2.0 Interactions in ecosystems support the transfer of energy and the cycling of matter.

All ecosystems feature biotic and abiotic interactions, the transfer of energy, and the cycling of matter.

What You Will Learn

In this chapter, you will:

- describe the transfer of energy in ecosystems
- describe the cycling of matter in ecosystems
- explain how changes in ecosystems affect sustainability and the balance of interactions

Skills You Will Use

In this chapter, you will:

- investigate occurrences that affect the balance within a local ecosystem
- use appropriate science and technology vocabulary in oral and written communication

Why This Is Important

Studying the transfer of energy and the cycling of matter can help you understand ecosystems. You can then determine how your actions might affect both the biotic and abiotic elements in the ecosystems around you.

Before Reading

Thinking Literacy

Predict-Read-Verify

Making predictions about what you think a chapter will be about helps you stay focussed as you read. Before you start reading this chapter, scan each section (2.1, 2.2, 2.3). Look for information that is presented visually in photographs, diagrams, charts, and maps. Read their captions. List two or three main ideas for each section. After you study each section in class, revisit these main ideas to confirm or modify them as needed.

Key Terms

- energy pyramid
- cycle
- limiting factors
- food web
- cycling of matter
- sustainability

Interactions in ecosystems support the transfer of energy and the cycling of matter.

2.0 Getting Started

Figure 2.1 Ecosystems need rainfall as well as sunlight in order to support biotic elements.

Water is one of the basic needs of all living things. Earth's water has been moving through the water cycle for millions of years. The same water has been a liquid in the ground or in rivers, lakes, or oceans. It has evaporated and been a gas in the form of vapour. It may have become tiny droplets in clouds or fog. It has circulated in the atmosphere around Earth and come back down as rain or snow.

The water may stay deep in the ground for decades or be frozen in a glacier for centuries before it is cycled back into the atmosphere as a gas and returned to Earth again. The water that comes down

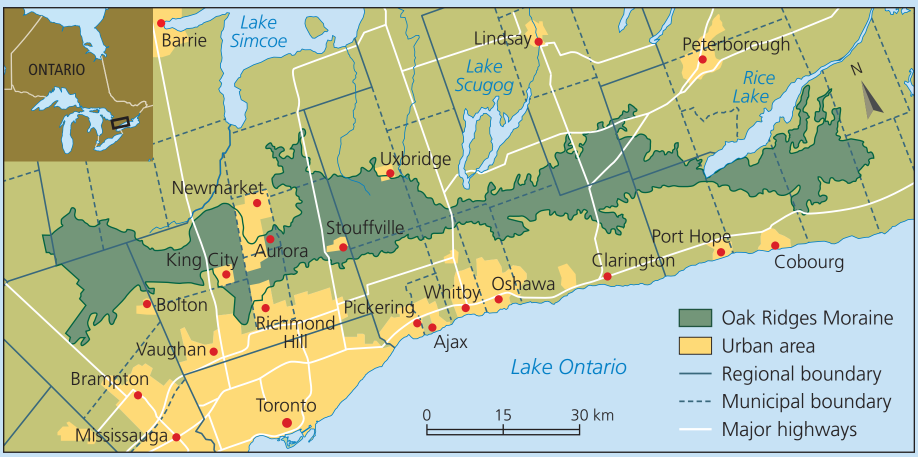


Figure 2.2 The Oak Ridges Moraine lies just north of Lake Ontario.

on you as rain or snow has fallen to Earth before, in another time and another place.

If you live in southern Ontario, the water you drink may flow through the Oak Ridges Moraine. The moraine, shown in Figure 2.2, was formed over 13 000 years ago from the sand and gravel left behind by melting glaciers. It filters and distributes the water that flows in the many rivers and streams that supply water to ecosystems in wetlands, creeks, ponds, meadows, forests, and human communities. **Wetlands** are areas of soft soil intermingled with water. A marsh is a wetland.

As human populations grow, their communities need more land. This expansion by humans affects the ecosystems around them, including how water recycles through the land. This could affect the water supplies of many Ontario towns and cities. An understanding of cycling in ecosystems helps in making important decisions about human activities.

A19 *Quick Lab*

Recycling Paper

Recycling programs started in the 1980s to reduce the amount of waste going into landfills. The goal is to re-use some of the resources used to make tin, aluminum, paper, and glass products. Re-using these materials means reducing waste and saving the resources. Paper is something that can be recycled and re-used fairly easily in order to save trees.

Purpose

To identify ways schools can use paper more wisely

Materials & Equipment

- paper and pencil

Procedure

1. With a partner, estimate how many sheets of paper each of you throws away in one week. Compare your estimates with those of two other pairs of classmates.
2. Use your estimate to calculate the amount of paper used and thrown out by your whole class in one week.
3. Use this figure to estimate the amount of paper thrown out by your school in one month.
4. With your partner, make a list of ways the school could reduce its use of paper.

Questions

5. What happens to the paper that is thrown out at school? By the community?
6. Could reducing the amount of paper used be as important as recycling the paper that is used? Explain your reasoning.

2.1 The Transfer of Energy in Ecosystems

Here is a summary of what you will learn in this section:

- Food chains show how energy is transferred in an ecosystem.
- At each step in a food chain, less energy is available to the next consumer.
- A group of interconnected food chains is called a food web.

Figure 2.3 When a predator like this raccoon eats its prey, it is getting the energy it needs to survive. A food chain represents the transfer of energy from the prey to the predator (consumer).

