3 Governments, groups, and individuals work together to promote sustainable ecosystems.

This farmers market is in the Kitchener area. Using farmers markets is one of the many actions that groups and individuals are taking to live in a more sustainable way.

Skills You Will Use

In this chapter, you will:

- find sources of information that are relevant to the questions you are researching
- select, organize, and record the relevant information you find as you research a topic

Concepts You Will Learn

In this chapter, you will:

- assess the impact of a human activity that threatens the sustainability of an ecosystem
- evaluate the effectiveness of actions people are taking to ensure that ecosystems are sustainable.

Why This Is Important

You need to know what actions governments, organizations, and individuals are taking to correct the damage humans have done to ecosystems. Once you know the things they are doing, you can evaluate whether their actions are effective. You can also decide what types of actions you can take to help the environment.

Before Writing

Thinking Literacy

Preparing to Select and Organize Information

When you are researching a topic, not all the information that you read will be useful to you. Get in the habit of deciding what's truly important and what's not essential. As you think about issues related to sustainable ecosystems, skim section 3.1 and decide which information could be truly useful and which is just nice to know.

Key Terms

• at risk • ecological footprint • endangered • environmental steward • ex-situ conservation • extirpated • in-situ conservation • integrated pest management • special concern • threatened

3.1 Government Action to Protect Canada's Ecosystems

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

- Conservation biology works to protect biodiversity, partly by assessing which species are at risk of extinction and developing strategies to protect these species.
- Species at risk are protected in their own surroundings by improving their habitat or by removing them from the wild until their wild habitats can be restored.
- Governments use laws to enact programs to protect ecosystems.

Figure 3.1 Many people enjoy Lake Erie.

Lake Erie: "The Comeback Kid"

Lake Erie, the shallowest and smallest of the Great Lakes, can be the ultimate Canadian getaway. Because the lake is shallow, it warms quickly in the summer. This makes it popular for many different recreational activities (Figure 3.1).

In the 1970s, Lake Erie was very different. Its water was full of sewage, farm chemicals, and industrial chemicals (Figure 3.2). This chemical "soup" had the potential to cause a collapse of the entire lake ecosystem. The most visible example was runaway algae growth, which left an unsightly scum across the lake. When the algae grew, it choked out other organisms. When it died, its decay removed dissolved oxygen from the water, causing massive fish kills.

Figure 3.2 A pulp and paper mill dumps polluted waste water directly into Lake Erie in the 1970s.

How did this come about? There are many pressures on the lake. More than 12 million people live near its shores. The Lake Erie watershed is one of the most intensely farmed regions on the continent. With population growth came industry. Many people, though not all, operated for decades on the assumption that the lake was so large that it could safely absorb any amount of substances put into it by humans. By the 1970s, the effects of this approach had produced a smelly lake filled with sick or dead fish. No one wanted to go near Lake Erie.

Governments Take Action

In 1978, the United States and Canadian governments signed the Great Lakes Water Quality Agreement. Its goal was to restore the chemical, physical, and biological integrity of the Great Lakes in a co-ordinated way. As a result, the Ontario provincial government and various U.S. state governments created management plans to clean up each of the Great Lakes. One of the many actions proposed in Lake Erie's management plan was to restore wetlands along its shores. In addition to restoration projects, the Essex County Stewardship Council has helped private landowners create new wetlands on their land. These wetlands filter the water entering the lake and remove contaminants from it. The amount of chemical fertilizer, pesticide run-off, and untreated sewage entering the lake was also reduced. As a result, Lake Erie has made a significant recovery, though there is still much work to do.

Lake Erie's ongoing restoration is an example of the power of collective action. When governments, groups, and individuals work together for a common purpose, great things are possible.

A19 *Quick Lab*

Modelling a Wetland

Plants can purify water as they live and grow. In this activity, you will investigate this process.

Purpose

To model a wetland removing chemicals from water

Materials & Equipment

- 50-mL beaker
- 2 large test tubes and stoppers
- warm water
- phenol red indicator
- straw
- 2 aquatic plants
- aluminum foil
- bright light source

Procedure

1. Fill a beaker with 50 mL of water.
2. Add five drops of phenol red solution to the beaker, and use a straw to blow bubbles into it until the solution just turns yellow.
3. Fill two test tubes three-quarters full with the solution.
4. Place an aquatic plant into each test tube, and seal each test tube tightly with a stopper.
5. Wrap one of the test tubes with aluminum foil. Put the foil-wrapped test tube in a dark place, and place the unwrapped test tube under a bright light. After 20 min, observe each one.

Questions

6. The colour change that occurred in step 4 was a result of removing carbon dioxide from the solution. Consider which tube the colour change occurred in, and explain how carbon dioxide was being removed.
7. Explain how this model demonstrates the ability of a wetland to purify water.

Conserving Biodiversity

The modern science of **conservation biology** seeks to understand and protect biodiversity. Part of this task includes assessing which species are most in danger of extinction as well as developing strategies to protect them.

Species at Risk

If you had strolled through meadows near Peterborough sometime in the 1900s, you might have seen the bright blue wings of a Karner blue butterfly as it flew from plant to plant. Today, this would be impossible because the butterfly no longer exists in Ontario. Luckily, it still exists in small populations elsewhere in North America.

Around the world, extinctions are happening at a rapid rate. But species do not become extinct overnight. When populations of a species decline over time, the species may be at risk. **At risk** means any native species that is in danger of becoming extinct or disappearing from a region. There are different levels of risk (Table 3.1).

Table 3.1 Definitions of Some Risk Levels for Species

Level of Risk	Definition
Extirpated	A species that no longer exists in Ontario but still occurs elsewhere
Endangered	A species that faces extinction or extirpation
Threatened	A species that is at risk of becoming endangered if limiting factors are not reversed
Special concern	A species with characteristics that make it sensitive to human activities or natural events

Figure 3.3 Some at-risk species in Ontario. (a) The Karner blue butterfly is extirpated. (b) The eastern prairie fringed orchid is endangered. (c) The eastern Massasauga rattlesnake is threatened. (d) The red-headed woodpecker is of special concern.

There are currently over 200 species at risk in Ontario (Figure 3.3). There are two conservation strategies that governments and groups are using to protect biodiversity.

Conservation Strategies

One problem in conserving biodiversity is that plants and animals do not recognize national boundaries. In order to co-ordinate conservation efforts, governments of different countries use international treaties. A treaty is an agreement, usually between nations, in which they agree to do certain things to achieve a common goal. The Convention on Biological Diversity is the name of an international treaty whose goals are to conserve Earth's biodiversity and to use this biodiversity in a sustainable way. The Convention on Biological Diversity has been signed by 161 countries, including Canada. It makes use of two broad strategies: one is to protect species in human-made environments such as zoos, while the other protects species in their native habitats.

Protecting Species in Human-Made Habitats

The black-footed ferret was extirpated in Canada in 1937, and by the 1980s, only 18 individuals remained in Wyoming. The decision was made to capture these individuals and take them to various zoos, including the Metro Toronto Zoo. This is an example of ex-situ conservation (Figure 3.4).

Figure 3.4 The Metro Toronto Zoo maintains a population of black-footed ferrets through its captive breeding program.

During Writing Thinking Literacy

Making Notes

As you research, take notes in point form. Never copy word for word. Instead, choose key words, definitions, and any direct quotes that will support your writing purpose.

Figure 3.5 Constructed 120 m below the ice on an island in the Arctic Ocean, the Svalbard Seed Bank can conserve up to 4.5 million seeds. These seeds can act as a backup for any plants that have been lost due to accidents, mismanagement, or natural disasters.

Ex-situ conservation conserves species by removing them from their natural habitats. This strategy is used when a species' habitat is threatened or no longer exists, or if the existing population is extremely small. The at-risk individuals are taken to zoos, botanical gardens, or reserves.

Zoos play an active role in preserving biological diversity through breeding programs and other efforts. Many zoos across North America participate in Species Survival Plans (SSPs). SSPs are breeding programs specifically for species threatened with extinction. The strategy seems to have worked for the black-footed ferret. The Metro Toronto Zoo's SSP has been very successful, and hundreds of ferrets have been reintroduced to protected areas in the U.S. prairies. The zoo and various other organizations are currently developing plans to reintroduce the ferret into Grasslands National Park in Saskatchewan.

Seed banks are an additional ex-situ conservation strategy (Figure 3.5). Seeds of endangered plants and rare crop plants can be stored in seed banks. Seed banks may be used to maintain the ability to restore the population even if it completely disappears from the wild.

Protecting Species in Their Native Habitats

WORDS MATTER

"In situ" is Latin for in the original place, and "ex situ" is Latin for out of the original place.

Ex-situ conservation is considered a strategy of last resort. **In-situ conservation** focusses on conserving species in their natural surroundings. In-situ conservation uses many strategies, but the main one is protecting species' habitats. For example, the endangered eastern loggerhead shrike needs short grasslands surrounded by trees, shrubs, and hedgerows (Figure 3.6). Much of this habitat has been lost by farmers removing hedgerows and converting pastureland to other crops. By getting farmers to preserve their pastureland and hedgerows, the shrike's habitat is maintained and the population may increase.

Figure 3.6 A loggerhead shrike

Another strategy is to help protect a species from its predators. For example, female Blanding's turtles leave their eggs in buried nests. The eggs are vulnerable to raccoons and coyotes, who dig up the nests. One strategy is to protect nest sites by fencing them off.

