

3.0

We can change our actions and technologies to better protect the environment.



Modern societies rely on a variety of technologies. Many of these technologies affect ecosystems.



What You Will Learn

In this chapter, you will:

- distinguish between primary succession and secondary succession in an ecosystem
- assess the impact of certain human technologies on the environment
- analyze the costs and benefits of certain strategies for protecting the environment

Skills You Will Use

In this chapter, you will:

- use research skills to investigate occurrences that affect local ecosystems
- use a variety of forms to communicate with different audiences

Why This Is Important

Our activities can damage ecosystems.

Understanding how ecosystems sustain themselves naturally can help us minimize the effect of our actions on the environment.

Before Writing



Letters to the Editor

Writers sometimes express their opinions about an issue or situation by writing a letter to the editor. Find examples of this type of letter in your local newspapers. What common characteristics do you see? Think about the structure, word choice, vocabulary, and use of facts in these letters. How are these letters the same or different from a letter you would write to a friend?

Key Terms

- succession
- pioneer species
- primary succession
- climax community
- secondary succession

3.0 Getting Started



Figure 3.1 Forest fires suddenly change the conditions in an ecosystem by destroying plants, animals, and habitat.

In the summer of 2007, an aerial view of the communities of Sandy Lake, Deer Lake, and Keewaywin in northwestern Ontario showed large areas of darkened soil and a variety of shrubs and small bushes. These producers were food for deer, moose, and a number of smaller animals such as squirrels and hares. Eagles soared over the open ground in search of a meal.

Prior to 2006, the aerial view was a very different sight. The area was covered with spruce, pine, and fir trees native to the boreal forest of northern Ontario. The summer of 2006 was very dry, and lightning started forest fires that destroyed thousands of hectares of the boreal forest. Residents of Deer Lake, Sandy Lake, and Keewaywin were evacuated as fire threatened their homes. Animals of the forest fled as their habitat was consumed by flames. As soon as the fire was out, however, a new community of living things began to establish itself.

Ecosystems change constantly, and the interactions between biotic and abiotic elements are balanced over time. Sudden and severe natural events such as a fire or a storm can disrupt these interactions very quickly (Figures 3.1, 3.2). Fires, tornadoes, and landslides destroy habitat, animals, and plants. In the next activity, use your knowledge of how cycling of matter and the transfer of energy work in ecosystems to predict what might happen in a badly damaged ecosystem.



Figure 3.2 The ice storm of 1998 destroyed trees and damaged ecosystems.

A34 Quick Lab

Dealing With Sudden Natural Events

Purpose

In this activity, you will model how changes in an ecosystem can affect everything in the ecosystem without destroying it.

Materials & Equipment

- 1 deck of playing cards for every 3-5 students
- paper, pencil, and markers to record connections

Procedure

1. The different suits in the deck of cards represent the biotic and abiotic components in a meadow ecosystem as follows: spades — water; hearts — air; diamonds — soil; clubs — living things.
2. Place the cards face up on the table and have members of the group take turns choosing one card from each suit. They should place these cards face up in front of their positions.
3. Once all the cards have been selected, students should arrange their cards on their paper to show the connections between the

different elements in the ecosystem. They can use a large sheet of paper and a marker to show the connections among the different elements in the ecosystem.

4. Consider the effect of the following events on the ecosystem:

- a drought reduces the amount of water in the area (remove all spades below 7)
- a forest fire burns a large part of the meadow (remove all the clubs above 7)

Questions

5. How did the events (the removing of the cards) affect the different connections in the ecosystem? Were there any ecosystems that were wiped out?
6. What other events could affect an ecosystem? Do you think the ecosystem would be able to recover?

3.1

Succession, Recovery, and Renewal in Natural Communities

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

- Ecosystems change in predictable ways known as succession.
- Ecosystems can establish themselves in places where there has never been an ecosystem.
- Ecosystems can recover from catastrophic natural changes.

If people did not cut the grass on their lawns or weed them, the grasses would grow tall and go to seed. They would soon be joined by plants that can outcompete some of the grasses for resources. The newer plants in turn might be replaced by plants that could outcompete *them*.

As the type of plants changed over time, the lawn's animal community would also change. New populations of insects, small animals, and birds would take up residence as suitable habitat became available. After a time, there would be little similarity between the community of biotic elements that used to inhabit the lawn and the community that has moved in.