Some of the light and heat that flows from the Sun is absorbed by producers. Through photosynthesis, the producers change that energy into sugars that they use for food. Herbivores and omnivores then eat some of the producers. These consumers can convert the sugar in the producers to energy they can use.

Food chains are a way to show how energy and matter flow from one biotic element to another. The energy transfer in an ecosystem always begins with the Sun and producers. It then continues through a series of consumers in a food chain (Figure 2.3).

A20 *Starting Point* Skills A C

Representing Food Chains

Illustrating food chains in different ways helps you understand the interactions among producers, consumers, and decomposers. Your teacher will give you a worksheet that identifies the following components of an ecosystem:

carnivores
decomposers
herbivores
producers
omnivores
scavengers
Sun

Use the worksheet to complete the following steps.

1. Write the definition for each term in the space provided.
2. Using scissors, carefully cut out each component.
3. Arrange all the components in a way that illustrates your understanding of a food chain. Remember you must use all the components in your diagram.
4. Glue each of the components to a sheet of paper and add any labels or illustrations you think would better illustrate your thinking.
5. Describe any patterns or shapes that you observe.
6. Share your findings with your class.

Energy Transfer

Food chains show how energy travels through an ecosystem on a one-way path. Energy goes from the Sun to producers to herbivores and omnivores and then to carnivores and omnivores. At each level of a food chain, some of the energy is used for living, a lot is given off as heat, and some is stored. It is only the stored energy that is available to the next level. Ecologists estimate that about 10 percent of the energy taken in by a food source is available to the organism that consumes it.

Primary consumers eat producers. Both herbivores and omnivores are primary consumers. They are the first level of consumers in a food chain. Carnivores and omnivores that eat primary consumers are **secondary consumers**. They are the second level of consumers. Secondary consumers may be eaten by other carnivores or omnivores, called **tertiary consumers**. They are the third level. As a food chain gets longer, less and less of the Sun's energy is transferred from one biotic element to the next.

WORDS MATTER

"Primary" is from the Latin word for first, *primus*.

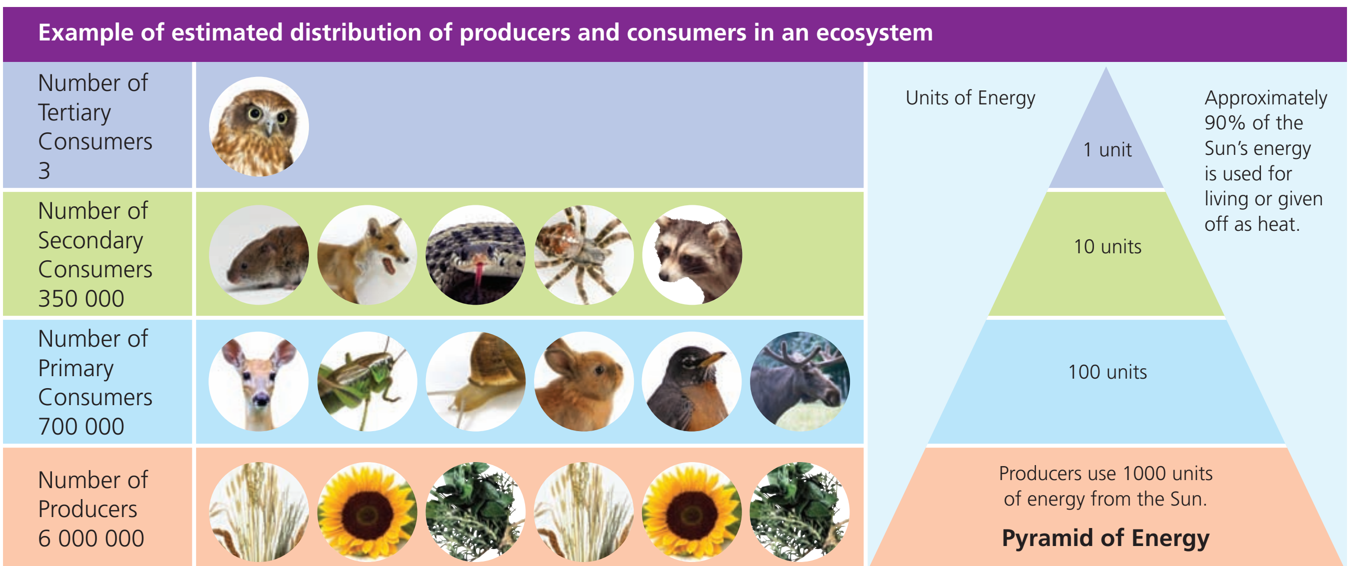
"Secondary" is from the Latin word for following, *secundus*.

"Tertiary" is from the Latin word for third, *tertius*.

Energy Pyramids

Figure 2.4 is a type of graphic representing an energy pyramid. An **energy pyramid** shows the amount of energy transferred in a food chain. There are fewer organisms at each level as you move up the pyramid. This occurs because only about 10 percent of the energy consumed at one level is transferred to the next level. Less energy means fewer organisms, which is why this type of graphic is called an energy pyramid.

Figure 2.4 In this energy pyramid, 6 000 000 producers have 1000 units of energy. These producers can support only about 700 000 primary consumers. There are fewer primary consumers because they can obtain only 100 units of energy by consuming the producers.



A21 *During Reading*

Thinking Literacy

Reading like a Writer

Sometimes writers help their readers understand complex ideas and concepts by presenting some information graphically as photographs, charts, diagrams, or maps. Graphics usually have text such as labels and captions. Information displayed in this way is more concise because graphics can say a lot in a small space. How do the chart on page 39 and the diagram on this page help you understand energy transfer and food webs better?