Other strategies include cleaning up or restoring habitat or isolating a habitat from human activity by creating reserves. For animals, this usually means establishing large enough land reserves to allow the population to recover to sufficiently large numbers.

Recall that biodiversity means much more than just having many different kinds of species in an ecosystem. A population

within an ecosystem must have sufficient genetic diversity to be able to adapt to changing circumstances and to evolve over time. When a large population is brought back from just a few surviving pairs, all the offspring are very closely related. A single disease could wipe out the entire population in one epidemic. This problem rarely occurs in a healthy, genetically diverse population. In-situ conservation helps keep organisms interconnected with their habitat and, over time, helps re-establish genetic diversity.

Learning Checkpoint

1. What is the difference between a species that is endangered and one that is threatened?
2. What is a treaty?
3. What are the two main conservation strategies endorsed by the Convention on Biological Diversity?
4. Which of the two strategies in question 3 is considered to be a strategy of last resort? Why is it a last-resort strategy?
5. Explain the importance of genetic diversity within a species.

Protecting Endangered Species

The American badger is endangered in Ontario (Figure 3.7). Fewer than 200 individuals remain in isolated pockets, mostly on private land. In 2007, the Ontario government passed the Endangered Species Act. This law prohibits killing, capturing, possessing, selling, or trading species that are endangered in Ontario. The law not only protects at-risk species, it protects their habitats as well. This means that it becomes illegal to damage or destroy ecosystems that the species depends upon. This gives developers, local governments, and people who live or work in the habitat direction as to what is or is not permissible in a given situation. For example, landowners that have American badgers on their property are responsible for preserving the badgers' habitat. The law has some flexibility so that local concerns about resource use in a particular habitat can be addressed. However, individuals or groups that ignore the law can be accountable and financially liable for repairing the damage they cause.

Figure 3.7 The badger's main food is woodchucks and rabbits, which it catches by digging into their burrows.

Establishing Protected Areas

Establishing protected areas is one method to slow down the loss of biodiversity. Protected areas include national and provincial parks, wildlife reserves, and marine sanctuaries. Choosing which areas to protect can be a challenge. Worldwide, conservation biologists have identified "biodiversity hot spots," areas that have many unique ecosystems and whose biodiversity is threatened (Figure 3.8). These areas contain species found nowhere else on Earth. Many of these species are endangered.

The Role of Parks

In Ontario and the rest of Canada, parks and wilderness areas protect ecosystems by keeping them relatively undisturbed. Leaving ecosystems undisturbed helps conserve biodiversity.

Figure 3.8 The biodiversity hot spots are shown in orange on the map.

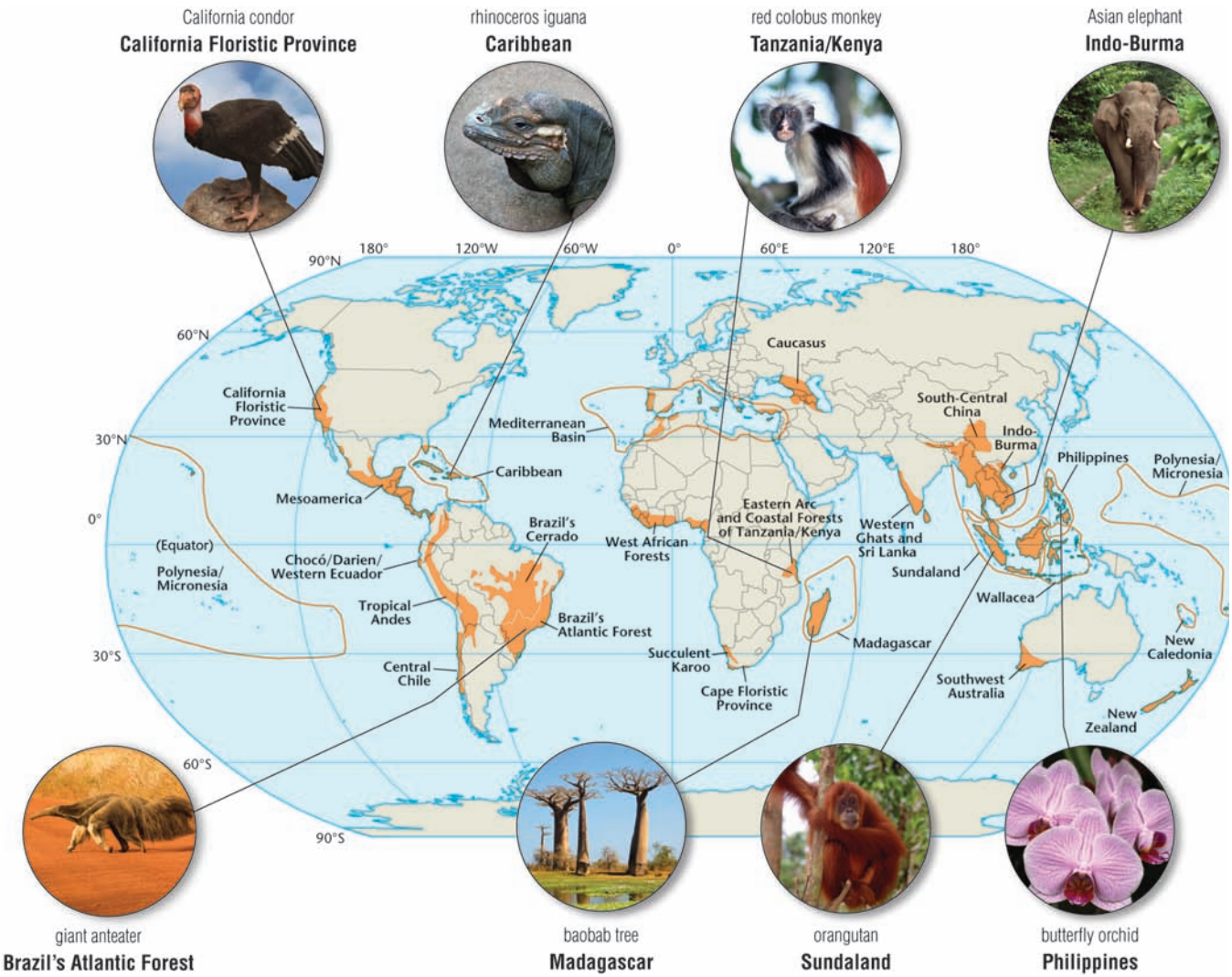


Figure 3.9 Algonquin Park receives about six million visitors a year.

Another role of parks is to allow humans to enjoy these ecosystems. Sometimes, this is difficult. For example, Algonquin Park is one of Ontario's larger provincial parks, but it is also one of the most heavily visited (Figure 3.9). Parks officials work hard to balance humans' need for recreation with ecosystems' need to remain undisturbed.

Creating Action Plans to Restore Ecosystems

Suggested STSE Activity
A20 Decision-Making Analysis on page 102

As we have seen, many human activities cause damage to the natural environment. Remedial action plans involve governments, industries, and community groups working together. For example, the St. Lawrence River near Cornwall had many environmental problems, including bacterial and heavy-metal contamination and habitat destruction. The first stage of the remedial action plan for the area was to identify the specific causes of the problems. In the next stage, government agencies, industry representatives, and community groups met to develop specific plans to fix the problems. As a result, Cornwall's municipal government improved its sewage treatment plants to reduce bacterial contamination in the river. Domtar Fine Papers' pulp and paper mill improved its waste water treatment process to reduce the amount of heavy metals entering the river. Also, various agencies built artificial reefs and small wetlands along the shore to improve fish habitat.

The third stage of remedial action plans is to monitor conditions to check that the actions taken are working. In Cornwall, the actions seem to have worked. Water quality as well as fish diversity and populations are starting to improve. But there is still more work to be done.

Figure 3.10 Because plants take time to grow, habitat restoration often takes many years to complete.

Many wetlands in Ontario have been threatened by population growth, farming, and industrial activities. One major focus of remedial action plans is habitat restoration, such as returning a disturbed wetland to a condition as close to its original state as possible (Figure 3.10). For example, the Oshawa Second Marsh has been undergoing a complex clean-up and replanting to restore it.

Preventing the Introduction of Invasive Species

Ontario is home to many species of hardwood trees, including the sugar maple. These trees have evolved for thousands of years and adapted to life in this region. The Asian long-horned beetle, a species native to China, was first detected in North American forests in 1996 (Figure 3.11). It may have arrived in wooden packing crates used to deliver goods from Asia. These beetles are now a serious threat to hardwood tree species in Ontario.

Various levels of government are involved in preventing the spread of the Asian long-horned beetle. For example, the City of Toronto is trying to stop further spread of the beetle by establishing by-laws against moving firewood and other wood products that may contain the beetle (Figure 3.12).

Figure 3.11 The Asian long-horned beetle was first discovered in Toronto and Vaughn in 2003.

Figure 3.12 The City of Toronto, the Municipality of Vaughn, and Agriculture Canada are working together to prevent the spread of the beetle.

Also, Agriculture Canada, a branch of the federal government, has strict laws against citizens or visitors bringing foreign food, animals, or plants into the country. This helps prevent people from unwittingly introducing foreign organisms into Canada's ecosystems (Figure 3.13).