A35 Starting Point

Skills **A** **C**



What Happens to a Vacant Lot?



Figure 3.3

What to Do

With a partner or in a group, study the photograph of plants in a vacant lot in Figure 3.3. Do you think the vacant lot has an ecosystem?

Consider This

1. What do you think is happening in the vacant lot?
2. If the lot is left alone, what do you think it will look like in two years? In five years? Explain your reasoning.

Succession

Succession is the natural replacement of one community of living things by another. The changes take place over a long period of time, and they happen in a predictable way. For example, an untended field of soil will first be inhabited by small plants and insects. Those plants and insects will die, and their nutrients will be added to the soil. The soil will slowly become rich enough to support larger, different plants and the living things that depend on them. In this way, communities are followed, or succeeded, by other communities.

The populations in any succession process will always be suited to the changing habitat. Only organisms that can meet their basic needs will survive. An untended field can become a meadow and, perhaps, later a forest. The plant and animal populations will gradually change as the abiotic conditions change. Any sudden changes to the abiotic elements may have a serious effect on the plants and animals that inhabit the area.

Scientists distinguish between two different types of succession: primary succession and secondary succession.

Primary Succession

Primary succession is the formation of a new community where no community has existed. For example, primary succession takes place on newly formed volcanic islands, rocky shores, and sand dunes. The earliest plants to take root must be tough enough to survive in harsh conditions that may not even provide soil for nutrients.

Plants and plant-like species that are part of primary succession are often called **pioneer species**. They could be lichens that can cling to rock surfaces and absorb enough nutrients to survive (Figure 3.4). These tough species are the ones that break down the rock surface and begin the process of forming soil. Pioneer species also include grasses with roots long enough to hold sand dunes in place.

Once tiny amounts of soil appear or sand is anchored, other plants have a place to grow. Their seeds may have been blown to the site by the wind, dropped by a passing bird, or perhaps scraped from the sole of a hiker's boot. The seeds sprout, and a plant sets down roots.

WORDS MATTER

A *pioneer* is a person who does something first or prepares the way. The term *pioneer species* refers to plants or animals that come to live in an area where plants and animals have not lived before.

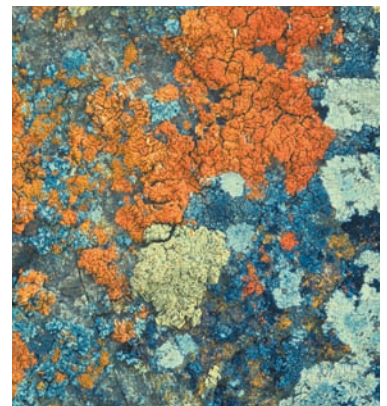


Figure 3.4 Lichen is a pioneer species made up of algae and fungi. It is tough enough to survive in very harsh conditions.

Secondary Succession

Secondary succession occurs when a community has been destroyed or disturbed by natural occurrences or human activities. A new community then replaces it. Secondary succession is different from primary succession because, in secondary succession, these habitats previously supported life. A farmer's field, a vacant lot in the city, a newly forested area, and even a strip mine are examples of where this type of succession occurs. Figure 3.5 shows how untended farmland could change to a meadow, a bush, and then to a forest over 40 years.

Natural communities will change in this way until a fairly stable community forms (Figure 3.5(d)). This community is called a **climax community** and features large plants and animals such as those found in a forest. Climax communities change slowly in small ways over a long period of time. Major changes can occur suddenly because of extreme events, such as fires or storms, or human intervention.



Figure 3.5(a) Year 1 Farm field



Figure 3.5(b) Year 2 Meadow



Figure 3.5(c) Year 10 Bush



Figure 3.5(d) Year 40 A climax community



Change Over Time

Semantic Mapping

After you have read the information on secondary succession, draw a series of boxes in your notebook. Connect the boxes with a series

of lines. In each box, write a few words to describe the different stages in a gradual change to a new ecosystem.

Recovery and Renewal

Ecosystems that have suffered catastrophic events such as fires, floods, avalanches or landslides, or even earthquakes can recover. Succession will take place as long as the essential abiotic elements remain to support living things.

An example of the recovery process is the growth of fireweed in a newly burned area (Figure 3.6). This wildflower's seeds travel to open areas on the wind. Fireweed grows best where sunshine is not blocked by tall trees. As the area recovers, bushes and trees will grow taller, and the fireweed will not survive in the shade. However, in the early days, its roots held the soil in place, so those bushes and trees could grow. Decomposers returned nutrients from dead fireweed plants to the soil.