Food Webs

An ecosystem contains a number of different food chains. A single food source can be a part of many of the food chains that are interconnected. For example, many different herbivores, such as rabbits, squirrels, and mice, eat the grass or seeds in a meadow. Carnivores such as owls prey on the mice and other herbivores. Some omnivores, such as the red fox, might also think of mice as a tasty meal.

A **food web** shows interconnected food chains. A food web is a complex network of feeding relationships. It is also a more accurate way of showing how energy is transferred in feeding interactions in an ecosystem. Figure 2.5 shows a model of a food web in a meadow.

Take It ***Further***

The Grand Banks off the coast of Newfoundland have been home to a rich and diverse ecosystem. Find out more about the food webs that have existed for centuries. Begin your research at ScienceSource.

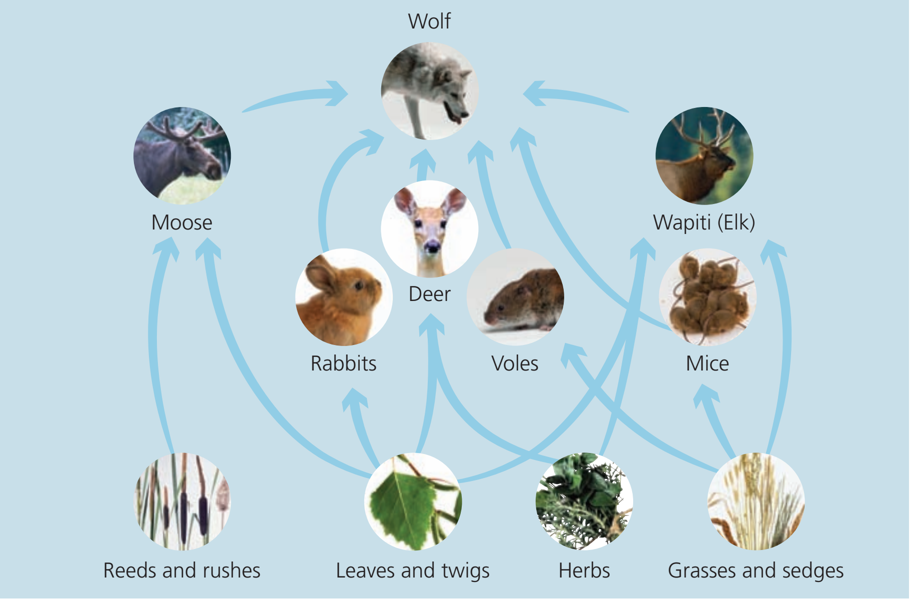


Figure 2.5 In a meadow, energy flows from the Sun to different producers. The producers turn the energy into sugars. The energy is then transferred to a variety of consumers through feeding interactions.

A22 *Quick Lab*

Pass It On

Figure 2.6

Purpose

To demonstrate how energy is transferred through a food chain

Materials & Equipment

- 1 L container of fruit juice
- 250 mL graduated cylinder
- 2 test tubes
- medicine dropper

Procedure

1. Have a student hold the graduated cylinder. Pour 100 mL of the juice from the 1 L container into the graduated cylinder. Put the remaining 900 mL of juice still in the container to the side.
2. Have a second student hold a test tube. Pour 10 mL of juice from the graduated cylinder into the first test tube.
3. Have a third student hold the other test tube. Use the medicine dropper to remove 1 mL of juice from the first test tube and drop it into the second test tube.

Questions

4. The 1 L of juice represents 1000 units of energy from the Sun. What did the 100 mL of juice in the graduated cylinder represent?
5. How does the amount of juice in the two test tubes represent energy moving through the next two levels of the food chain?
6. What does the energy (juice) that is not passed on to the next level of consumer represent?
7. About how much of the original energy from the Sun did the final consumer get?

Figure 2.7 This activity shows how much energy is transferred from producers to consumers in a food chain like the one shown here.

2.1 CHECK and REFLECT

Key Concept Review

1. How is the Sun's energy passed along in an ecosystem?
2. Why is a food web a more accurate representation of feeding interactions in an ecosystem than a food chain is?
3. There is less energy available to consumers at higher levels in a food chain. Why?

Connect Your Understanding

4. How are food webs on land and in the water similar? How are they different?
5. Draw a diagram to show how the Sun's energy is transferred in a food chain that ends with a chicken sandwich and you.

Practise Your Skills

6. A freshwater lake like the one shown below has hundreds of plants along its shore. They provide habitat and food for animals and insects. The insects are eaten by dragonflies and fish. The dragonflies and fish are consumed by heron. Draw an energy pyramid of this lake ecosystem.

For more questions, go to ScienceSource.

A23 *Thinking about Science and the Environment*

Holes in the Food Web

An endangered species has a population so small that the species is struggling to meet basic needs and reproduce. This may be due to disease, change in climate, destruction of habitat, or loss of a main food source. A species is described as endangered when it is likely to disappear from all ecosystems.

The Committee on the Status of Endangered Wildlife in Canada reports that the barn owl and the American chestnut tree are two endangered species in Ontario. Suitable habitat and food sources for barn owls are disappearing. The American chestnut has been almost wiped out by disease.

Consider This

With a classmate or as a whole class, discuss the following questions.

1. What happens to a food web when one or more of its organisms disappear? Study the meadow food web in Figure 2.5 on page 40. Trace what will happen when one organism disappears. How many organisms are affected? What if two organisms disappear?
2. Compare what would happen to a food web if two producers disappear to what would happen if two tertiary level consumers disappear. Predict the effect on the food web.