Figure 3.13 This sniffer dog at Pearson International Airport is trained to detect food and plants in luggage.

Learning Checkpoint

1. List four ways in which governments can help sustain biodiversity.
2. (a) How does the establishment of protected areas help sustain biodiversity?

   (b) What are three types of protected areas used by governments to do this?
3. What is a remedial action plan? Give an example of such a plan.
4. What organism currently threatens Ontario hardwood species, and what government actions are being used to slow its spread?

Take It Further

According to some estimates, species are going extinct at a rate of 1 every 20 minutes. Data collected by ecologists are combined with models to calculate this average rate. The model helps estimate how many species are currently on the verge of extinction. Go to ***ScienceSource*** to find out more about the model.

A20 STSE *Decision-Making Analysis* Skills Reference 4

SKILLS YOU WILL USE
- Identifying and locating research sources
- Thinking critically and logically

Assessing a Government Program — Recycling

Issue

Recycling programs divert wastes from landfills. Recycling was practically unknown only a generation ago. Now, all municipalities in Ontario participate in some form of recycling program. It is not without its difficulties, and making it possible to connect everyone into a recycling network is still a major goal.

Background Information

Garbage disposal is a major issue for many municipalities across Ontario because the use of landfills only is not a sustainable approach. Landfills have a tendency to fill up. Building new landfills is expensive, and local residents are usually reluctant to have them near their property. Chemicals can leak out of an improperly constructed landfill. Heavy metal contamination from old batteries and electronics is just one example.

Blue and grey boxes, green bins, and yard waste composting programs have generally been successful in Ontario (Figure 3.14). For example, in the City of Toronto, 42 percent of residential waste is redirected from landfills through recycling programs. However, apartment dwellers recycle only 13 percent of their garbage.

Suppose that you have been hired by your local council to create an action plan to increase participation in the local recycling program. The council wants you to find out which groups cannot or will not participate in the current recycling program.

Figure 3.14 Some municipalities do not have curbside pickup for recycling.

They also want you to suggest ways to increase participation. Be aware that some members of the council do not see the benefits of recycling. In order to make the case for expanding the recycling program, you have to outline the benefits to them as well.

Analyze and Evaluate

1. ***ScienceSource*** On the Internet, find information about the diversion of solid waste from landfills. Also look in print materials for information on waste diversion from landfills.
2. Research your local recycling program. Find brochures, fact sheets, and newspaper articles to answer the questions below.
   - Who can participate in the program? Businesses, single-family dwellings, apartment buildings? People in rural areas?
   - How does it work? Is there curbside pickup, or do residents have to take their recycling to a depot?
   - Is it difficult for some groups to participate? If so, which groups, and why?
3. Use your research to develop a plan that could improve current recycling efforts for the groups you have identified that have trouble participating.
4. **Web 2.0** Develop your findings about recycling for the local council in the form of a Wiki, a presentation, a video, or a podcast. Make sure to outline your action plan to improve participation in the recycling program.

Skill Practice

5. Prepare a five-point summary specifically designed to explain the benefits of recycling to someone who may not think recycling is worthwhile.

3.1 CHECK and REFLECT

Key Concept Review

1. What is the role of conservation biology in ecosystem management?
2. List four levels of classification of at-risk organisms, and explain the meaning of each.
3. Give an example for both in-situ conservation and ex-situ conservation.
4. What is the difference between extirpated and extinct?
5. List two approaches that the Convention on Biological Diversity uses to help conserve species.
6. What are two major roles for zoos?
7. What are the advantages of protecting a species without removing it from its natural habitat?
8. How does the Ontario Endangered Species Act work to protect at-risk species?

Connect Your Understanding

9. Why is it important for there to be an agreement between Canada and the United States to help rehabilitate the Great Lakes?
10. Suppose the Canadian government has decided to create more national parks. You have been asked to decide which places should be considered as potential sites for parks. How would the concept of biodiversity hot spots help you make decisions?
11. How has the rehabilitation of the Great Lakes helped to ensure ecological sustainability?
12. Propose a course of action to successfully reintroduce the Karner blue butterfly to the meadows near Peterborough.
13. The grey fox, pictured in the photograph, is threatened in Canada. It is estimated that there are at least several thousand breeding pairs. Would in-situ or ex-situ methods be most appropriate to protect this species? Explain.

Question 13

14. Canadian border officials allow a family to bring a box of grapefruit home to Canada from their trip to Florida. However, United States border officials confiscate a box of grapefruit that another family wishes to bring with them on their trip to the U.S. Propose a reason for the different responses to the grapefruit by U.S. and Canadian officials.

Reflection

15. This section identified different actions that governments can take to ensure the sustainability of ecosystems. Which of the actions interested you the most? Why?
16. How can you, as an individual, have an impact on the way your municipal, provincial, or national government takes care of ecosystems?

For more questions, go to *ScienceSource*.

3.2 Environmental Stewardship

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

- Ecological footprints show individuals, groups, or nations how much land is needed to produce what they consume and absorb their wastes.
- Environmental stewardship means taking care of resources in a sustainable way.
- Organizations and individuals are taking action to make sure we use resources in a sustainable way.

Figure 3.15 An artist's rendition of the restored Brick Works, once it is completed.

The Toronto Evergreen Brick Works

What happens when you combine leading-edge technologies in sustainability, support for local food producers, use of abandoned heritage buildings, and a way to connect a city community with its own local ecosystem? In Toronto, the result is Evergreen Brick Works, an urban restoration project (Figure 3.15).

The Brick Works was originally built in 1889 on a flood plain in the Don River Valley, in the heart of the city. The factory produced many of the bricks used in many of Toronto's buildings, as well as buildings across Ontario and Canada.

As the city grew, the Don Valley was spared from development because the river flooded occasionally. This helped keep the area available as parkland. The Brick Works closed in the 1980s, and the buildings were abandoned.

Today, these abandoned buildings are being transformed into a national centre for environmental education. The centre will offer programs on how to integrate sustainability into daily living. One of the first projects to open was a farmers market. Every weekend, it is filled with shoppers (Figure 3.16). The market supports local producers and connects consumers with high-quality, locally produced food.

Figure 3.16 The Brick Works farmers market opened in 2007 and has been a great success.

Restore, Reduce, Renew

The restoration plan for one of the buildings includes many measures to reduce the building's environmental impact. It incorporates a vertical garden or "living wall" to help moderate the building's temperature. To reduce the need for heating and cooling, a series of movable panels on the exterior walls shade the building in summer and help to warm the building in winter. Large-scale art installations can be attached to the panels.

The Don River is also being restored to make its banks more suitable for native species to thrive. In this way, both the lands and the buildings are undergoing renewal. Evergreen Brick Works is one of many examples of how environmental stewardship continues to take hold in our society (Figure 3.17).

Figure 3.17 Evergreen Brick Works site in the Don Valley

A21 *Quick Lab*

Making Connections

"Environmental stewardship" is a term that relates many ideas that you have studied in this unit. In this activity, you will have an opportunity to recall the meanings of some of these ideas and will practise connecting them in sentences.

Purpose

To make connections between concepts related to environmental stewardship

Materials & Equipment

- 1 six-sided die

Procedure

1. Pick a partner.
2. To start, one partner rolls the die three times. The first roll of the die corresponds to a Society factor listed below, the second corresponds to an Environment factor, and the third corresponds to an Impact factor. For example, if the first roll is 4, then the factor is "regulations."
3. The roller now creates one to three sentences that connect the three terms together.
4. While the first roller writes, the other partner does steps 2 and 3.
5. Repeat as many times as time permits.

Questions

6. Share with your class the best sentence that you came up with, and explain why you think it worked so well.
7. List any combinations of words that did not work well together, and suggest a reason why this was the case.
8. Think of one new word for each category, and write a sentence connecting the new words.

Society	Environment	Impact
1 Conservation	1 Nutrients	1 Overexploitation
2 Culture	2 Water	2 Habitat change
3 Politics	3 Air	3 Invasive species
4 Regulations	4 Soil	4 Pollution
5 Consumption	5 Habitat	5 Climate change
6 Recycle	6 Energy	6 Technology

Suggested Activity •
A23 Quick Lab on page 115

Ecological Footprint

An **ecological footprint** is an estimate of how much land and water is needed to support your lifestyle (Figure 3.18). This includes all the land and water needed to produce the resources you consume as well as absorb all the wastes you produce. The wastes include all the emissions produced in manufacturing the products you consume. All the things that ecosystems provide are also considered to be a part of your ecological footprint, including providing fresh water and decomposers that recycle wastes.

