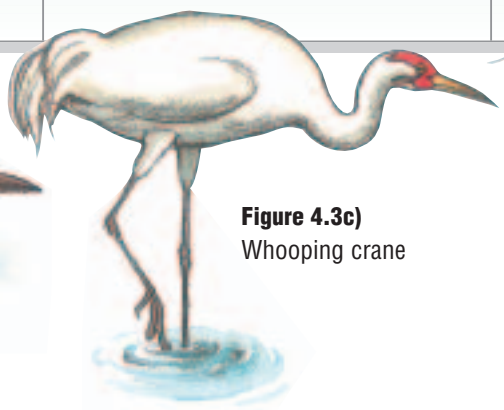


Figure 4.3c) Whooping crane

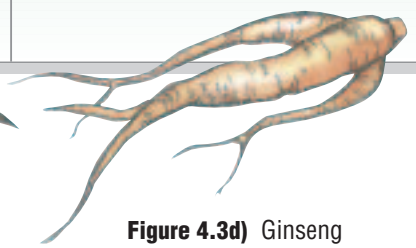


Figure 4.3d) Ginseng

Decision Making Activity

Crossing the Border

The Issue

If you take a trip outside Canada, when you return, you must fill out a Canadian customs form declaring what you are bringing back to Canada. There is a list of things that are not allowed to be brought into the country. Why do you think this is?