2.2 Cycling Matter

Here is a summary of what you will learn in this section:

- Decomposers break down organic matter in order to recycle basic elements.
- Carbon, nitrogen, and phosphorus atoms are basic elements of matter that are cycled in ecosystems.
- Cycling interactions are part of the constant change in ecosystems.

When you clean out your locker and find a very old sandwich under your science notebook, you will likely find decomposers at work. They are busy breaking down the organic matter of your sandwich into abiotic elements.

You may find decomposers in action in containers in the back of your refrigerator, in the composter in your yard, or in any natural environment. The decomposers are breaking organic matter down into abiotic elements that can be reabsorbed by biotic elements.

This over-and-over-again movement of matter from abiotic elements into biotic elements and back to abiotic elements is called a **cycle**. Decomposers are the engines of Earth's recycling program for nutrients.

Figure 2.8 Many communities have green bin programs for the disposal of organic matter.

A24 Starting Point

Skills A C

Organic Wastes and You

In nature, organic wastes are broken down for recycling by decomposers. What happens to the organic wastes you produce — apple cores, potato peelings, and other food materials? These things used to be thrown out with the garbage that went to landfills. Recently communities have started programs to keep this organic matter out of the landfills and create compost that returns minerals and nutrients to the soil more quickly (Figure 2.8).

Consider This

1. What is organic waste?
2. Research a community that recycles organic waste. What are citizens asked to do with their organic garbage?
3. List the benefits of a community organic waste disposal program.
4. Find out how your school recycles organic waste.

Figure 2.9 Decomposers will slowly reduce these carrots to mush that can be stirred back into the soil. The carrots will be broken down into nutrients to be reabsorbed by other organisms.

Cycling Organic Matter

Water is an abiotic element that moves through a cycle in ecosystems. Other abiotic elements also flow in cycles. These include carbon, oxygen, hydrogen, nitrogen, and phosphorus. Carbon is in carbon dioxide in the air, and oxygen and hydrogen are in the air and water. Nitrogen is in the air and in soil. Phosphorus is in soil.

The **cycling of matter** is a series of steps in a cycle that allows abiotic elements to be used over and over again. These abiotic elements are absorbed and used by producers to form organic matter. Consumers then absorb the organic matter through feeding interactions and use it for growth. As they grow, they produce organic waste. Decomposers break down the organic waste from living or dead organisms into abiotic elements that producers can use again (Figure 2.9).

The cycling of matter makes sure that there will be a constant supply of abiotic elements available for interactions in ecosystems.

A25 *Learning Checkpoint*

Going in Circles

1. When a bear leaves the remains of a salmon carcass in the forest, decomposers break it down into abiotic elements, including carbon and nitrogen and other nutrients (Figure 2.10). Describe how these different abiotic elements from the dead salmon are then reintroduced into an ecosystem.
2. Describe the difference between the way energy moves through ecosystems and the way abiotic elements such as carbon and nitrogen move through ecosystems.

Figure 2.10 The parts of the salmon that the bear did not eat will be broken down into abiotic elements and used again in the ecosystem.

Changes Resulting from the Cycling of Matter

As energy is transferred and matter is cycled, ecosystems are changed in very small ways. When you look at an ecosystem, it may not appear to change from one hour or day to the next. Over time, however, you will notice changes. From one season to the next or one year to the next, plants grow, perhaps shed leaves, or die. Animals build nests, reproduce, and then abandon their nests. Seeds sprout. Insects, birds, and animals die. Organic matter piles up. These changes are the result of the normal process of cycling matter.

The cycling of matter is continuous, in the same way that the transfer of energy is continuous. Small changes to the ecosystem are also continuous. Only by visiting an undisturbed ecosystem over a number of years will you see the results of all of the tiny changes taking place there (Figure 2.11).

Take It *Further*

A variety of abiotic elements move in cycles through ecosystems. These include carbon, nitrogen, and phosphorus. Choose one and find out why the way it cycles is important in ecosystems. Begin your research at ScienceSource.