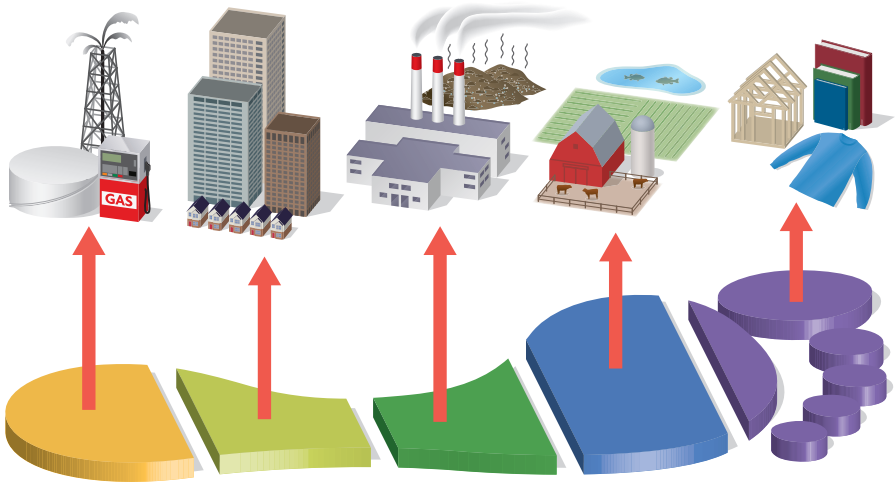


Figure 3.18 A person's ecological footprint includes the space needed for extracting energy, living and working, manufacturing and waste disposal, growing food, and extracting resources (timber, pulp and paper, textiles).

Table 3.2 Some Other Nations' Footprints

Country	Footprint (ha/person)
India	0.86
Pakistan	0.64
Japan	4.77
United States	9.57

The average Canadian requires 8.9 ha to maintain his or her lifestyle. This is equivalent to about 17 football fields. If everyone on Earth had the same ecological footprint as a typical Canadian, we would need 5.7 Earths! The size of people's ecological footprints varies widely throughout the world (Table 3.2).

An ecological footprint is a tool that can be used to determine how much resources a person, an organization, or even an entire country consumes. Once we know our ecological footprints, individuals, organizations, and countries can then know to what extent they need to engage in more sustainable activities. Many Canadian municipalities are now using ecological footprints to measure their progress towards sustainability. A large number of environmental stewardship programs also calculate ecological footprints in order to evaluate their progress. An ecological footprint can be calculated for a person, a building, a nation, or a whole continent.

Scientists are concerned that as populations increase and consumption of resources also increases, at some point, the world's ecological footprint will eventually equal all the available land and water on Earth. A number of estimates now suggest that we reached that point in 1990. From that time on, we have been consuming Earth's resources faster than the planet can regenerate them. We live in a unique and risky period where we consume more than Earth can produce. We have to change the way we use Earth's resources.

Environmental Stewardship

A good steward is someone who manages any sort of resource wisely. Being an **environmental steward** means taking care of our natural resources to ensure that they are used in sustainable ways for current and future generations. Stewardship includes activities such as reducing the amount of resources we use, reusing items instead of throwing them away, and recycling used items. It also includes conserving existing ecosystems and restoring damaged ones. To be successful, environmental stewardship requires governments, organizations, and communities to work to prevent or reduce threats to ecosystems.

Suggested Activity
A24 Quick Lab on page 115

Sustainable Agriculture

In the 1980s, a group of Ontario farmers were worried about the effects that some farming methods were having on the environment. For example, some were concerned about the effects that fertilizers were having on water quality. Others were concerned that their tilling methods were causing soil erosion. Together, they developed plans to address problems related to pollution from farms. With the assistance of the federal government and agriculture organizations, they developed a program called the Environmental Farm Plan (EFP). The EFP is a tool that farmers can use to identify environmental problems on their farms and develop action plans to address these problems (Figure 3.19).

For example, pesticides can have many negative effects on ecosystems. In the 20 years since the EFP started, pesticide use has been reduced by 50 percent on Ontario farms. EFPs are now being used on farms across Canada.

Environmental farm plans can include actions such as using **integrated pest management**, which is a method of pest control

Figure 3.19 Environmental Farm Plans have become a useful tool for Ontario farmers.

that uses knowledge about a pest's biology and habitats. The technique is to choose the best combination of common-sense methods to keep the pest population under control, rather than using pesticides to totally eradicate them. For example, rotating different crops in the same field each year can be used to control pests that only eat one of the two crops. If the pest has nothing to feed on, its population drops. Reducing pesticide use helps the surrounding ecosystems and it also reduces risks to human health.

Soil Conservation and Organic Farming

Soil is a limited resource. It takes hundreds of years to form, but it can be blown or washed away very easily. **Soil conservation** means using farming methods that protect the soil from erosion and loss of nutrients. No-till farming is a method of planting and growing crops from year to year that does not disturb the soil (Figure 3.20). This means leaving the stubble and roots of last year's crop in the soil. The roots hold the soil and prevent erosion. The next year's crop is planted among the stubble. However, not all crops can be grown using no-till farming.

Some farmers use **organic farming**. On organic farms, farmers do not use chemical fertilizers or pesticides. This helps to reduce water pollution. However, organic farms may not be able to produce the same amount of food as a non-organic farm.

During Writing Thinking Literacy

Organizing for Writing

Once your research is complete, begin to organize your notes. Create headings for major subtopics, and gather your notes under each heading. If you use sticky notes to record your research points, then you can arrange and rearrange them under the appropriate headings to create maximum impact.

Figure 3.20 A new crop of soybeans is growing among the stubble of last year's corn crop in a no-till field.

Eating Locally Produced Foods

Your lunch may have contained oranges from South Africa or apples from New Zealand. Before modern refrigeration processes and efficient transportation networks, most foods were consumed close to where they were produced. We have benefited from being able to move foods great distances very quickly. We can now eat fresh fruit and vegetables in the middle of winter.

Currently, in North America, many foods are grown and processed on a very large scale. It is very efficient, but it can lead to problems. Most food items, including fruits and vegetables, are packaged or processed in large, centralized processing plants and then shipped all over the continent. If food spoilage or contamination is found in one of these centralized plants, food that has already been distributed has to be recalled and removed from supermarket shelves all over North America. This is costly and time-consuming. Decentralized food production can help reduce this problem. Also, the amount of energy needed to bring California-grown strawberries to Ontario is much greater than the amount needed to bring Ontario-grown strawberries to a local farmers market.

Sustainable agriculture and eating locally produced foods, if they are available, are connected. Buying locally produced food supports local farmers. If these farmers get enough income from their farms, they will continue to use their land for agriculture rather than selling their land to be developed for housing or other purposes. Locally grown produce tends to be fresher because it has been picked more recently than produce grown in California or other distant areas (Figure 3.21). In season, you might be able to eat corn that was picked less than 24 hours before. Even when more food is sustainably produced, some foods will have to be transported long distances, especially in Ontario, where our growing seasons are relatively short.

Figure 3.21 The Niagara region produces many fruits such as peaches, apples, and plums.

Learning Checkpoint

1. What is meant by the term “ecological footprint”?
2. What do calculations of the total ecological footprint of all of humanity say about our current use of Earth’s resources?
3. What does it mean to be an environmental steward?
4. What is an Environmental Farm Plan?
5. How is soil conservation related to sustainable agriculture?

Figure 3.22 The FSC's tree check logo identifies products as being produced from wood from sustainably managed forests.

Sustainable Forestry

The Forest Stewardship Council of Canada (FSC) is a non-governmental organization, or NGO. This means it operates independently of any government. The FSC originated in Ontario but now operates around the world. This organization sets standards for sustainable forest management and certifies forests and forestry practices that meet their standards. For a forestry practice to be certified:

- Waterways and wildlife habitat have to be protected.
- Parts of the forest have to be preserved.
- The cut areas have to be replanted.
- The cut areas cannot be replanted with just a single species. The forest must be able to achieve a wild state.

The FSC also provides a way for consumers to know whether the wood or wood product they are planning to buy has been made without endangering an ecosystem. For example, someone who wants to buy a wooden bench can look for an FSC symbol on the product (Figure 3.22). The symbol indicates that the wood was obtained in a responsible manner.

There are different sustainable management standards for different types of forests and different locations. For example, there is one set of standards for national boreal forests and a different set of standards for British Columbia's forests. However, this is taken into account in the certification process, so the consumer simply has to look for the logo on the product to know the appropriate standards were followed.

Urban Forests

It is easy to think of forests as existing only away from settled areas, but there are urban forests too (Figure 3.23). Like a wild forest, an urban forest includes all the trees and shrubs present as well as their soils. Healthy urban forests can help communities achieve many sustainability goals, such as removing excess carbon from the atmosphere. Trees store carbon and continuously remove it from the atmosphere. Large trees can remove 50 times more carbon than small trees can. They also reduce energy consumption by providing shade. If urban buildings are shaded, the need for air conditioning is reduced. Less air conditioning means less energy consumption.

Urban forests provide many other benefits as well. They help slow the run-off of water from rainstorms. This reduces the

Figure 3.23 Part of Ottawa's urban forest

pressure on a city's storm-drain system. Trees protect soils from erosion and filter chemicals from water and air. Urban forests can actually help repair damaged ecosystems by repairing unhealthy or damaged soils. They also provide habitat for other species, so they help increase biodiversity. And, of course, trees are also enjoyable to look at and be around.

Many cities and municipalities realize the importance of planting and maintaining healthy trees on public land. Most have urban forestry departments. The many trees on private land are vital too. There are many different organizations that educate the public about planting trees. For example, Tree Canada is an organization that promotes planting trees on both public and private land. In the last week of April, Arbour Week focusses on educating the Ontario public about the advantages of planting trees.

Sustainable Construction

Most people in Canada spend a lot of time in buildings, especially in the winter. The thousands of large buildings and millions of homes in Canada have a significant effect on the environment. Building them, living in them, and heating and cooling them uses energy, uses many different resources, and produces many different types of pollution. Sustainable construction methods help reduce these impacts.