Areas that have experienced sudden natural events such as avalanches and landslides, which rearrange the landscape but do not kill all the plants, will also recover as existing plants re-establish themselves. Insects, birds, and animals will return to the habitat to feed and nest.

Catastrophic events caused by human activity may be harder for ecosystems to recover from because they often damage the abiotic elements. For example, human activity may poison the water or the air. After such events, plants will not be able to grow, replenish soil, or support animal life. Instead, the ecosystem may collapse, and nothing will grow on the site for many years.



Figure 3.6 Fireweed is one of the first plants to establish itself in an ecosystem after a fire.

Take It Further



The volcanic island of Surtsey formed off the coast of Iceland in 1963. Find out how scientists have been studying the way abiotic and biotic factors have slowly developed an ecosystem on this island. Begin your research at ScienceSource.

- Determining bias
- Stating a conclusion

Managing Forests and Forest Fires



Figure 3.7

Issue

Since 1900, Canada's park and forest managers have worked hard to prevent forest fires and quickly extinguish ones that do break out. This policy resulted in a large number of climax communities in the form of mature forests.

In August and September of 2003, a fire in Okanagan Mountain Park in British Columbia burned 25 000 hectares of forest and destroyed 239 homes. About 27 000 people were evacuated from the area. This fire, and recent others like it, has led officials to reconsider their policy for managing forest fires. What is the best way to manage and care for the forest ecosystems in Canada's wilderness?

Background Information

- Aboriginal peoples regularly burned areas in the spring. They used fire to create grazing areas and keep travel routes open.
- In areas with cool temperatures, the decomposition process is slow. Decaying wood, leaves, and needles (which are fuel for a fire) accumulate on the forest floor.
- Mature forests are dense, with tall trees that shut out the light. Little else grows in mature forests. This means that there is not much habitat for insects, animals, or birds.

- Grassland ecosystems that burn regularly have a rich supply of young herb and grass plants. They are less likely to be taken over by shrubs and trees.
- Fire quickly turns organic material into ash that is rich in minerals and can be returned to the soil.
- Forests that have burned have openings that allow sunlight to reach the ground. New growth on the forest floor provides habitat for small animals, as well as food in the form of berries and leaves.
- The seeds of trees such as the lodgepole and jack pines are sealed in cones covered with a sticky substance called resin. The cones open to drop the seeds only after fire has melted the coating.
- Lightning has caused fires in forests and grasslands for thousands of years.
- Warmer temperatures and decreased rainfall or snow cover will dry out forests and grasslands and create ideal conditions for fires.

Analyze and Evaluate

1. Use your knowledge of the cycling of matter and succession to explain why fires are a necessary part of healthy forest and grassland ecosystems.
2. If organic matter is piling up on the floor of a mature forest, should a fire be set? Explain your reasoning in an oral report.

Key Concept Review

1. Describe the differences between primary and secondary succession.
2. Write a paragraph to explain to an adult what would happen to a vacant lot in your community if it were left alone for the next 25 years.
3. Make a list of four different events that could change a climax community. For each one, suggest what the area might look like two years after the event.
4. How does your knowledge of ecosystems help you understand the process of succession?
 - (a) fish-eating birds land on rocky islands
 - (b) a coconut is washed up on a beach
 - (c) an especially high tide washes seaweed onto a sandy beach
6. In primary succession, do biotic or abiotic elements arrive first? Use examples when explaining your response.


Practise Your Skills

7. Use a series of small diagrams to show how a forest such as the one shown here might recover after a fire. Be sure to include animals in your diagrams.



Connect Your Understanding

5. Explain how the following events could be important in the formation of a new community of living things:
 - (a) fish-eating birds land on rocky islands

For more questions, go to ScienceSource. 

A38 Thinking about Science and the Environment



Declaring War on Weeds

Lawns and grass in neighbourhoods, golf courses, and some public parks require water and fertilizer. They also require care in the form of regular mowing. Many people want a well-kept lawn with no weeds or pests in it. Some people use insecticides to kill unwanted insects and rodents and herbicides to kill unwanted plants in their lawns. Herbicides are also known as weedkillers. Fertilizer, insecticides, and herbicides often find their way into the soil and local water.

Homeowners also often rake up and take away the grass clippings when they have finished cutting the grass.