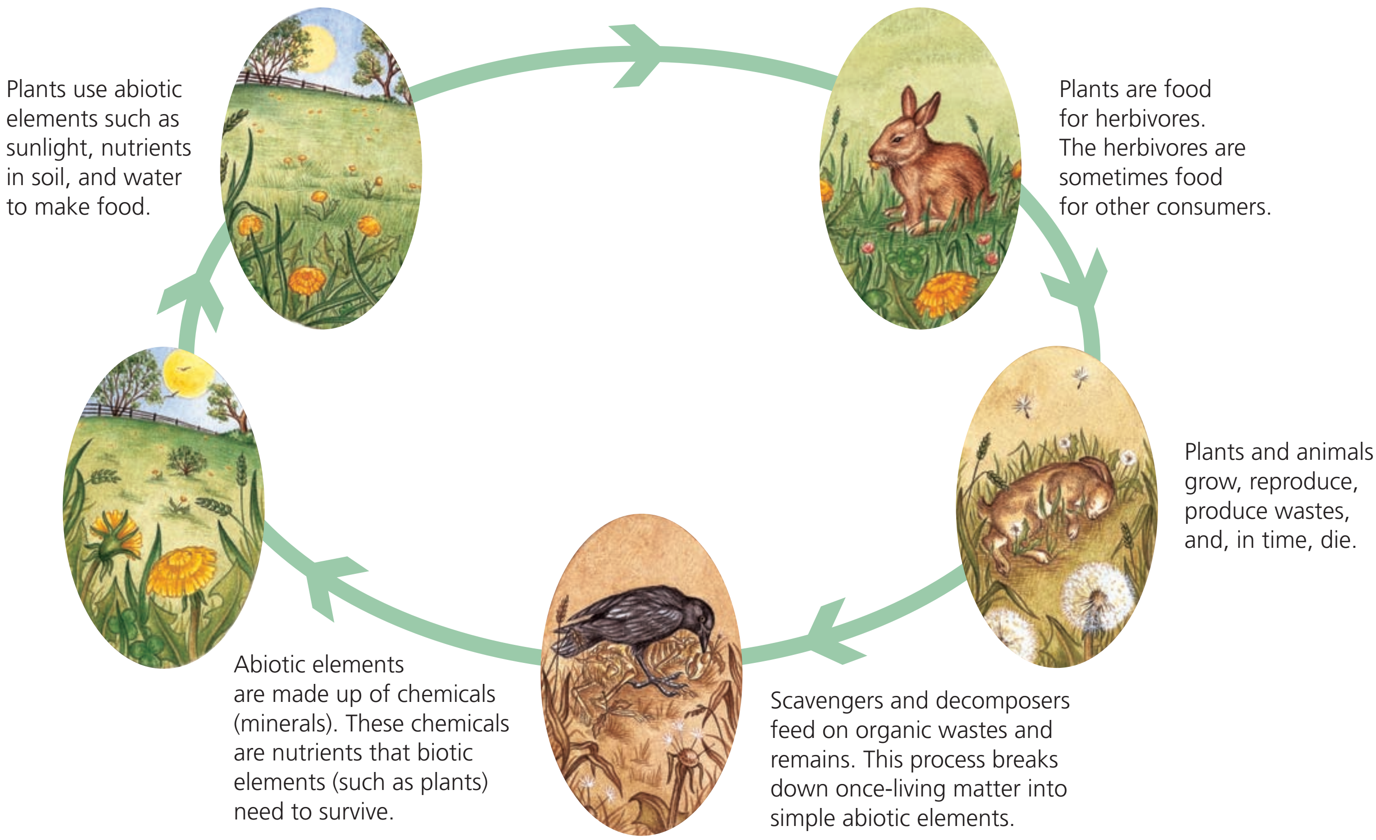


Figure 2.11 The cycling of matter in an ecosystem

A26 *Problem-Solving Activity*

Toolkit 3

SKILLS YOU WILL USE
- Identifying a problem
- Designing, building, and testing

Redesign a Package

Recognize a Need

Most goods sold in Canada must be shipped long distances. The goods must arrive in perfect condition and often require a lot of label information. Most packaging ends up as waste in landfills or ecosystems. If it is not made of organic matter, decomposers cannot break it down.

Figure 2.12

Problem

How can you make a secure package that can be broken down by decomposers?

Materials & Equipment

- a plastic vase of flowers with water, or
- a pyramid of marbles, or
- 4 hard-boiled eggs (not in carton)
- packaging materials of your choice

Criteria for Success

Your model addresses the following issues:

- the package can be broken down by decomposers
- goods in the package are not damaged in transit
- labelling requirements (required customer information) are met
- the package is appealing to customers

Brainstorm Ideas

1. Research the packaging for any one of the items listed. Answer the following questions: How is the item protected? How is it transported? How is it sold? What happens to the packaging?

2. What is the impact of the packaging on the environment? Can decomposers break it down? How long will it take?

3. What packaging alternatives would be better for the environment?

Build a Model

4. Create a package that meets the criteria for success but at the same time reduces the amount of packaging that would end up as waste.

Test and Evaluate

5. Using your new package, transport your item along the hall and up or down the stairs to another floor at the other end of the school using a custodian's two-wheeled device to transport it. Did your package meet the criteria for success?

6. Share and compare your ideas and findings with your classmates' plans and findings. Did anyone have ideas exactly like yours? Similar to yours? Completely different from yours? How do your results compare with theirs?

Communicate

7. Prepare a poster, computer slide show presentation, or a packaging "fair" to display alternatives. Or present your findings to the class in a form suggested by your teacher.

2.2 CHECK and REFLECT

Key Concept Review

1. What is organic matter?
2. Describe the cycling of matter. Give an example.
3. How can humans help with the cycling of basic nutrients in ecosystems?
4. Would you expect an ecosystem that had not been disturbed for 20 years to remain the same? Explain why or why not.
5. What kinds of changes would you expect to see in an ecosystem over time?
6. "Earth's ecosystems recycle." Is this statement true or false? Explain your answer.

Connect Your Understanding

7. What do you think would eventually happen in an ecosystem if there were no decomposers?
8. Why is the movement of basic elements in ecosystems different from the transfer of energy?

Practise Your Skills

9. Design a test for a package of yogurt. Define your criteria for a successful package. Include in your criteria that it can be broken down by decomposers. List the tasks the test would include.

For more questions, go to ScienceSource.

A27 *Thinking about Science and the Environment*

STSE

Chemicals in Food Chains

In 1938, a Swiss scientist discovered that a chemical called DDT could kill insects that destroyed crops and caused diseases such as malaria. For years, DDT was used around the world to kill millions of insects.

Decomposers broke down the dead insects and other organic matter treated with DDT. However, DDT itself was not broken down. Instead, it stayed in the organic matter and became part of local food chains. DDT in organic matter, in the soils, and in the water was absorbed or consumed by every organism in the areas where it was used.