Just as it is possible to certify a forest as being used in a sustainable way, buildings can be certified as being built in a sustainable way as well. The Canada Green Building Council uses the Leadership in Energy and Environmental Design (LEED)

LEED® Project Facts

Gross Floor Area:	8463	(m^2)
Energy Density:	176	(kWh/m^2)

Category	% Performance
Water Savings	
Irrigation	67 %
Indoor Use	31 %
Energy Savings	42 %
Waste Diversion	91 %
Recycled Content	24 %
Regional Content	48 %

LEED® Silver

(b)

Figure 3.24 (a) The École secondaire jeunes sans frontières building in Brampton is a LEED-certified building. It has a green roof, energy-efficient windows, and water-efficient plumbing, and 91 percent of the construction waste was recycled or reused on other projects. (b) LEED statistics on the building.

rating system. Libraries, schools, office buildings, and homes can be scored on how efficiently they reduce water consumption, reduce energy consumption, use renewable energy sources, reuse and restore existing buildings, incorporate daylight, and many other factors (Figure 3.24).

Businesses and Sustainability

Many businesses are responding to consumers' demands to improve their business practices by promoting sustainability and reducing their footprints (Figure 3.25). Many manufacturers of cleaning products are introducing "green" cleaning products that do not have phosphates and other substances that cause eutrophication or degrade ecosystems in other ways. Many manufacturers have their products certified by independent ecological certifying organizations, such as EcoLogo.

Two Canadian businesses are taking sustainability seriously. Bullfrog Power is an Ontario company that sells environmentally friendly electricity produced from renewable sources such as wind turbines and low-impact hydroelectric projects. These sources produce no emissions and so do not contribute to climate change or acid rain. Bullfrog's electricity costs slightly more than conventionally produced electricity, but many businesses, government agencies, and homeowners buy their power from Bullfrog. The company that produces Boomerang paints takes recycling seriously. It takes leftover paint from recycling centres, sorts the leftovers by colour, and blends similar shades into new paint shades. The leftover paint cans are melted down and

Take It Further

The Canadian Federation of Municipalities has conducted a survey of ecological footprints of large municipalities across Canada. How does your city or a city near you compare with the rest of the country? Begin your research at ***ScienceSource***.

Figure 3.25 (a) Clorox has introduced cleaners that use more environmentally friendly ingredients. (b) EcoLogo has been certifying products as environmentally friendly for over 20 years. (c) Boomerang paints are reused paint and recycled paint cans.

reshaped into new paint cans. The reclaimed paint is then sold in the recycled cans. By reusing paint and recycling cans, they reduce the amount of waste going to landfills and use no new resources to make the paint.

Individuals and Sustainability

Table 3.3 lists actions individuals can take to use resources in a more sustainable way. You and your family may have already started to do many of these things.

Table 3.3 Environmentally Sustainable Actions

Action	Consequence
Reduce emissions.	• Riding your bike, taking public transit, and using fuel-efficient vehicles are all ways to reduce carbon emissions.
Save energy.	• Lowering the thermostat, unplugging small appliances, and installing compact fluorescent light bulbs all reduce the demand for electricity, which is often generated by burning fossil fuels. • Reducing electricity consumption indirectly reduces air pollution.
Eat food produced locally.	• Buying food from local farmers reduces pollution from the trucks used to transport the produce. Buying from local organic farmers reduces pollution from pesticides as well.
Plant wisely.	• Planting native plants reduces the chance of introducing an invasive species. • Planting drought-tolerant plants reduces water usage in summer.
Buy wisely.	• Buying only what you really need reduces waste and reduces pressure on ecosystems. • Think about the impact that using and disposing of the item will have on the environment. • Choose products that have the EcoLogo or that you know were made in an environmentally responsible way.
Get involved.	• Check out your school community. Does it have an environmental awareness group? Is a full recycling program in place? If so, check it out. If not, think about organizing one. • Invite your family and friends to do an ecological footprint assessment. • Check out local or national organizations promoting environmental sustainability.

Learning Checkpoint

1. How does the Forest Stewardship Council help make it possible for consumers to make environmentally responsible decisions regarding the purchase of wood products?
2. What is meant by the acronym "NGO" with respect to community groups?
3. List four standards that any forestry practice must meet to receive Forest Stewardship Council certification.
4. What are three ways in which an urban forest can benefit a community?
5. What are three ecological benefits that result from using sustainable building construction methods?
6. Identify one environmentally sustainable action that an individual can do, and give one or two positive consequences of this action.

A22 STSE Science, Technology, Society, and the Environment

What's for Dinner?

Figure 3.26 The produce section of the supermarket has items from many countries.

For many Canadians, a typical dinner may contain food shipped from all over the world. As you walk through your local supermarket, have you considered how much of the food is actually "fresh"? For example, the tomatoes you see in the produce section were probably picked weeks ago in California and shipped thousands of kilometres by truck or airplane before arriving at your local grocery store.

1. Would you consider changing what you eat in order to eat more locally grown food? How difficult would it be?
2. If you did eat more locally grown food, what changes would you have to make to your diet during the winter?
3. If you did eat more locally grown food in the summertime, what changes would you have to make to your diet?

A23 Quick Lab

Calculating Your Ecological Footprint

Purpose

To determine the size of your ecological footprint and determine if your lifestyle is sustainable

Materials & Equipment

- computer with Internet access

Procedure

1. Use the ecological footprint calculator your teacher provides to calculate your ecological footprint.
2. Record or print out the relevant information.

Questions

3. How does your footprint compare to the average Canadian's footprint? Give reasons for why yours is higher or lower than average.
4. How does your footprint compare to that of an average person living in China (1.4 ha/person)?
5. Is the ecological footprint of China greater or less than the ecological footprint of Canada? Explain.
6. What factors cause the average Canadian footprint to be so much larger than those in the developing world (Nigeria: 1.2 ha/person; Brazil: 2.2 ha/person)?
7. List three things that you could do to reduce your ecological footprint.

A24 Quick Lab

Environmental Organizations

Purpose

There are many environmental organizations in Ontario and Canada. What are some of these organizations doing to sustain ecosystems?

Materials & Equipment

- computer with Internet access

Procedure

1. ***ScienceSource*** Use the Internet to research one of the following environmental organizations or another approved by your teacher:
   - World Wildlife Fund
   - Pollution Probe
   - Ducks Unlimited
   - Greenbelt of Ontario
   - Nature Conservancy of Canada
   - The Sierra Club of Canada
   - The Suzuki Foundation
2. Find out what types of projects your organization is doing in Ontario or across Canada.

Questions

3. What kinds of environmental problem(s) does the organization attempt to improve?
4. How does the organization promote sustainable use of ecosystems?
5. Do you think the organization's projects are effective? In what ways do you think they could be more effective?
6. Write a short summary of your findings, and present it to the class.

3.2 CHECK and REFLECT

Key Concept Review

1. How does the idea of an ecological footprint help an individual determine whether he or she is living in a sustainable fashion?
2. The ecological footprint of all of humanity has been calculated to be equivalent to 1.3 Earths. What does this mean?
3. How do Environmental Farm Plans help Ontario farmers?
4. What two technological developments contributed to the ability to ship food products very long distances?
5. What is organic farming?
6. How can shopping locally promote the conservation of farmland?
7. How do good soil conservation practices reduce soil erosion?
8. How do forests act like air conditioners to cool a region during hot spells?
9. List five ways that urban forests benefit urban ecosystems.
10. What percentage of Canada's contribution to excess carbon in the atmosphere comes from office buildings and homes?
11. List three ways that individuals can help reduce emissions from transportation.

Connect Your Understanding

12. The Evergreen Brick Works project embodies the ideas of "restore, reduce, and renew." Give one example of how each of these terms is put into action at the Brick Works.
13. An owner of a plant nursery finds aphids, a small insect pest, on some of her plants. She decides to introduce ladybugs to eat the aphids.
    (a) Name the strategy she is using to control the pest.
    (b) Explain the benefits of this strategy.
14. What is the meaning of the symbol shown below, and how might you make use of it?

Question 14

15. Eco-labels help consumers by demonstrating to them that the producer of a product has operated in a sustainable fashion. Meeting the certification standards can mean a lot of extra work for a producer. Yet many producers strongly support the use of eco-labels. Suggest four ways that eco-labels are a benefit to suppliers.

Reflection

16. Will the ideas encountered in this section affect the way you live? How?
17. If you were determined to make one personal lifestyle change that would have the greatest impact on improving sustainability in your community, what would it be? Explain.

For more questions, go to *ScienceSource*.

COOL IDEAS

from JAY INGRAM

Jay Ingram is an experienced science journalist, author of *The Daily Planet Book of Cool Ideas*, and host of the *Daily Planet* on Discovery Channel Canada.

Panamanian Cowbird Puzzle

Back in the 1960s, a biologist named Neil Griffith Smith, working in Panama, could not understand the behaviour of cowbirds (Figure 3.27). A cowbird is a nest parasite: a female lays an egg in another bird's nest, and the host bird raises the foreign chick along with its own chicks. Usually, female cowbirds have to be stealthy or else the host bird will recognize the cowbird's egg and remove it from the nest. But in Panama, cowbirds behaved in two different ways. Some cowbirds behaved normally: a female would hide until the host bird left the nest and then lay one or two eggs that looked almost exactly like the host bird's eggs. Other cowbirds were strangely obvious. In this situation, a cowbird would sit next to a nest in plain view of the host bird. When the host bird flew off, the cowbird would sit on the nest and lay an obviously foreign-looking egg among the host bird's eggs (Figure 3.28). But why did the mother bird not just get rid of that egg when she returned?