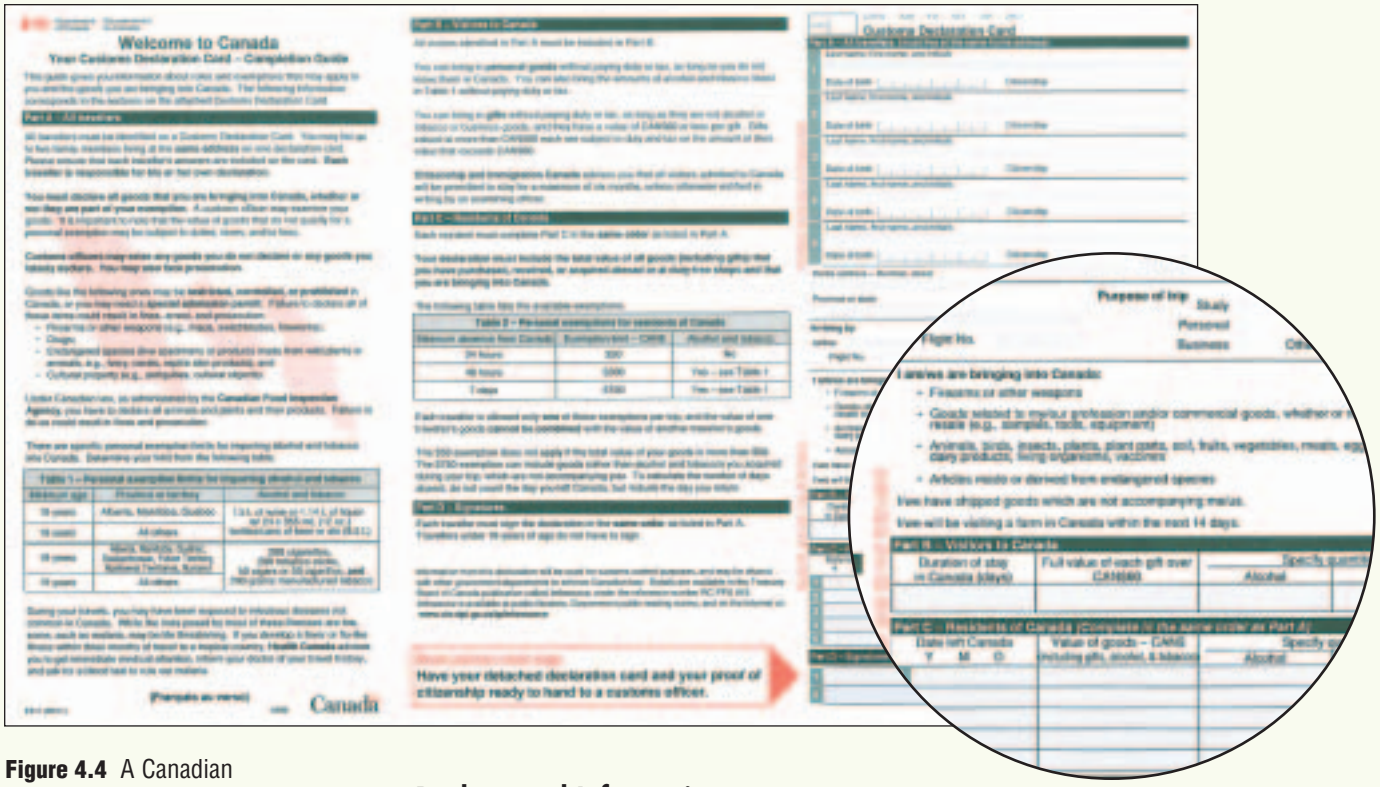


Figure 4.4 A Canadian customs form

Background Information

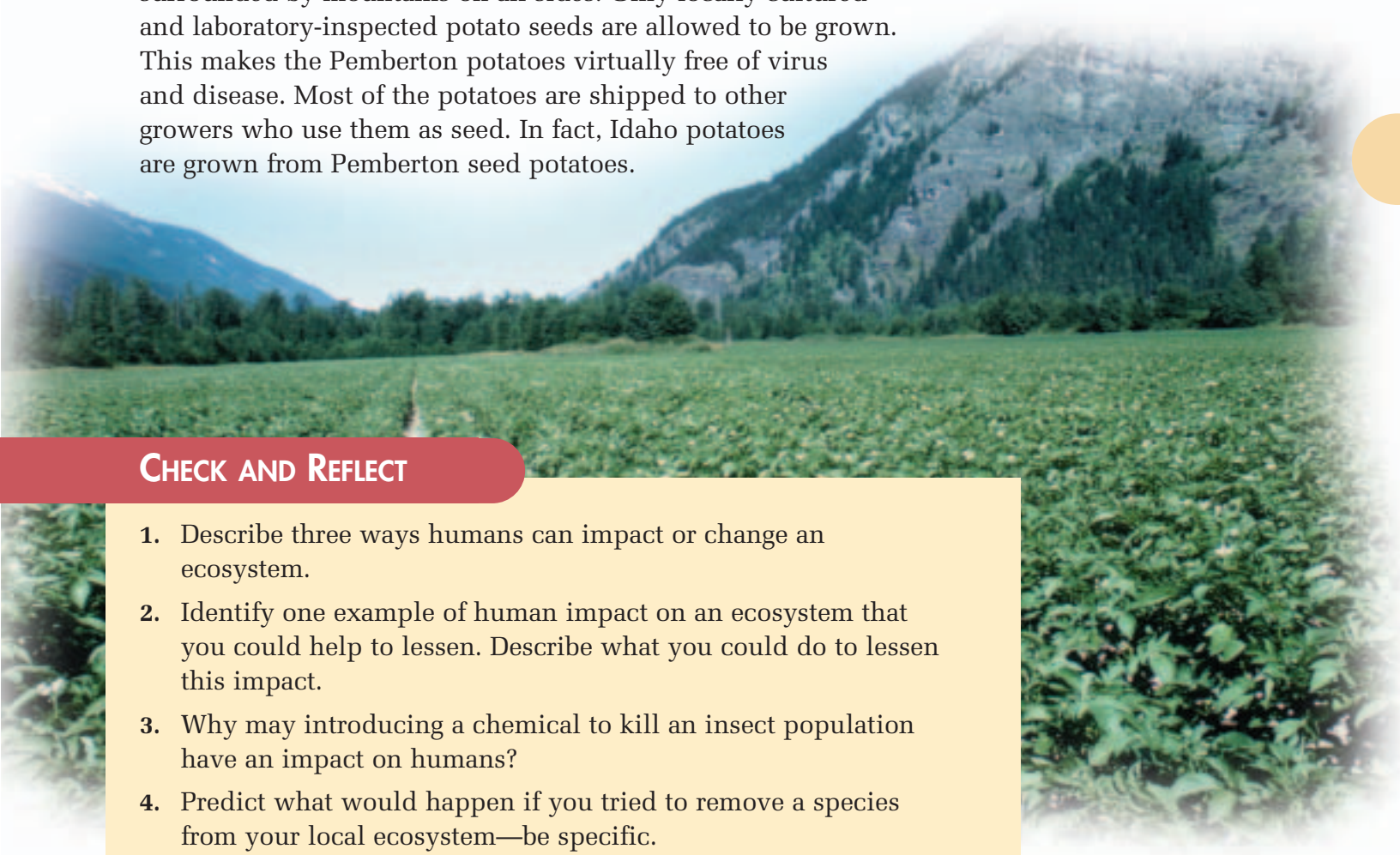
Look at the form shown here. Look at the list of things that must be declared. Often people try to sneak exotic animals into the country by hiding them on their person or in their luggage. According to Canada Customs, long trench coats lined with pockets are used to hide exotic birds such as parrots. In luggage, such things as poisonous snakes, baby alligators, and rare turtles have been found. One of the most dangerous animals found in luggage was the green Mambo snake from Guam. It is one of the most poisonous snakes in the world! Foods such as bacon and sausage, soft cheeses, flour, vegetables, and plants for the garden will be confiscated because they may carry disease. If these and other illegal items are brought into the country, how would they affect our ecosystems? Why do you think it matters if you are visiting a farm in Canada within 14 days of returning from your trip?

Support Your Opinion

Write a paragraph summarizing your viewpoint on this topic. Make sure you support your viewpoint with facts from the unit or other resources.

Famous Potatoes

In a small town called Pemberton, north of Whistler, in British Columbia, exists the home of world-famous potatoes. These potatoes are respected internationally by almost every potato farmer in Canada and the United States. Why? Since 1949, the area has been quarantined. Isolated, Pemberton is situated in a valley, surrounded by mountains on all sides. Only locally cultured and laboratory-inspected potato seeds are allowed to be grown. This makes the Pemberton potatoes virtually free of virus and disease. Most of the potatoes are shipped to other growers who use them as seed. In fact, Idaho potatoes are grown from Pemberton seed potatoes.



Check and Reflect

1. Describe three ways humans can impact or change an ecosystem.
2. Identify one example of human impact on an ecosystem that you could help to lessen. Describe what you could do to lessen this impact.
3. Why may introducing a chemical to kill an insect population have an impact on humans?
4. Predict what would happen if you tried to remove a species from your local ecosystem—be specific.
5. Create a poster or picture that illustrates the present state of endangered or threatened species in Canada.
6. In what ways do the following human activities affect ecosystems?
   a) clearing farmland to build a new housing development
   b) cutting down trees to make paper and building materials
   c) transporting crude oil across the ocean
   d) burning logs in a fireplace
   e) growing an apple orchard to sell the apples
   f) harvesting rare plants to make new medicines from chemicals they contain

TRY This at Home

ACTIVITY

IMPACTS ON THE ENVIRONMENT

Humans regularly pollute the air, water, and soil on which all life depends. These pictures show a few examples of ways we have changed or polluted our own planet.

Figure 4.5a) Each year people throw away great amounts of garbage. Potato chip bags, fruit pits and peels, bottles, and paper and plastic of all kinds make up the majority of this litter. Who do you think pays to have the garbage collected? How would living things be affected if we left the garbage where it lay?