Birds and other consumers ate plants, seeds, and insects that had been sprayed. DDT was stored in their bodies and passed on to the next level of consumers.

As DDT became part of food chains, the populations of many organisms decreased. The DDT they consumed either killed them or damaged them enough to make it difficult for them to reproduce. DDT was banned in North America in the 1980s, but it is still used in countries with a malaria problem.

Consider This

1. Communities where malaria is still a problem face a difficult choice. What factors should they consider when deciding whether to use DDT or not? What would you suggest?
2. Weed and insect killers are other popular chemical compounds. What benefits do they bring? What problems do they cause?

2.3 Interactions and Changes in Ecosystems

Here is a summary of what you will learn in this section:

- The supply of resources in ecosystems is limited.
- A big change in the supply of resources will disrupt the interactions in an ecosystem.
- A sudden change in resources can threaten the survival of biotic elements in an ecosystem.

Figure 2.13 When a consumer like the lamprey enters an ecosystem, there may be no predators to consume it. Its population can grow rapidly and wipe out other species.

In the Great Lakes and all other ecosystems, the size of the populations of biotic elements is controlled by factors such as available food, predators, climate, and suitable habitat. These factors control or limit the number and health of biotic elements in ecosystems. They are called **limiting factors.**

Ontario's Great Lakes provide a rich habitat for many different species of fish. For years, these fish were a source of food for reptiles, birds, mammals, and people living on and around the lakes. This changed suddenly in the 1960s, when the lamprey, a type of jawless fish, was introduced into the Great Lakes food web via the St. Lawrence Seaway (Figure 2.13).

In the Great Lakes, there was no predator to consume the lamprey. The lamprey had an abundant supply of salmon and lake trout to consume. While the lamprey population increased, the supply of lake trout decreased by almost 90 percent.

A28 *Starting Point*

Skills I C

Limiting Factors

In the example of the lamprey above, there were no predators, which would normally be a limiting factor. Without this limiting factor, the lamprey population grew out of control. The food web of the Great Lakes changed in many ways after the introduction of the lamprey.

Consider This

1. Work with a partner and try to predict when the lamprey population would stop growing.
2. What do you think happened to the fish populations the lake trout used to eat?

Why Ecosystems Change

The flow of energy and the cycling of matter are factors that affect the interactions of producers, consumers, and decomposers in ecosystems. The health and size of populations of producers and consumers are directly related to the amount of oxygen, water, food, energy, and suitable habitat available to meet their basic needs. The populations of biotic elements in an ecosystem adjust or regulate themselves so that the supply of these factors matches the needs within the ecosystem.

An ecosystem is constantly affected by a variety of factors that can cause it to change. For example, a lack of rainfall may cause the number of producers to decrease (Figure 2.14). As a result, the number of consumers in the food web will also decrease. Or if the number of producers increases because of higher rainfall, the populations of consumers may increase. Populations of biotic elements are limited by the supply of abiotic and other biotic elements that meet their basic needs.

Change is always happening in ecosystems. Ecosystems change because matter is always being cycled. They change because living things grow and die. Ecosystems may change because the supply of biotic or abiotic elements has changed for a short time. Or they may change because the supply of a biotic or abiotic element has changed permanently. Change in ecosystems can also be caused by an event such as bioinvasion or a change in competition for resources.

Figure 2.14 A long-term change in abiotic elements, such as a lack of rainfall, can kill the biotic elements in an ecosystem.

Bioinvasion

Many of the plants and animals that you may think are native to Canada actually have come from somewhere else. **Native species** occur naturally in a given area. European settlers introduced plants and animals from their home countries. Other species were introduced accidentally. An **introduced species** is one that was brought to an environment where it did not live before (Figure 2.15).

Scientists use the term **bioinvasion** to describe the introduction of foreign species into native ecosystems. Many of these new species were stronger than the native species or, like the lamprey, had no natural enemies. They quickly multiplied. Their effects on ecosystems and on other living things have been dramatic.

Figure 2.15 Purple loosestrife is an introduced species that is also invasive. Its roots are so dense that other plants in the area cannot survive.

Figure 2.16 Zebra mussels had no natural predators in the Great Lakes and found habitat that allowed their populations to grow quickly. They clog intake pipes in water treatment facilities and damage the machinery.

Zebra mussels were first noticed in the Great Lakes in 1988. By 1994, there were as many as 50 000 mussels/m^2 in some rivers near the Great Lakes (Figure 2.16). They have pushed native mussels out of their spot in the food web and taken over their habitat.

Both purple loosestrife and zebra mussels are **invasive species**. These are introduced species that are successful in their new environment that they interfere with the natural ecosystem (Figure 2.16). Native species can no longer survive where the invasive species lives.

Competition

Changes also occur in the populations of species in ecosystems because of their interactions 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, a human competition involves more than one person trying to reach the same goal. All living things compete with all other living things in their community. They compete for resources like food, water, and habitat. However, the supply of these resources is limited. This means living things are always struggling to meet their needs at the expense of other living things.

A29 *During Reading*

Thinking Literacy

Visualizing

Good readers often create pictures in their minds to help them understand what they are reading. What pictures came to your mind as you read about each of the following terms?

- producers
- consumers
- decomposers
- interaction
- energy transfer
- cycling of matter
- competition
- bioinvasion

Draw a summary of this section using these pictures. Create a poster, a computer graphic, or any graphic you wish to link your pictures and to summarize the key points in this section about change in ecosystems. Label your drawings.

Sustainability

Figure 2.17 Modern communities often destroy natural habitat when they expand.