Smith discovered that it was all about botflies and bees. Botflies lay their eggs on newly hatched chicks, and the larvae feed on the chicks. Chicks infested with botfly larvae died. But they did not die if a cowbird chick shared the nest with them. The cowbird chick would eat the botfly larvae, thus protecting the other chicks. Of course, there was a price for this service: the cowbird chick took up most of the nest and ate most of the food. One or two deprived chicks would die as a result, *but not all of them*. In this situation, host adult birds tolerated the presence of a cowbird (Figure 3.29).

However, if the nest was near a beehive, it was a different story. The bees kept the botflies away. With a smaller fly population, chicks were less likely to be infested with larvae. In this case, there was no advantage to having a cowbird chick in the nest. Female cowbirds had to be much stealthier or their eggs would be removed by the host bird.

Question

1. A cowbird has different strategies for laying eggs in a host's nest. Explain what each strategy is and when a cowbird would use each one.

Figure 3.28 In this case, the cowbird's egg looks very different from the host bird's eggs.

Figure 3.29 Cowbirds often lay eggs in the nests of crested oropendolas.

Figure 3.27 The giant cowbird is native to Panama.

3 CHAPTER REVIEW

ACHIEVEMENT CHART CATEGORIES

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

Key Concept Review

1. What is the risk level classification for a species that is at risk of becoming endangered if limiting factors are not reversed? (k)

2. (a) What is the difference between ex-situ and in-situ methods of conservation? (k)
   (b) Which is considered a method of last resort? (k)

3. How can botanical gardens play a role in the conservation of some species? (k)

4. What is often the single most important factor determining the success or failure of the in-situ protection of a particular species? (k)

5. What law helps to protect the approximately 200 species at risk in Ontario? (k)

6. What is the main ecological purpose of establishing provincial parks, national parks, wildlife reserves, and marine sanctuaries? (k)

7. What are "biodiversity hot spots"? How are conservation biologists working to protect them? (k)

8. What major Ontario industry is threatened by the Asian long-horned beetle, and what measures are being taken to limit the beetle's spread? (k)

9. The amount of biologically productive land and water area on Earth is about 6 ha per person.
   (a) Currently, the average American uses about 10 ha per person. What does this mean about consumption by the average American compared to the availability of resources on Earth? (k)
   (b) How do Canadians compare to Americans in terms of average consumption per person? (k)
   (c) Do Canadians, on average, live within Earth's ability to supply resources for generations to come? (k)

10. What is the term that relates to taking care of our natural resources to ensure they are used in sustainable ways for future generations? (k)

11. The image below shows a typical farmers market that sells local produce. What are three ecological benefits from buying locally produced foods? (k)

Question 11

12. Name three different actions individuals can take that lead to sustainable use of resources, and explain how these actions help the environment. (k)

Connect Your Understanding

13. Explain how the restoration of Lake Erie is an example of effective collective action. (k)

14. Suggest ways that governments could encourage sustainable building construction practices. (a)

15. The bird's-foot violet shown below is endangered because of habitat loss due to farming. It often thrives in areas that have had a forest fire, but such fires are limited by humans. Suggest a method of protecting this plant other than banning farming or permitting wildfires. (t)

Question 15

16. Sometimes, a forestry company will log an area and replant the entire area with a single tree species. Would this company be certified as using sustainable practices? Explain why or why not. (a)

17. Suppose you have been hired by a tree planting organization to promote tree planting by individuals. Create a brochure to educate homeowners about the benefits of planting trees on their land. (c)

18. Create a concept map that shows how government, group, and individual actions promote environmental sustainability. (c)

19. The average Canadian's ecological footprint is 8.9 ha of land. If this land area were multiplied by the total number of people in the world, would it be greater or less than the total area of the planet? (t)

20. Certification programs are effective ways to demonstrate sustainable use of resources. However, some certification programs have been criticized as being ineffective. What might make a certification program ineffective? (a)

Reflection

21. Given that humanity is consuming resources faster than Earth can produce them, how will you take action to create a sustainable future? Write a short paragraph outlining the action you will take. (c)

After Writing

Thinking Literacy

Reflect and Evaluate

Share your summary of information about an environmental organization with a classmate who wrote about a different organization. Listen to a reading of your classmate's article. What was the most important information you heard? What was nice to know but not entirely necessary? Reconsider your own summary with the same questions. Write a statement to express what you have learned about researching and taking notes.

Unit Task Link

In the Unit Task, you will be designing a sustainable community with a small ecological footprint. Reflect on the examples of government, group, and individual actions to promote sustainability. How have groups and individuals worked together to take action to promote sustainable communities?

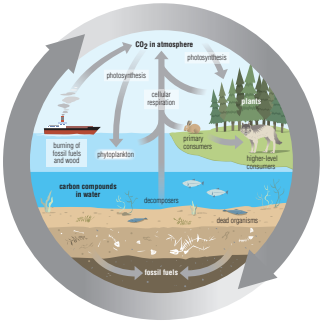
UNIT A Summary

KEY CONCEPTS	CHAPTER SUMMARY
1 Ecosystems are complex, self-regulating systems of organisms and their abiotic environments.	
• Abiotic and biotic characteristics • Photosynthesis and cellular respiration • Nutrient cycles and energy flows • Equilibrium and carrying capacity	• The biodiversity on Earth is found in the biosphere, which includes the lithosphere, atmosphere, and hydrosphere. All of these spheres interact. (1.1) • Energy in ecosystems comes from the Sun. It is transformed into chemical energy by plants. As energy travels along food chains, the amount of usable energy decreases. (1.2) • Matter is recycled in ecosystems. Plants use matter from the soil and air to make their tissues. Matter then passes along food chains, which are the biotic parts of ecosystems. (1.2) • Decomposers release the substances in organic matter back into the soil, and the substances are reused by plants. (1.2) • Abiotic and biotic factors affect the size of populations in ecosystems. (1.2) • A population's carrying capacity is the maximum number of animals that the habitat can support over a long period. (1.3) • When a population is at carrying capacity, it is at equilibrium. The number of births equals the number of deaths, and the population is steady. (1.3)
2 Human activity affects the sustainability of ecosystems.	
• Factors affecting biodiversity • Soil profile and soil types • Factors affecting water quality • Bioaccumulation and biomagnification	• Biodiversity includes species diversity, genetic diversity, and ecosystem diversity. (2.1) • Overexploitation, habitat destruction, pollution, invasive species, and climate change are factors that decrease biodiversity. (2.1) • Soil is made up of humus, rock particles, and living organisms. Soil can be clay, sandy or loam, and it can vary in acidity. (2.2) • Water's quality is assessed by its oxygen levels and acidity as well as by the presence of heavy metals, nitrogen, phosphorus, and pesticides. Poor water quality affects organisms that depend on the water. (2.2)
3 Governments, groups, and individuals work together to promote sustainable ecosystems.	
• Conserving biodiversity • Conservation strategies • Environmental stewardship and sustainable use	• Extinction means the loss of biodiversity. Ex-situ and in-situ conservation strategies work to protect at-risk species. (3.1) • Governments use legislation to enact programs to protect ecosystems. (3.1) • Ecological footprints are a way of representing our resource use. (3.2) • Environmental stewardship means using resources in a sustainable way. Groups and individuals are taking action to increase sustainable use. (3.2)

VOCABULARY

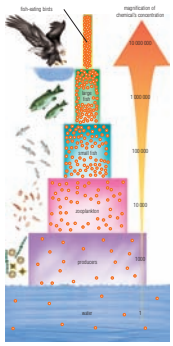
KEY VISUALS

- abiotic (p. 13)
- aquifer (p. 25)
- atmosphere (p. 19)
- biodiversity (p. 9)
- biome (p. 16)
- biosphere (p. 18)
- biotic (p. 13)
- boreal forest (p. 17)
- carnivores (p. 30)
- cellular respiration (p. 29)
- chlorophyll (p. 28)
- community (p. 14)
- components (p. 11)
- consumers (p. 30)
- decomposers (p. 30)
- denitrifying bacteria (p. 26)
- detritivores (p. 30)
- ecology (p. 12)
- ecosystem (p. 13)
- elements (p. 24)
- environment (p. 8)
- freshwater (p. 17)
- grasslands (p. 17)
- habitat (p. 14)
- herbivores (p. 30)
- hydrosphere (p. 19)
- lithosphere (p. 19)
- marine (p. 17)
- niche (p. 14)
- nitrifying bacteria (p. 26)
- nitrogen fixation (p. 25)
- nutrient (p. 22)
- nutrient cycle (p. 24)
- omnivores (p. 30)
- organic matter (p. 30)
- photosynthesis (p. 28)
- population (p. 14)
- primary consumers (p. 30)
- producers (p. 30)
- reservoir (p. 24)
- scavengers (p. 30)
- secondary consumers (p. 30)
- species (p. 14)
- stewardship (p. 8)
- sustainability (p. 9)
- system (p. 11)
- temperate coniferous forest (p. 17)
- tertiary consumers (p. 30)
- tundra (p. 17)