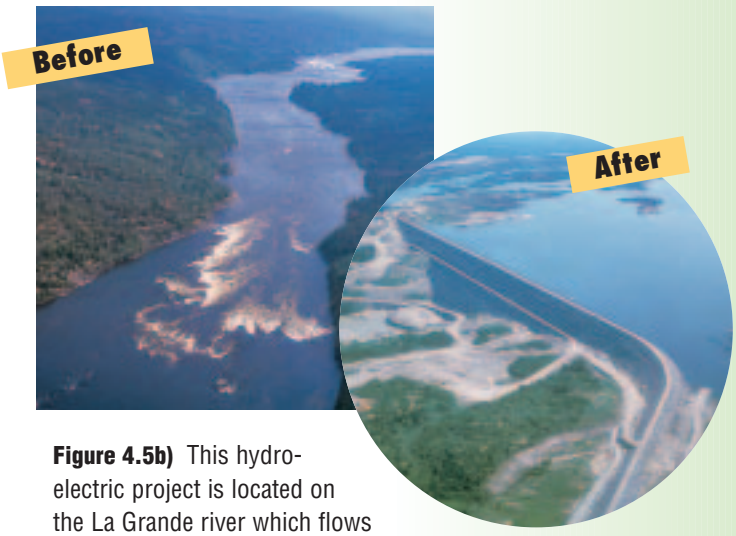


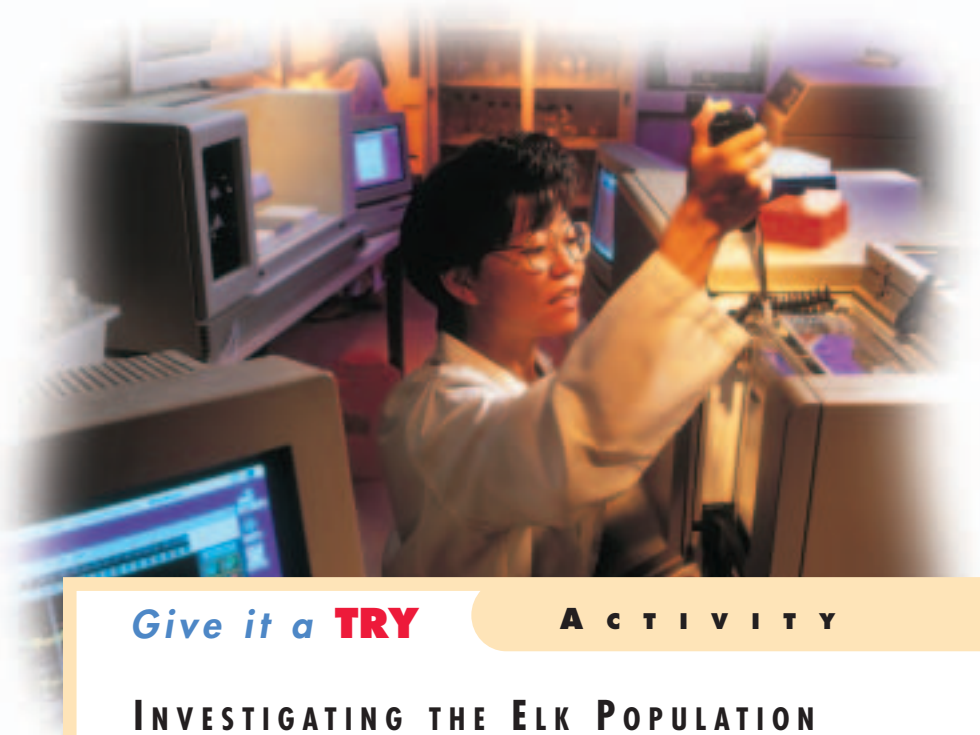
Figure 4.5b) This hydro-electric project is located on the La Grande river which flows into James Bay in northern Québec. The top picture shows the river before the dam was built for the plant, and the bottom picture shows the site seven years later. The dam is nearly 3 km long and now contains the reservoir which extends over 2835 km^2. In what ways do you think the environment was changed to build the electricity-generating plant? What effects would these changes have had on living things?

Figure 4.5c) Some industries produce pollution. Emissions by these industries must be monitored to ensure that they are within safe limits. Scientific research helps us determine what these safe limits are. How does this pollution affect living things in the air and on land?

Each of these examples of pollution is a technological response to meet a human need. How could this need still be met without creating as much pollution and minimizing the damage to the environment? What could you do at home to help minimize the damage?

4.2 Information from Scientific Investigations Can Assist Environmental Decision-Making

When scientists want to understand why changes happen in an ecosystem, they plan an investigation to study it. When scientists want to add or take something away from an ecosystem, they study how this could affect the abiotic and biotic factors that are living in it. This information can help us to make a responsible decision about the environment.



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A Pesty Career
Agricultural researchers study insect life cycles to determine how to control these pests without using dangerous pesticides that can harm the environment.

Give it a **TRY** ACTIVITY

Investigating the Elk Population

Ecologists are scientists who study the relationships among living things and their environment. For example, ecologists study the birth and death rates of elk so they can predict the future of the population.

Imagine that the size of the elk population in a small town located in the Rocky Mountains suddenly decreased. How could you find out what happened to the elk? What scientific data would you look at? Would you look at the population over the past few years? Have any new predators been introduced to the region? How could your data help you make an informed decision about the elk population? How could you determine which information is correct?

Compare your ideas with those of your classmates. Did you have similar ideas? Discuss any answers you are unsure of. Modify your answers if necessary.

The Saving of the Peregrine Falcon

Science and technology can be used to observe, monitor, and assess the status of endangered wildlife. In Canada, an organization called Canadian Wildlife Service's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) monitors species at risk of extinction in Canada. COSEWIC is a committee of representatives from federal, provincial, territorial, and non-governmental environmental agencies as well as independent experts. The goal of this committee is to increase the numbers of all at-risk species to levels that are no longer considered endangered.

The peregrine falcon is an example of a species that was placed on the endangered species list. The major cause of the drop in the peregrine falcon populations was agricultural pesticides that were present in the environment. These pesticides caused thinning of the eggshell, which led to eggs breaking. This meant there were fewer eggs that hatched, which in turn reduced the number of birds that were born. This is no longer a major problem because the use of these pesticides has been banned in North America.

Figure 4.6 A peregrine falcon chick that has been tagged so its progress in the wild can be monitored

The peregrine falcon was monitored from 1970 to 1995, where status surveys were conducted in most regions of Canada. The data collected from these surveys helped assess the peregrine's situation. Once the numbers of these populations became dangerously low, a recovery plan was developed to help the survival rate of this bird. Captive breeding programs across the country were used. Captive breeding involves breeding the birds in a protected environment where they cannot be harmed.

Many positive results came of the efforts to help the peregrine. In 1994, at the captive breeding facility in Wainwright, Alberta, a record-breaking 115 young birds were raised. Also, the National Department of Defense agreed to modify its low-level aerial training flights in Labrador, Newfoundland, to reduce the effects on nesting peregrines. Once the birds are able to live on their own, they enter a release program. This program helps the peregrines return to the wild. The birds are tagged so that they can continue to be monitored to assess if their entry to the wild was successful. The captive breeding programs were very successful, and so the peregrine falcon was down-listed from endangered to threatened.

Peregrine falcons released in Toronto, Edmonton, and Calgary build nests on ledges of tall buildings. Scientists think the peregrines are mistaking these buildings for cliffs. Cliffs are natural nesting sites for peregrines.

RESEARCH

The Marmot

Research the Vancouver Island marmot, an endangered species. What type of scientific investigations are being conducted to help save it?

Check and Reflect

1. How does scientific data assist with environmental decision-making?
2. Is scientific data the only thing that should be considered when making an environmental decision? What else needs to be considered?
3. Design an action plan to help solve an environmental issue in your community. How would you collect your data? Explain your answers.