Consider This

1. Using what you know about succession, explain why weeds appear.
2. Is it a wise idea to try to keep an ecosystem like a lawn from changing? Explain your reasoning.

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

- Many modern human technologies have affected the quality of air and water for all living things.
- Many human interactions with the environment have affected the habitat of other living things.
- Many of the waste products of human technology cannot be cycled by decomposers.



Human communities benefit from technology. Inventions and human-engineered materials have improved human survival and quality of life. Technology allows us to live comfortably in harsh habitats. It also helps us produce large quantities of food and transport food, goods, and ourselves long distances.

Throughout each day and night, members of human communities consume oxygen, water, and food and produce waste. We use energy for transportation, heating and cooling, and to power businesses and industries. We interact with biotic and abiotic elements for survival, just as other living things do.

When we are developing new technologies to improve our lives, we do not always stop to consider what impact they will have on the other biotic elements in our ecosystem or the abiotic elements in the environment in general.

Figure 3.8 A water pump, whether it is small enough for a family or large enough for a city, is a technology that saves labour and improves the quality of life.

A39 Starting Point

Skills **A** **C**



Ecotourism

Untouched ecosystems are becoming rare. One way to maintain them is to close them off and protect them from development and visitors.

Another idea is to show people the complex relationships among the biotic and abiotic elements in these special places by opening them to visitors. Ecotourism is a growing business in areas like Wabakimi Provincial Park near Thunder Bay, where it helps to support the park financially.

These visitors need places to stay and eat, as well as transportation. Roads and buildings must

be built. Power sources are required. Opening an unspoiled area to visitors could have some negative costs for the ecosystem.

Consider This

With a partner or in class, debate the following:

Visitors should be kept out of ecosystems that are fragile or unique.

Choose your viewpoint and support your argument.

Assessing Human Impact

While our activities and technologies improve our quality of life, they also affect local ecosystems and Earth's supply of resources. Many of these technologies have damaged ecosystems shared by all. Table 3.1 lists a few of the impacts human activities have on ecosystems.

Table 3.1 Selected Environmental Impacts of Human Activities

Element	Impact
Air	<ul style="list-style-type: none">Burning fossil fuels for heating, transportation, and industry pollutes the air.
Water	<ul style="list-style-type: none">High water consumption by humans reduces the amount of water available for other organisms.Development of human communities can disrupt the flow of water through watersheds.Improper or casual disposal of chemicals can damage water quality.Chemical spills occasionally poison rivers, lakes, and oceans.
Habitat	<ul style="list-style-type: none">Destruction of habitats means fewer producers are available to anchor food chains.Destruction of habitats removes a basic support to all living things in the ecosystem, possibly leading to extinction of some species.

Housing, Transportation, and Recreation

Outside of Ontario's big cities, communities are building on ecosystems in order to add single-family homes, shopping areas, businesses, and schools (Figure 3.9). These growing communities also need roads so the people who live there can travel to work, get food, and get to other communities. The roads cut through ecosystems, dividing or destroying habitat.

In 2005, it was estimated that Ontario's 8 million vehicles were driven almost 125 billion kilometres. Those trips added carbon dioxide and other pollutants to the air. Shipping goods by train takes cars and trucks off the roads, but accidents can result in chemical and fuel spills that could poison water and soil (Figure 3.10). Ecosystems may take a very long time to recover from the loss of these abiotic elements.

Popular recreational activities such as mountain biking and riding off-road vehicles are other human activities that can cause serious damage to ecosystems (Figure 3.11).



Figure 3.9 New subdivisions of single-family homes are sometimes described as “urban sprawl” because they spread over land formerly occupied by ecosystems.



Figure 3.10 Train accidents like this one often result in poisonous leaks into rivers and lakes.



Figure 3.11 Popular outdoor activities with off-road vehicles can tear up the landscape and destroy plants and habitat.

These human activities can damage ecosystems, yet many of these activities are necessary for humans to live. Large farms are needed to provide food. Roads are required to transport food and goods to human consumers. Land is needed for human habitat.

A40 During Writing

Thinking
Literacy

Gathering Ideas for Writing

New homes, roads, and businesses are needed for growing populations. However, they often harm local ecosystems. How can the needs of human communities be met while still protecting the local environment and not destroying the habitat of other living things?