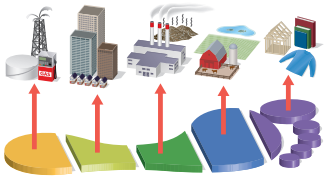
Carbon cycle

- acid rain (p. 70)
- acidity (p. 74)
- bedrock (p. 72)
- bioaccumulation (p. 79)
- biological oxygen demand (p. 77)
- biomagnification (p. 79)
- clay soil (p. 73)
- clearcutting (p. 62)
- climate (p. 60)
- climate change (p. 60)
- crop rotation (p. 75)
- dissolved oxygen (p. 77)
- eutrophication (p. 78)
- extinction (p. 54)
- genetic diversity (p. 54)
- global warming (p. 60)
- habitat change (p. 55)
- habitat fragmentation (p. 56)
- heavy metals (p. 79)
- invasive species (p. 59)
- loam soil (p. 73)
- native species (p. 55)
- non-point source pollution (p. 58)
- overexploitation (p. 56)
- pesticides (p. 80)
- point source pollution (p. 58)
- pollution (p. 58)
- sandy soil (p. 73)
- soil (p. 72)
- soil erosion (p. 74)
- subsoil (p. 72)
- sustainable use (p. 54)
- topsoil (p. 72)
- urban sprawl (p. 62)



Biomagnification

- at risk (p. 94)
- conservation biology (p. 94)
- ecological footprint (p. 106)
- endangered (p. 94)
- environmental steward (p. 107)
- ex-situ conservation (p. 96)
- extirpated (p. 94)
- in-situ conservation (p. 96)
- integrated pest management (p. 107)
- organic farming (p. 108)
- soil conservation (p. 108)
- special concern (p. 94)
- threatened (p. 94)



Ecological footprint

UNIT A Task

Building a Sustainable Community

Getting Started

Changing your light bulbs and being more conscientious about recycling are two simple ways to move towards a more sustainable lifestyle. Imagine if your entire community adopted such practices as a way of life. There are communities that do. They even have a name: eco-villages. Eco-villages are completely self-sufficient, sustainable communities designed to have a minimal footprint on surrounding ecosystems. Eco-villagers carefully control their fuel and food consumption. Eco-villagers try to live, work, and play in a small region to minimize commuting, which reduces energy consumption. Walking a short distance to work or school can be a lot more satisfying than spending hours a day in traffic.

A green-roofed cabin in Findhorn, an eco-village in Scotland.

Your Goal

The project has three parts.

- First, you will investigate in what ways certain aspects of your local community may be ecologically unsustainable.
- Then, you will research changes that can be made to make some of these aspects more sustainable.
- Finally, you will use your research to design a completely sustainable community for your area.

Criteria for Success

You will work effectively and co-operatively as part of a team designing a new eco-village. You will assume a specific role on the team, such as:

- builder
- food specialist
- technologist
- water manager
- waste supervisor
- restoration specialist

You will research aspects of the eco-village relating to your area of research and collaborate with the other team members to design the village.

For the area of expertise you select to research, you must:

- outline the ways the current situation is unsustainable
- outline specific changes that will increase the sustainable use of local ecosystem resources

What You Need to Know

Most eco-villages share several key characteristics, including the following:

- use of renewable energy sources
- agriculture that is closely related to natural local conditions
- homes built using techniques and materials that have a minimal impact on the environment
- homes that have the capacity to provide power, water, and sewage solutions without relying on a centralized system

What You Need

- computer with Internet access

Procedure

1. In your group, brainstorm aspects of your local community that are unsustainable. Organize your thoughts into the following categories: buildings, food, technology, water, waste, and restoration. Brainstorm possible problems with:
   - current building design and construction techniques
   - current food production and consumption patterns
   - energy demand at global, national, and local levels
   - local water sources and how much people use for such things as irrigation, washing, and food preparation
   - how well your community reduces, reuses, and recycles
   - local ecological issues such as habitat change or fragmentation or pollution
2. Decide which expert role each person will assume. Use the results of the group brainstorming that relate to your field of expertise to start a graphic organizer.
3. ***ScienceSource*** On the Internet, find information related to the aspect of sustainable communities you are researching. Look for terms such as "eco-village," "sustainable community," and "permaculture" in your search.
4. As a group, decide on the best location for your eco-village. Keep in mind that your village must be as self-sufficient as possible. Your location should have ready access to building materials, water, places of employment, and schools.
5. Collaborate with your team to design an eco-village that incorporates some of each expert's ideas.
6. Decide how to present your design ideas. Will you create a pamphlet, a PowerPoint presentation, a poster, a Web page, or use some other method?
7. Present your eco-village design.

Assessing Your Work

8. Do you think building a completely sustainable community is possible? Explain.
9. What were the advantages and disadvantages of having a group of experts create the eco-village design?

Beddington Zero Energy Development is an eco-village in London, England. Its homes use 10 percent of the energy needed to heat similar-sized conventional homes.

This eco-village vegetable garden makes use of existing materials.

UNIT A Review

ACHIEVEMENT CHART CATEGORIES

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

Key Terms Review

1. Create a concept map that illustrates your understanding of the following terms and how they relate to sustainable ecosystems. (c)

- abiotic factors
- atmosphere
- biodiversity
- biomagnification
- biosphere
- biotic factors
- carrying capacity
- cellular respiration
- ecosystem
- equilibrium
- hydrosphere
- limiting factors
- lithosphere
- photosynthesis
- population
- sustainability

Key Concept Review

1 Ecosystems are complex, self-regulating systems of organisms and their abiotic environments.

2. Describe an abiotic factor that could affect a population of squirrels. (k)

3. How is a food chain related to a food web? (k)

4. Snapping turtles eat frogs, frogs eat grasshoppers, and grasshoppers eat grass.
   (a) Construct a food chain using the above organisms. (c)
   (b) Add a decomposer to your diagram. (c)
   (c) Add a source of energy for the producers to your diagram. (c)

5. The nitrogen cycle relies on the actions of several distinct types of bacteria. List and describe the function of each. (k)

6. Describe three types of symbiotic relationships, and give an example for each one. (k)

2 Human activity affects the sustainability of ecosystems.

7. Define the term "genetic diversity." (k)

8. List five major factors that affect biodiversity. (k)

9. List the elements that make up soil. (k)

10. Which type of soil would most gardeners prefer to have? Why? (k)

11. What type of measurement can be used to determine the acidity of the soil? (k)

12. What method can farmers use to restore nutrients in the soil of their fields? (k)

13. Do "dissolved oxygen" and "biological oxygen demand" describe the same phenomenon? If not, how are the two terms different? (k)

14. How are modern pesticides an improvement over earlier ones? (k)

3 Governments, groups, and individuals work to promote sustainable ecosystems.

15. Place the following categories in order from the least serious to most serious: extirpated, special concern, extinct, endangered, threatened. (k)

16. How can soil erosion be reduced? (k)

17. What is one measure the federal government takes to prevent invasive species from being accidentally introduced into Canada? (k)

18. Name an international treaty that protects biodiversity in Canada and around the world. (k)

Connect Your Understanding

19. Explain why it is more accurate to define the biosphere as a global ecosystem rather than a global community. (t)

20. Hypothesize what would happen to an ecosystem that had all of its decomposers removed. (t)

21. Bacteria are bad for your health and are responsible for many diseases that hurt humans, animals, and plants. All efforts should be taken to completely eradicate bacteria on the planet.

(a) Evaluate the validity of this statement. Support your answer. (t)

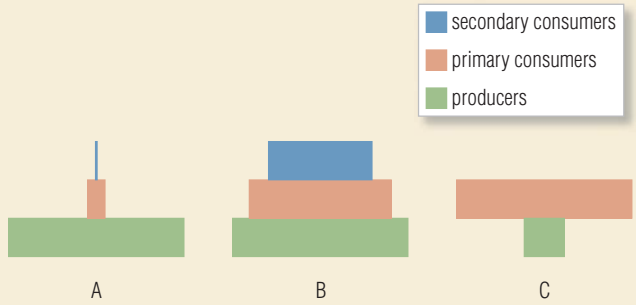
(b) If necessary, modify the statement to make it more accurate. (c)

22. Study the following energy pyramids.

(a) Which pyramid best represents a sustainable ecosystem? (a)

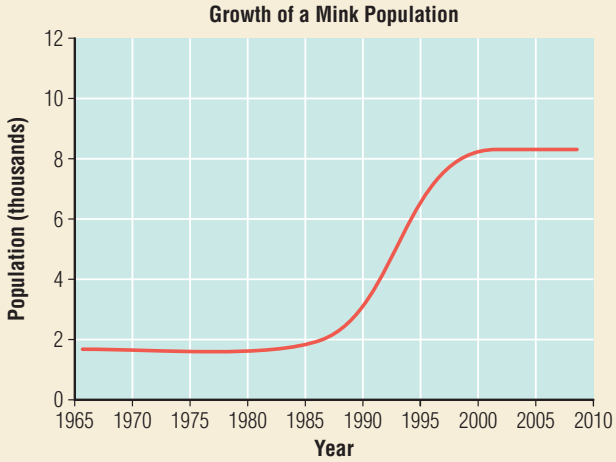
(b) Explain why each of the other two pyramids is unsustainable. (a)

(c) Suppose data were collected from the ecosystem represented by B in 10 years' time. Draw an energy pyramid that might describe energy flow in the ecosystem at that time. Explain why you drew it the way you did. (c)



Question 22

23. Examine the graph below.



Question 23

(a) During which years is this population of minks growing the fastest? (t)

(b) What is the carrying capacity of the population? (t)

(c) What factors cause the population to level off rather than continue to increase? (t)

(d) What may have contributed to the sudden increase in minks? (a)

24. Decide which factor each of the following scenarios describes. (a)

(a) A new school is built near a forest. A section of trees is clear-cut, and a nearby creek is diverted away from the building area.