4.3 There Are Limitations to Scientific and Technological Knowledge

When people are trying to decide what to do about a specific environmental issue, they often involve scientists to plan investigations or conduct research so that an informed decision can be made. Unfortunately, not all issues can be addressed by science and technology. Sometimes there is no answer, due to lack of evidence, or studies, about an issue.

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Ultraviolet Radiation

Ultraviolet radiation is produced by high-temperature surfaces, such as the sun. Most of the ultraviolet radiation in sunlight is absorbed by oxygen in Earth's atmosphere, which forms the ozone layer. When the ozone layer becomes thin, more ultraviolet radiation reaches Earth's surface and may have hazardous effects on organisms.

Figure 4.7 The golden toad

Such is the case with the golden toad of Monteverde, Costa Rica. This amphibian has been missing since 1988, and researchers have no idea what happened. In fact, it is not the only frog to have puzzled biologists. Around the globe, in such locations as Australia, North America, Costa Rica, Puerto Rico, and Brazil, there are many unexplained amphibian die-offs, and a high rate of deformities have occurred in a large number of the amphibians that remain. Where a habitat has been destroyed or contaminated, the cause is obvious. Yet more often than not, this is not the reason. No one can pinpoint the cause, but most scientists think the environment is somehow to blame. The four top theories are climate change, pollution, disease, and increased ultraviolet radiation due to the thinning of the ozone layer. However, researchers are not sure just how many of the world's amphibian species are in trouble because in many parts of the world, including most of Asia and Africa, they haven't been studied.

The Walk That No Wolf Would Take

In 1996, Parks Canada completed a project designed to allow animals to cross the Trans-Canada Highway safely. Large sections of the road were fenced off, and two overpasses and 10 underpasses were designed specifically to encourage wildlife to use them and not the highway. Monitoring devices have spotted elk, deer, coyotes, and other mammals using the overpasses and underpasses. The Bow Valley wolf pack is using the underpasses, but no wolf has used either of the two overpasses yet.

Figure 4.8 An aerial photograph of Redearth Overpass in Banff National Park

No one is sure why the wolves are not using the overpasses. Opinions are divided. Some experts think that there should be sections of highway elevated or put through underground tunnels to protect the wolves. Other experts think that the wolves need time to get used to the overpasses, and will eventually find and use them.

Check and Reflect

1. Why do scientific limitations make it difficult to make a decision about an environment? Explain your answer.
2. What types of resources are needed to make an informed decision?

*re*SEARCH

Limited Knowledge

Research two more environments for which decisions are limited by scientific and technological knowledge. Explain the issues present.

4.4 Using Evidence from Many Sources Can Help Analyze a Local Environmental Problem

As you have worked through this unit, you have had opportunities to learn about ecosystems, abiotic and biotic factors, and the impact of human actions on them. You are also aware of the intended and unintended consequences of human activity on a variety of ecosystems. This leads to the need for responsible decision-making and action to help reduce human impact on these ecosystems.

Is there a way that you can become involved within your community that can make a difference to your local ecosystem and, on a larger scale, to the global ecosystem of Earth? The answer is yes, thanks to some innovative thinking by two researchers at the University of British Columbia.

Mathis Wackernagel and William Rees of the University of British Columbia wanted to find a way to measure the environmental impact of human activities on the planet. At the same time, they were looking for a method to report their results. They wanted the results to be easy to understand and to provide suggestions for how people could reduce their impact on ecosystems.

Ecological Footprint

What Wackernagel and Rees developed was an idea called the **ecological footprint**. Think about the footprint your foot makes. Every time you place your foot on the ground, you affect the biotic and abiotic factors under your foot. When you lift your foot up, you can see the exact area that you've affected. The ecological footprint helps us understand the effect that our way of life has on Earth. It shows us the imprint that our lifestyle makes on Earth's ecology.

To determine an ecological footprint, Wackernagel and Rees looked at the food, housing, transportation, consumer goods, and all the services we use every day. For each item, they calculated

how much energy, materials, and land we need. They also included the land needed to dispose of the waste produced by the way we live. They converted this information into an estimate of the total amount of land required to support each one of us. This amount of land is called the ecological footprint.

The average Canadian has an ecological footprint of 7.7 ha (hectares, 1 ha = 10 000 m^2). That means it takes about 7.7 ha of land for each one of us to have food, travel in cars, heat our homes, shop at the mall, throw out garbage, etc. This number tells us how much of the world's ecological resources an individual Canadian like you uses. But is that a lot or a little?

Comparing Ecological Footprints

Wackernagel and Rees used their technique to calculate how much land is actually available to support each person on Earth. This number is only 1.7 ha per person! When they looked at most of the countries in the world, they found that the average ecological footprint per person worldwide was 2.2 ha. This means that overall, people on Earth are using more of Earth's resources than they should if they want to protect the environment. And in Canada and other similar countries, we are using a great deal more than we should. In fact, if everyone on Earth had the same ecological footprint as the average Canadian, we would need four Earths to support us!

Now for the good news. There are ways to reduce your ecological footprint. Some of these changes can be immediate, while some will take a long time. These changes include reducing the amount of water, energy, and materials we consume and recycling the waste we produce.

*info*BIT

A City's Footprint

The City of Edmonton has a population of about 656 000. If each resident has an ecological footprint of 7.7 ha, the whole city has an ecological footprint of about 5 051 200 ha. But the actual area of the City of Edmonton is only about 67 000 ha. So the people of Edmonton require 75 times more land to support their lifestyle than they actually live on.