An ecosystem is described as being sustainable when it can maintain a balance of needs and resources over time. In the past, the small Aboriginal populations used local resources in ways that did not drain the ecosystem of resources needed by other biotic elements. These practices supported **sustainability** — that is, the ecosystem's ability to continue or sustain itself.

Aboriginal peoples believe that they are part of local ecosystems. Non-Aboriginal peoples do not tend to think of themselves as part of local ecosystems. As these populations grow, their activities, even in areas far away from natural environments, affect the sustainability of ecosystems. Industry has changed the quality of abiotic elements such as air and water. Development has destroyed habitat, and the quantities of waste have overwhelmed the process of cycling organic matter (Figure 2.17).

Modern Human Impact

Scientists are questioning whether modern lifestyles will harm ecosystems in ways that could destroy them. Scientists are asking:

- What kinds of changes will happen in ecosystems as a result of our modern way of life?
- Will these changes destroy the sustainability of local ecosystems?
- Can human populations survive without ecosystems to supply their basic needs?

In 1987, the United Nations stated that human activity must not interfere with the ability of ecosystems to sustain themselves. This means that human activity should use technologies and practices that do not do long-term damage to the biotic and abiotic elements that all organisms need.

Take It ***Further***

Cities in Canada and elsewhere are trying to reduce their impact on the environment. Look at what they are doing and list the effects these changed activities could have on the environment. Begin your research at ScienceSource.

SKILLS YOU WILL USE
- Asking questions
- Recording and organizing data

Competition in Ecosystems

Figure 2.18 The plants in this meadow compete for resources.

Question

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

Design and Conduct Your Investigation

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 will 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 am 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?

A31 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Drawing conclusions
- Reporting results

Ecosystem in a Jar, Part 2

Question

How does knowledge of the transfer of energy and the cycling of matter explain what has happened in the sealed ecosystem?

Materials & Equipment

- sealed ecosystem created in A16 Ecosystem in a Jar, Part 1
- chart of observations made over the past several weeks
- drawing/photo of the sealed ecosystem made when it was set up
- drawing of what you originally thought the sealed ecosystem would look like after several weeks

Procedure

1. Review the chart of observations made over the past several weeks.
2. List the interactions you think occurred in the sealed ecosystem.
3. Classify the interactions according to whether they related to the transfer of energy or the cycling of matter.
4. Record the roles of the different biotic elements in the sealed ecosystem.
5. Compare your predictions and drawing of the sealed ecosystem with what it looks like now.

Figure 2.19

Analyzing and Interpreting

6. For any changes you observe in the ecosystem, suggest reasons that might explain what happened.
7. What organisms were able to meet their basic needs in your sealed ecosystem? How do you know? Which ones did not meet their needs? What could have led to these biotic elements not meeting their needs?

Skill Builder

8. How can you organize your data to report the progress of your sealed ecosystem?

Forming Conclusions

9. In what ways did your prediction match the result? In what ways was it different from your expected result?
10. How does the information you have learned since you created your sealed ecosystem explain your results?
11. How was your ecosystem limited in the number of living things it could support?

2.3 CHECK and REFLECT

Key Concept Review

1. Explain in your own words how populations are limited in ecosystems.
2. How can a new species with no natural predator affect the populations of other species in an ecosystem?
3. (a) What effects would a drier-than-average summer have on a pond ecosystem?

   (b) How is this different from the effects resulting from draining the pond?
4. What is sustainability?
5. What factors affect the populations in an ecosystem?

Connect Your Understanding

6. How might the building of a new highway affect the sustainability of the ecosystem it goes through?
7. Some schools work to reduce the use of paper. Some communities have organic waste treatment programs. Are these examples of sustainable approaches to the environment? Explain your thinking.

Practise Your Skills

8. Design a poster or short multimedia presentation to share ideas on the importance of sustainability.

For more questions, go to ScienceSource.

A32 *Thinking about Science and the Environment*

Revisiting Your Consequences Map

In Chapter 1, you used a consequences map to show a possible chain of consequences resulting from an activity. There are many human activities that can have short- and long-term effects on the environment. As people begin to understand the concept of sustainability, they need to look carefully at the environmental consequences of their activities.

Work with a classmate and make a list of different human activities that can affect the interactions among biotic and abiotic elements, the flow of energy, or the cycling of nutrients in ecosystems. Activities could be related to transportation, entertainment, or lifestyle choices.

What to Do

1. Review the list of activities. Which ones have you done in the past two weeks? Choose one, and create a consequences map for the activity. Be sure to identify the possible chain of consequences.
2. Compare the chain of consequences in your map with a classmate's map. In what ways are they similar? How are they different?

Consider This

3. How does a consequences map help you understand how human actions and decisions can affect the sustainability of ecosystems and the environment?

Foresters

Figure 2.20 Foresters spend much of their time out in the field.

Forests are an important part of Canada's economic resources, providing employment for workers and a variety of products. The trees provide oxygen for Earth, habitat for plants and animals, and fuel and shelter for communities.

Foresters manage and supervise Canada's forest resources. They assess the size and type of trees to determine the value of the wood. When assessing the value of a forest, foresters may decide that it is more valuable if it is left as a habitat, and logging companies will look elsewhere for trees to harvest.

Forest Ecosystems

When making these decisions, foresters consider the ability of diverse and healthy ecosystems to survive logging. Foresters also monitor the impact of cutting trees in animal habitats and work to make sure that there is minimal damage when logging companies proceed with their work.