(b) Emissions from industry and automobiles are entering the atmosphere and contributing to increasing temperatures around the planet.

(c) Sea otters have the thickest fur of any animal. Humans prized their fur for making coats. Sea otters were hunted almost to extinction.

25. What activity does the photograph show?

(a) What effects does the activity in the photograph have on a nearby aquatic ecosystem? a

(b) What effects might the activity have on a boreal forest ecosystem? a

Question 25

26. Many people assume that if water appears clear, then it is safe to drink. Are they correct? What indicators would you use to determine whether the water is actually safe? a

27. The pond in the photo is located in a farming area. Hypothesize what may have occurred in the pond. t

Question 27

28. Many pollutants enter an ecosystem in very small amounts. If the amounts are so small, how can they harm ecosystems? t

29. The black-footed ferret population is increasing as a result of captive breeding programs. The ferrets' main habitat is grassland. Most of their habitat was turned into farmland. The ferrets' primary source of food is prairie dogs, which live in large colonies. The ferrets also use abandoned prairie dog burrows for shelter. They are vulnerable to sylvatic plague, a disease that is transmitted by fleas on prairie dogs. Create an in-situ conservation strategy to increase the ferret population. a

30. (a) What changes would you recommend to your local lumber supplier to reduce its ecological footprint? c

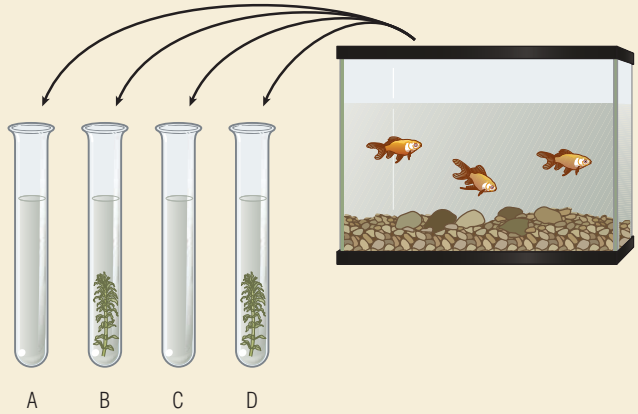
(b) If, as a result of following your recommendations, the products cost more than similar products in other stores, would you buy the product from this store? Explain why or why not. a

31. Suppose your school board wants to renovate your school to improve the building's LEED rating, and they have hired you as an ecological consultant. Create a report that outlines changes you think need to be implemented to increase your school's LEED rating. a

32. A homeowner dislikes the dandelions and chickweed in his front yard. He wants a lush, grassy lawn that his children could play on and that his neighbours would admire. He decides to use pesticides to eliminate the weeds. Critique his decision to use pesticides. List the positive and negative consequences of using pesticides. If you decide that using pesticides is not the best course of action, propose alternative actions the homeowner could take. c

Skills Practice

33. The diagram shows the set-up for an experiment. Water taken from a tank full of fish was added to all the test tubes. A small aquatic plant was placed in test tubes B and D. Carbon dioxide forms carbonic acid when it dissolves in water. Phenol red is a substance that turns yellow in the presence of carbonic acid. A few drops of phenol red were added to each test tube. The table shows the initial observations for the experiment. Test tubes A and B were placed in a dark, cool location. Test tubes C and D were placed in a sunny location.



Question 33

Experimental Observations

Test Tube	Water Colour	
	Initial	Final
A	yellow	
B	yellow	
C	yellow	
D	yellow	

(a) What is the purpose of test tubes A and C? t

(b) Using your knowledge of the carbon cycle, predict final water colour for each test tube. t

(c) Explain your predictions for each test tube. t

(d) The experiment is repeated, but each test tube is filled with cold tap water instead of water from a tank full of fish. Predict the initial and final colour of the water in each test tube. t

34. A pitcher plant is a carnivorous plant that traps insects such as crickets. The insects die inside the plant and decompose. The plant absorbs the nutrients from their decomposing bodies that the soil does not contain. The pitcher plants are consumed by herbivorous mammals. Draw a food chain that represents this scenario. c

35. In a particular ecosystem, it has been determined that the secondary consumers use 5200 kJ/m^2 of energy.

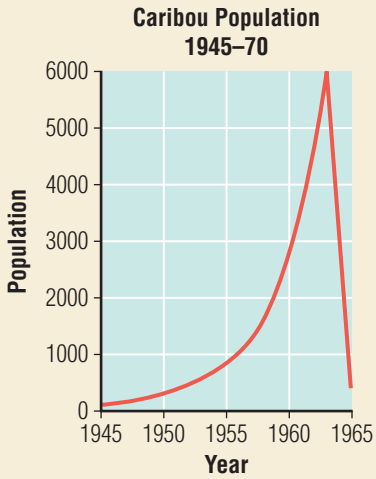
(a) How much energy was stored in the producers in that same food chain? t

(b) How much energy would be used by the tertiary consumers? t

36. (a) Create a graph that shows the population growth of an invasive species that has been recently introduced to a new area. c

(b) Why did you draw the graph the way you did? Justify your answer. c

37. The following graph shows the population of a group of caribou on an island. How would you explain the changes in population? t



Question 37

38. A population of wolves was also introduced to the same island that had the caribou in question 37. The following table contains wolf population data. Use the graph and data from the table to develop a hypothesis that explains the fluctuations in the deer population and the island's carrying capacity. t

Wolf Population 1950–1970

Year	Wolf Population
1950	100
1955	90
1960	50
1965	20
1970	0

39. Create a graphic organizer that shows different types of pollutants and how they affect terrestrial and aquatic ecosystems. c

40. The Department of Fisheries and Oceans collects data on fish catches as shown in the following table.

Fish Catches 1990–2000

Year	Total Groundfish Landed	Total Aquacultured Salmon Harvested
1990	791 246	49 594
1992	630 574	46 931
1994	452 896	57 147
1996	374 086	72 572
1998	287 498	91 499
2000	229 637	127 336

(a) Graph both sets of data. Analyze the trend of the groundfish that have been caught. t

(b) Predict how many groundfish will be caught in 2002 and 2004. t

(c) Propose an explanation for the decreasing groundfish catch in Canadian waters. t

(d) Based on the graph of total salmon harvested through aquaculture, will the fish needs of Canadian diets be met? t

(e) Add the extra data in the table below to your graph. t

Fish Catches 2002, 2004

Year	Total Groundfish Landed	Total Aquacultured Salmon Harvested
2002	255 994	171 035
2004	306 693	141 580

(f) How does this additional information change your prediction on how many fish will be available in 2006? t

(g) Why is it important to have long-term data when working with ecological data? a

Revisit the Big Ideas and Fundamental Concepts

41. The term "ecosystem" is short for ecological system. Ecosystems are complex, self-regulating systems of organisms and their abiotic environments.

(a) What is ecology? *k*

(b) What is a system? *k*

(c) Using the example of an aquatic ecosystem that has algae, a fish that eats algae, a trout that eats algae eaters, and eagles that eat trout, explain how matter cycles and energy flows through the ecosystem. *k*

(d) Suppose the population of algae eaters suddenly increased due to an increase in algae. How might the ecosystem self-regulate to restore the algae-eater population? *k*

42. Explain how sustainability and biodiversity are interrelated. *a*

43. What are the five main factors that increase loss of biodiversity on Earth? *k*

44. What are soils, and what are the most devastating effects of human activities on soils? *k*

45. Suppose you were given the task of assessing the water quality of a lake ecosystem, and you could have measurements of the water done by sending water samples to labs for analysis. What are some types of tests you would order to be done on the water? *a*

46. Governments are able to take certain kinds of actions that other groups cannot. For example, they can make treaties with other countries and also pass laws. Explain how making treaties and passing laws have worked to promote sustainable ecosystems in Ontario. *a*

47. What kinds of actions are available to individuals in Canada to help make us more ecologically sustainable? *a*

STSE Science, Technology, Society, and the Environment

48. The polluting of Lake Erie is a dramatic example of how activities in your neighbourhood can affect other parts of the province or even the world. Compile a short report that outlines how one or more personal activities could have a negative impact on distant ecosystems. Then, propose solutions to lessen these impacts on ecosystems. *a*

49. Governments, groups, and individuals are working to promote sustainability of ecosystems. Choose one of these that you have learned about, and explain what environmental issues they have tackled and their solutions to the problem. Elaborate on what you have learned, and suggest additional actions that they could take. *a*

Reflection

50. Suppose you were to throw a sustainability party for your friends, family, and neighbours to make them aware of the various factors that affect the sustainability of ecosystems. What kinds of things do you think you could do to make them aware of the problems and the possible solutions to these problems? *c*

51. What is the most important thing you have learned in this unit about the sustainability of ecosystems? *c*