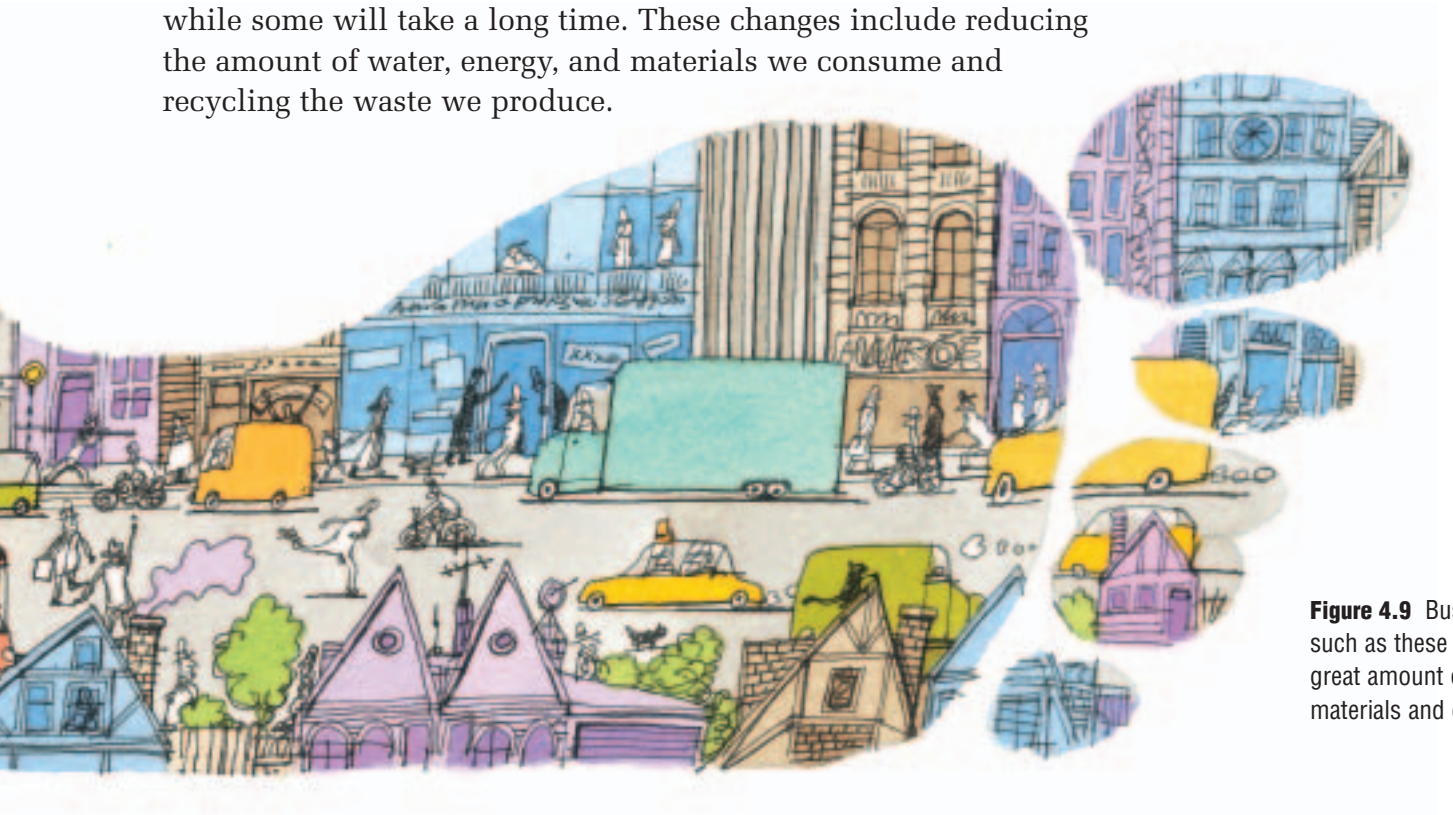


Figure 4.9 Busy lives such as these use a great amount of materials and energy.

Decision Making Activity

What Can You Do to Reduce Your Ecological Impact?

The Issue

Part of reducing your ecological footprint is to understand how your actions have an impact on the environment. For example, do you bring a drink for lunch each day? Do you use a reuseable container or do you throw away your container each day? Using a reuseable container helps to reduce your ecological impact. In this activity, you will be examining activities that may have an ecological impact. You will also be identifying strategies that you can use to reduce this impact. Using these strategies will help you work toward reducing your ecological footprint.

Background Information

Below are three activities that you can do to help you find ways of reducing your ecological impact. You will work either alone or in a group to complete each activity. For each activity, you will need to construct a table to record your information.

Activity 1—Water

1. Over the next 24 h, you will need to record how much water you use and what you use it for. While this will be only an estimate of your water usage, it will give you an idea of the amount of water you use.
2. To help you estimate your water usage, you will need to check with a variety of sources. Look in your math textbook or ask a math expert about how to calculate your water use, or check the Internet for statistics on water consumption. Or, you can use the chart shown here.

Activity	Typical Water Use
toilet flushing	15 L
shower	20 L/min
bath	150 L
teeth brushing	10 L
dish washing (for 3 meals)	40 L
washing clothes	225 L
washing car	400 L
watering lawn	35 L/min

3. Determine how much water you use in a 24-h period.

Figure 4.10a) Try to conserve water as much as you can.

Activity 2—Waste and Pollution

4 There are four categories of waste to consider: organic (will decompose), inorganic (will not easily decompose), items to be reused or recycled, and miscellaneous. In this activity, you will determine how much waste you generate in a day.

5 Use the garbage can in class to determine what categories of waste can be found. If a balance is available, determine the mass of each category. How could you determine how much waste per student was generated today? Wash your hands after you have touched the garbage.

6 When you go home today, observe and record what materials are put in the garbage. What materials could have been recycled or reused?

Figure 4.10b) This garbage should be sorted for recycling.

Activity 3—Materials and Goods

7 Make a list of everything you purchased in the last week. This includes any food.

8 Using catalogues and newspaper flyers, determine the approximate cost of these items.

9 Calculate the total cost for the week.

10 Review your list and identify which materials could be classified as not essential.

11 Recalculate your total cost for the week, but have two totals: one for essential materials and the other for non-essential materials.

Support Your Opinion

12 Make a plan that describes what you could do to reduce your ecological impact. Consider the following when creating your plan.

- Who in your class had the lowest totals in each activity?
- What did the person with the lowest totals in each activity do differently than you?
- What is one good idea you learned from your classmates that you could do to reduce your ecological impact?

reSEARCH

A Sustainable Lifestyle

The idea of the ecological footprint was developed to help people understand why they need to find a sustainable lifestyle. Find out what is meant by a sustainable lifestyle.

Factors That Reduce Your Ecological Footprint

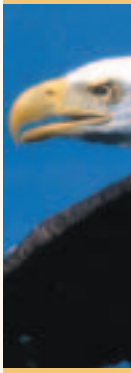
Factors that can help reduce your ecological footprint include reducing the amount of water, energy, and materials you use and recycling waste. When considering the amount of water you use, think of all the different ways you consume water. For some of the activities that involve water, it may be possible to reduce your water usage.