Trees are a renewable resource, and new trees that belong in the local ecosystem are planted after a harvest to restore the forest. Canada's logging industry can only continue if it follows the United Nations' suggestion and does not harm the ability of forest ecosystems to sustain themselves.

Technology and Forestry

Foresters use a variety of tools, including advanced infrared photography, satellite imagery, aerial photographs and even remote sensing to assess and manage forest resources. They use these technologies to keep an inventory of the number and types of trees in different forests, so proper decisions can be made on whether trees should be harvested for lumber, cut down to stop the spread of disease, or preserved for the wildlife in the area.

Professional foresters work for lumber companies, government monitors, or on their own. They play an important role in supporting a Canadian resource industry as well as preserving ecosystems.

Questions

1. What are some of the factors foresters have to consider before making decisions?
2. How does technology help foresters do their jobs?
3. How do you think the idea of sustainability influences the work of foresters?

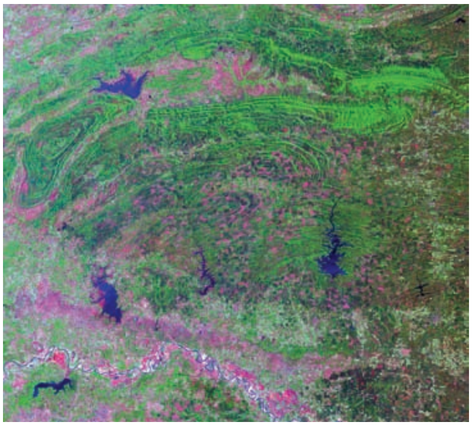


Figure 2.21 Infrared photographs show temperature differences. They can help foresters determine the amount of living and dead vegetation in an area.

2.0 Chapter Review

Assess Your Learning

Key Concept Review

1. Energy is a basic need for all living things. How do food webs demonstrate how different living things in an ecosystem get the energy they need to survive? (k)

2. What role do bacteria and other tiny organisms have in making sure that nutrients are always available in ecosystems? (k)

3. Explain how turning a small forest and the meadow around it into a shopping centre affects the environment. (k)

4. What types of activities could make a human community more sustainable? (k)

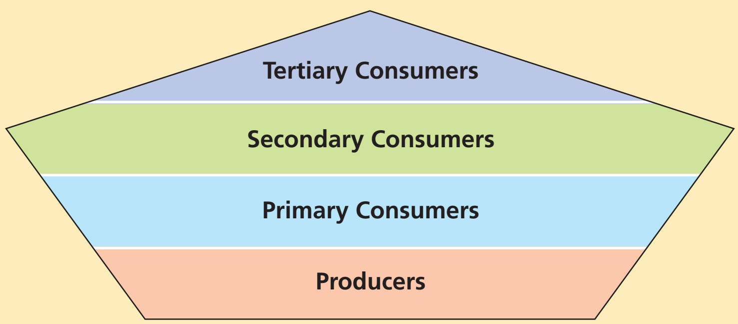
Connect Your Understanding

5. What mechanisms are in place in a stream ecosystem to make sure that the populations of biotic elements are controlled and interactions are balanced? (t)

6. Is recycling cans, bottles, and paper a practice that promotes sustainability? Explain your reasoning. (a)

7. The zebra mussel arrived in the Great Lakes about 20 years ago. Since then, its population has exploded, and it is found in many lakes and rivers. Prepare an oral news report to explain the rapid growth in the population of zebra mussels. Predict what you think may happen in the future. (t)

8. Look at the energy pyramid shown below. Do you think it represents an ecosystem that could survive for a long time? Explain your reasoning. (t)



After Reading — Thinking Literacy

Reflect and Evaluate

Revisit the preview you did at the beginning of the chapter. Review the main ideas you confirmed or modified as you worked on this chapter. Create a study outline explaining and illustrating each of these main ideas.

ACHIEVEMENT CHART CATEGORIES

(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

Practise Your Skills

9. How could an ecosystem sealed in a jar model a real ecosystem? a
10. Explain why brainstorming a number of options to solve a challenge could improve the final solution. t
11. How can knowing the inquiry process of science help you make decisions in your daily life? a
12. How can establishing criteria for a successful solution help you solve a problem? a

Unit Task Link

The cycling of matter is an important part of all ecosystems. In your science notebook, keep a "trash diary" for a week. Create a table with two columns, Recycled and Not Recycled. Classify the things you threw away in one of the two columns.

A33 Thinking about Science and the Environment

STSE

Impact of Expanding Human Habitats on Other Living Things

When natural ecosystems are undisturbed, the populations of producers, consumers, and decomposers and their interactions tend to be balanced. Through interactions, energy is transferred, and matter and essential nutrients are cycled continuously in habitats on land and in or on water.

Human habitats have made greater and greater use of technology over time. They are likely to feature materials that cannot be cycled quickly. Our demand for energy and other resources is usually more than what is needed to meet basic needs. It is also usually more than we can get from our local area. These resources must be brought in from outside the community.

Our use of technologies has had a big impact on the environment. The expansion of our habitat has often come at the expense of the habitat of other biotic elements.

What to Do

1. Work with a partner and discuss the following statement:

   Humans should minimize their impact on the habitat of other organisms when they are planning and building their own habitat.

   Do you agree? Why or why not?

Consider This

2. With a classmate or as a whole class, discuss the following questions.
   (a) How do human activities affect the interactions and balances in ecosystems?
   (b) How does human technology affect the interactions and balances in ecosystems?
   (c) How much should humans change their activities so that other habitats and ecosystems can continue to exist? Explain your reasoning.