Figure 4.11 Four ways to reduce consumption

Reusing and recycling materials is another way to help reduce your ecological footprint. For example, if you reduced your household garbage by 20 kg and recycled another 10 kg, your ecological footprint could be reduced by 4%. This may not seem like a lot, but it does help to reduce your impact on your local ecosystems, and consequently, the global ecosystems.

Check and Reflect

1. Why did Mathis Wackernagel and William Rees invent the concept of the ecological footprint?
2. How does the ecological footprint of an average Canadian compare to the world average? Why do you think there is a difference?
3. What steps can you take to reduce your ecological footprint?
4. In this section, the term lifestyle was used. What types of lifestyle activities or actions do Canadians have that could be considered to have a negative impact on a local ecosystem? a positive impact?



Assess Your Learning

1. Rising beaver populations are an issue in many communities in Alberta. List three ways how this could be dealt with. Discuss the intended and unintended consequences of each choice.
2. A community in Calgary is trying to decide whether their local ravine should be made into an off-leash area for dogs.
   a) What might you predict would happen in this ecosystem if the designation is changed from a leashed area to an off-leash area?
   b) Is it enough just to ask the residents what they want? Why?
   c) What else needs to be considered before a decision like this is made?
   d) How might you use science and technology to help you to make an informed decision about this issue?
3. What is an ecological footprint? What is its significance to the ecosystems in your area?
4. Describe two things you could do to reduce your ecological footprint.
5. Do you think species that are endangered or threatened should be saved? Write a paragraph explaining your view on this question. Consider why others may have a different point of view.

Focus On — Social and Environmental Context

Decisions regarding scientific and technological development involve a variety of considerations. In this last section, you studied how maintaining sustainable environments requires knowledge, decisions, and actions. As you begin to work on your project, think about the following:

1. What environmental issues did you consider in this section? How will that help with your project?
2. a) Where could you find reliable information about reducing human impact on ecosystems?
   b) Explain whether you agree or disagree with the statement: Human impact on ecosystems is necessary to meet our needs, but we must consider both the social and economic costs.

SCIENCE WORLD

Case Study

Forest Harvesting

The Issue

What methods can be used to harvest Canada's forests? What factors need to be considered when deciding how to harvest trees?

The most common method of harvesting trees in Canada's forests is called clear-cutting. With clear-cutting, all the trees in an area are cut down. After the area is harvested, seedling trees are planted. These new trees are protected from pests and weeds as they grow. Later they are thinned to ensure that the remaining trees have enough space to grow.

Another method of harvesting trees is called selective cutting. This method of logging involves cutting down only those tree species that are suitable for use in making forest products. These trees are then replanted in among the other tree species still standing.

Many factors affect how forest harvesting is done in a specific area. For example:

- the size and location of the areas to be cut
- the distribution of wildlife in the area
- the wildlife's need for specific habitat
- the need to maintain ground cover
- the safety of forest workers
- the cost
- recreational or other uses of the area

For each forested area, a detailed plan must be developed that identifies what will work best in that location. For example, a 1-km square block where all the land is similar would be harvested in a certain way. A 1-ha area that is not square and includes hills and valleys might be harvested in a different way.

Research is important in understanding forest harvesting. You have an opportunity to be a researcher by gathering and presenting information about forest harvesting methods.

Go Further

Now it's your turn. Look into the following resources to research information.

- Look on the Web: Check the Internet for information on forest harvesting methods.
- Ask the Experts: Try to find an expert on forestry. Experts can be found in many places: universities, forest companies, environmental organizations, and government agencies.
- Look It Up in Newspapers and Magazines: Look for articles about harvesting forests.
- Check Out Scientific Studies: Look for scientific studies about harvesting forests.

Organize the information you have gathered and determine what you will use to answer the questions at the beginning of this case study. Decide how you will present your findings—as a display, a multimedia presentation, or some other method. Use your chosen presentation method to describe what your findings show.

Unit Summary: Interactions and Ecosystems

Key Concepts	Section Summaries
1.0 • interactions and interdependencies • environmental monitoring • environmental impacts • environmental management	**1.0 Relationships exist between living things and their environments.** • Ecosystems are places on Earth where biotic factors interact with abiotic factors and other biotic factors. • There are three major types of symbiotic relationships: commensalism, mutualism, and parasitism. • The basic needs of all organisms are water, energy, food, oxygen, and sustainable living conditions such as space and a place for waste to go. • There is a need for responsible decision-making and actions using scientific information, and that involves consideration of environmental impacts.
2.0 • interactions and interdependencies • producers, consumers, and decomposers • nutrient cycles and energy flow • environmental impacts	**2.0 The flow of energy and the cycling of matter can be traced and interpreted in ecosystems.** • Ecosystems are composed of food webs that energy flows through. This energy is supplied by the sun. • Matter continually moves from the non-living things to the living things and back to the non-living things. Two important cycles of matter are the water cycle and the carbon cycle. • If any part of a food web changes, it will have an effect on all living things in that ecosystem.
3.0 • interactions and interdependencies • environmental monitoring • environmental impacts • species distribution • succession	**3.0 Changes can be observed and monitored in ecosystems.** • Ecosystems provide living things with all their needs. • Some of the ways that changes can occur in ecosystems include human activity, bioinvasion, resources competition, predation, and weather. • There are two types of succession: primary succession and secondary succession.
4.0 • endangered species • environmental monitoring • environmental impacts • extinction • environmental management	**4.0 Maintaining sustainable environments requires knowledge, decisions, and actions.** • Pesticides, such as DDT, can enter and move through an environment with deadly effects. • The consequences of human actions may have an impact on both the local and global environments. • The information that scientists collect can help them make informed decisions, but unfortunately, not everything that happens in ecosystems can be explained by science and technology. • When looking at a local environmental problem, it helps to analyze information from many sources to get a complete picture to make an informed decision.

PROJECT

DESIGN A LAND-USE PLAN

Getting Started

In this unit, you learned that ecosystems develop and are maintained by natural cycles and succession, and are impacted by human change. You have investigated human impacts on ecosystems, and you understand that human actions have intended and sometimes unintended consequences. Environmental monitoring and research are important in the decision-making process. Look through your notes from this unit. Think about the ways human actions can affect ecosystems. With a partner, discuss the responsibilities that people have for making sure that ecosystems are healthy. List the categories you think people should use when they make decisions that affect ecosystems. Afterward, share your list with other groups. In what ways are they similar and different? Are there any additions you would like to make to your list?

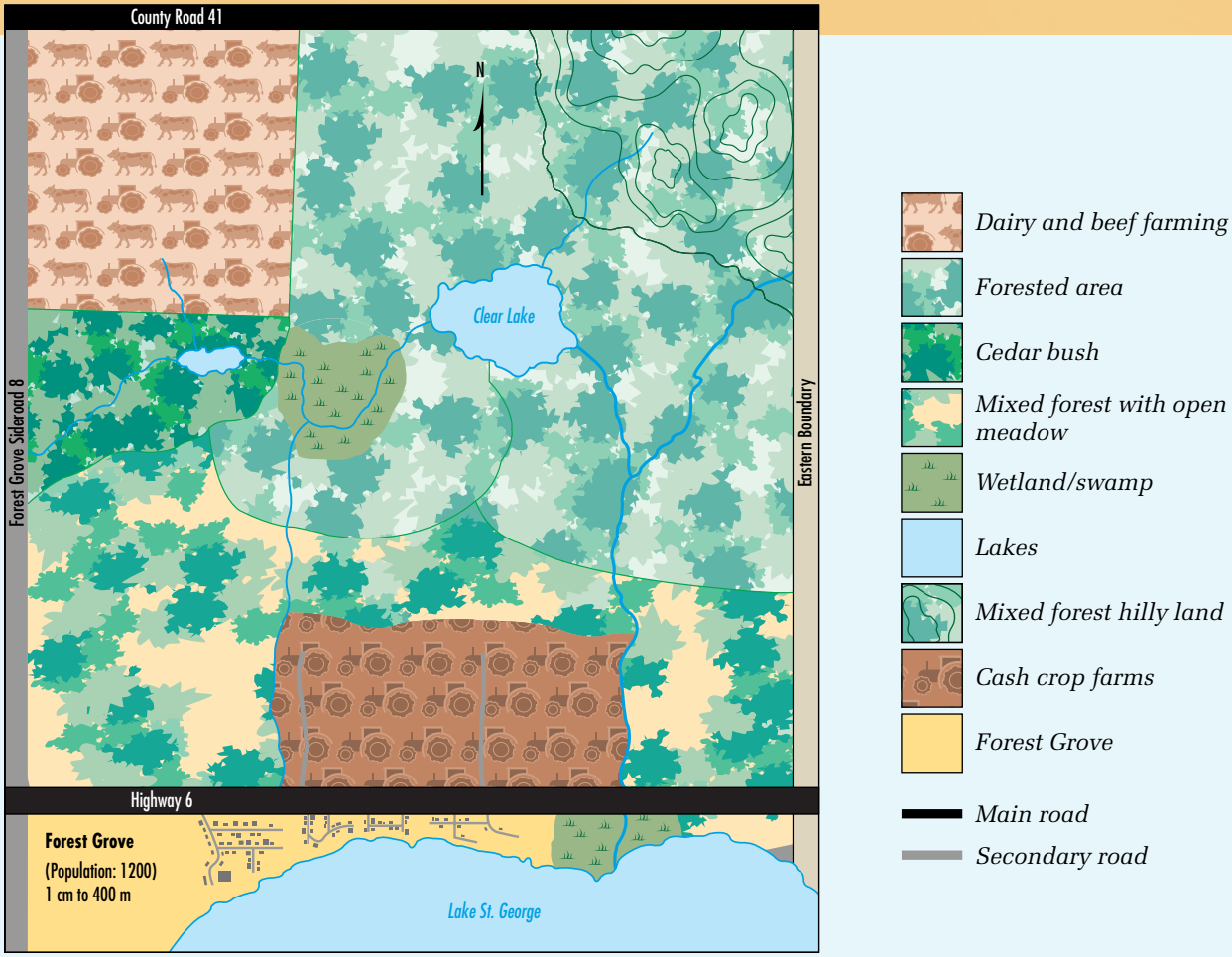
Your Goal

Your goal is to balance the needs for human growth and development with the needs of the biotic and abiotic factors of ecosystems.

What You Need to Know

The town of Forest Grove has a population of 1200 people. The unemployment rate has been 20% for the past several years. The town council has decided to develop a piece of unused land. It hopes to attract businesses, industries, and people to Forest Grove. The piece of land has an area of 2000 ha. (One hectare, or 1 ha, measures 100 m by 100 m.) Imagine you are a member of a land-use planning group. Forest Grove's town council has hired your team to design a plan to develop this land.

The map shown here outlines the various features of the land. Study it closely. Many different groups of people have ideas for developing this land. You will have to decide which ideas to use, which to ignore, and which to change. Use the Impact Assessment Checklist to help you evaluate your plans.



A map of Forest Grove

Impact Assessment Checklist

In what ways can your plans

- allow opportunities for more growth and development in the area?
- minimize the effects of growth and development on the habitats of the area?
- minimize the effects of growth and development on the living things of the area?
- deal with pollution and other negative effects to the area?
- balance the need for preserving natural ecosystems with the needs of people and their families?

Steps to Success

1 Design a land-use plan that addresses the following interests.

a) Industries: These will provide employment for the townspeople.

- A hospitality company wants to develop a camping and motel site. This complex will include a 25-unit motel, a small restaurant, a wooded camping area (about 5 ha), a recreation centre with tennis courts, a swimming pool, and a boat-launching ramp.
- A distribution company wants to set up a large warehouse depot for transferring goods to and from the surrounding communities. They will need good roads to get to the nearby highway.

b) Housing developers: They will want to build two new subdivisions for Forest Grove's growing population. The subdivisions will require roads to link them up with the existing town. They will need services such as water and electricity. The people who move into the new homes will also want their garbage handled in some way.

c) Businesses: These will provide stores and services such as restaurants, health care, a movie theatre, and a new shopping centre. Businesses will also need water, electricity, and garbage handling.

d) Local farmers: There are currently seven farms located to the west of the land you will be developing. All the farmers have expressed interest in expanding their operations. They would like some of the land set aside for them to lease or buy.

e) Private citizens: Many people in Forest Grove would like the land to be used for recreational purposes, such as parkland, with trails for walking and biking. They would also like to swim and boat on the river and in the lakes. A small group of citizens is urging you to leave the land as it is to preserve the local plant and animal populations. They are willing to consider limited use of the land for camping to attract people (and their money) to Forest Grove.

2 With your team, come up with a plan for the use of this land. Some of the questions you will need to take into account include:

a) How will you address the increase in garbage and other wastes?

b) What will happen if the town council wants to add to your development plans 10 years from now?

c) How will your decisions affect the quality of the air, water, and land?

d) How will your decisions affect the number and health of existing plant and animal populations?

3 Design a two-dimensional or three-dimensional model of the piece of land. Use different colours or structures to represent the different land uses.

4 When you have completed your plan, present it to your classmates. Be prepared to explain and, if necessary, defend your decisions.

How Did It Go?

5 Look back at the criteria you developed at the start of the Project. Look also at the Impact Assessment Checklist. How well does your finished plan reflect all these criteria?

6 In your opinion, how well did your plan balance the needs of people and other living things? Be as specific as possible in your answer.

7 If you could redesign your land-use plan, what would you decide to do differently. Why?

Unit Review: Interactions and Ecosystems

Unit Vocabulary

1. Create a mind map that illustrates your understanding of the following terms.

abiotic	food web
biotic	ecosystem
producers	succession
consumers	matter
decomposers	energy
food chain	human impact
interactions	endangered species

Check Your Knowledge

1.0

2. What is the difference between biotic and abiotic factors in an ecosystem?
3. Define mutualism and give an example of it.
4. What are the basic requirements of all living things?

2.0

5. Describe the unique role plants play in a food chain.
6. a) Give two examples of helpful microscopic organisms. Explain why they are helpful.

   b) Give two examples of harmful microscopic organisms. Explain why they are harmful.
7. What are two different types of consumers?
8. What are food chains and what is their purpose?
9. How is a food web different from a food chain?
10. Describe the difference between how matter and energy move through a food web.

3.0

11. Identify three ecosystems that you have walked through in the past few days. Explain how you know they are ecosystems.
12. Identify natural factors that can alter the living conditions in ecosystems.
13. What is succession? Give an example.
14. Describe three types of human activities that can impact an ecosystem.
15. What is meant by the term *bioinvasion*? Give an example of how this can impact an ecosystem.
16. Describe other factors that can affect ecosystems besides bioinvasion.

4.0

17. Identify a pollutant that moves through an environment and causes serious harm.
18. Look around your community. What evidence do you see of environmental problems caused by human activities? What evidence is there that your community is working to support living things and their living spaces?
19. Why have some species become endangered or extinct in North America?

20. Describe a situation that science and technology cannot answer.

Connect Your Understanding

21. a) Why would you expect to find each of the following in any ecosystem? Give reasons to support your answer.
- producers
- herbivores
- decomposers

b) Which group (or groups) of consumers is missing from part a) above? Why might it be possible for this group (or groups) to be absent from an ecosystem?

22. Listed below are four elements of ecosystems followed by five statements. Choose two of the statements. Take each chosen statement as a topic, and write a paragraph using the four elements of ecosystems.
- the role played by food webs
- the cycles of matter
- the flow of energy through ecosystems
- the interactions between living and non-living things

a) You sort your family's wastes into recyclables and non-recyclables.

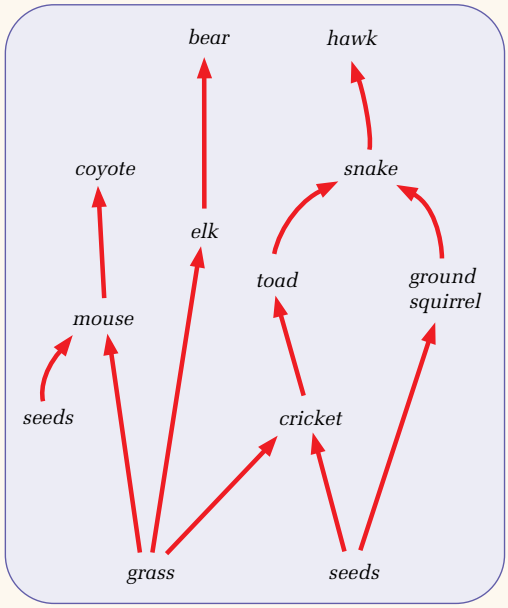
b) A concerned citizen is arrested for blocking a road to prevent loggers from cutting trees.

c) A food manufacturing company hires local villagers in Costa Rica to remove rain forest vegetation so it can set up a ranch to raise beef cattle.

d) A government decides to build a water-powered electricity generating plant. To do so, it must build a dam to stockpile water. Building the dam means that thousands of hectares of meadows and villages will be flooded.

e) Several families move to an island that has lots of rare slow-moving animals and flightless birds. The families decide to bring their pet cats with them.

23. a) Examine this food web.



Design a chart to record the following:
- all the producers
- all the herbivorous consumers
- all the carnivorous consumers
- all the scavengers and decomposers

b) Where might this food web be located?

c) Add eight living things to your chart, including: two each of producers, herbivores, carnivores, and decomposers.

24. A population of noisy crows has moved into your neighbourhood. They're chasing away the local birds, and their wastes are fouling the streets and rooftops. What action, if any, should be taken?

Practise Your Skills

25. In 1944, soldiers from the U.S. Army moved a herd of 29 reindeer to a remote island in the Arctic. Then the soldiers left. The only other consumers on this island were arctic foxes and voles (voles are mouse-like animals). There were numerous producers including grasses and plant-like living things called lichens, which reindeer love to eat.

In 1957, scientists visited the island. They discovered that the number of reindeer had increased to 1350. They also observed that there were fewer producers on the island. However, there were still plenty for the reindeer to feed on.

In 1963, scientists visited again. The reindeer now numbered 6000. The producers were nearly gone. One year later, when scientists arrived once more, they discovered that most of the reindeer had died. Only 42 remained.

a) Sketch a food web to show how you think the biotic factors of this island ecosystem were related.
b) What factors affected the population of the reindeer? Why?
c) What abiotic or biotic conditions might have led to a different ending to this story? Explain your answer.

Self Assessment

Think back to the work you did in this unit.

26. Do you think you will make decisions about the environment differently now that you have completed this unit? Why or why not?

27. Will you be able to take different perspectives about environmental decision-making? Provide an example to explain your answer.

28. In general, do humans respect the environment? Use three examples from the unit to support your answer.

29. What is one idea or issue covered in this unit that you would like to explore in more detail? Why?

Focus On — Social and Environmental Context

In this unit, you investigated the social and environmental context related to interactions and ecosystems. Consider the following questions.

30. What examples did you investigate that demonstrated how science and technology are developed to meet human needs?

31. Describe a hobby or interest for which science and technology provided an opportunity through the study of this unit.

32. Reread the three questions on page 7 about the social and environmental context. Use a creative way to demonstrate your understanding of one of the questions.