Summarize the issue that this question above addresses. Use what you read in this section and your own thoughts to begin an organizer, such as a chart or web, to record ideas about this issue. Add more thoughts and facts as you continue reading. The ideas in this organizer will help you write a letter to the editor about the issue.



Figure 3.12 Garbage, known as solid waste, is often disposed of in landfill sites.

Recycling vs. Waste Disposal

Human activities produce large quantities of waste material. You have learned that some waste is organic and can be returned to the soil through organic waste recycling programs. Other waste, such as paper, glass, metal, and some packaging, can be recycled. While these recycling activities remove some materials from the piles of trash, communities in Ontario still produce thousands of tonnes of garbage that must be disposed of. Community garbage is often sent to landfill sites, where the material is buried (Figure 3.12). In 2007, the city of Toronto sent about 441 350 tonnes of solid waste to landfill every day.

Early landfill sites leaked toxic substances and chemicals into the surrounding water and soil, poisoning abiotic elements. **Toxic substances** can cause harm or death to living things. Modern landfills are monitored and sealed to prevent toxic leaks from garbage that could include discarded medicines, home and industrial chemicals, and electronic equipment. We need landfill sites to store waste from our activities. No matter how carefully we manage them, landfills cover space once occupied by natural ecosystems.

Take It Further

A growing number of people want to buy organic foods. Find out what organic foods are and why some people may be looking for this type of food. Begin your research at ScienceSource.

- Organizing information
- Reporting results

Taking Out the E-Trash

Issue

Modern electronics are very popular. The technologies used in these products are always changing. New features are added. Products get smaller and easier to use, and consumers want to get the newest version. It has been estimated that Canadians throw out 1450 tonnes of cellphones alone in a year. Computers, cameras, game systems, and music players add to the pile (Figure 3.13).

Electronic products contain plastic and metals such as aluminum, copper, gold, iron, lead, mercury, steel, and zinc. None of these materials can be broken down by decomposers. What should be done with all this waste?

Background Information

1. In order to evaluate the best way to dispose of old electronic products, you need more information. Working in a group of six, each member will choose one of the following options for disposing of unwanted electronics. Not all of the options are available in Canada. Research will need to include options from around the world.
 - (a) donating the product to someone else
 - (b) sending the product to landfill
 - (c) incinerating the product
 - (d) recycling in a foreign country
 - (e) recycling in Canada for a fee
 - (f) requiring the manufacturer to take the old product back
2. Use the guidelines below to focus your research. Record the information and sources of your research in notes, charts, or tables. Use your judgement to choose the best methods for recording your data.
 - (a) Choose one electronic product you have discarded in the last year. Try to find out the estimated amount of this product that is being discarded every year in Canada.
 - (b) Describe how your preferred disposal option works.
 - (c) Describe the impact of your preferred option on the environment, if any.
 - (d) Describe the impact of your preferred option on human health, if any.
 - (e) Estimate whether or not your preferred option could absorb all or most of the electronic waste being generated in Canada.



Figure 3.13

Analyze and Evaluate

3. As a group, prepare a report recommending the best way or ways to handle electronic waste in Canada. Include the reasons for choosing the options the group is recommending and the reasons for rejecting other options.

A42 Problem-Solving Activity**Toolkit 3****SKILLS YOU WILL USE**

- Identifying a problem
- Designing, building, and testing

Cleaning Up an Oil Spill

Figure 3.14 Oil spills destroy the insulating qualities of the feathers and fur of many shoreline birds and animals.


Recognize a Need

Oil is shipped long distances in large tankers. From time to time, these tankers run aground and spill their contents along a shoreline. People living nearby must move very quickly to clean up the oil before it damages local ecosystems.

Problem

How can you clean up an oil spill in an ecosystem?

Materials & Equipment

- a square or rectangular shallow container (minimum 1.2 L)
- 1 L of sand
- 4-5 small rocks
- 2 small plants
- water
- 2 tbsp (30 mL) motor oil 
- materials of your choice for use in the clean-up

Criteria for Success

- Oil is completely cleaned out of the water and the other abiotic and biotic materials.

Brainstorm Ideas

1. Research the technologies used to clean up spills from oil tankers. How effective were these technologies?
2. What technologies could you use to clean up your model oil spill?

Build a Model

3. Create a miniature shoreline ecosystem in your container. Use the rocks to protect the sand. Add the water last, using just enough to create a model shoreline.

Test and Evaluate

4. Take 2 tbsp of the oil and add it to the water. Move the container from side to side to model gentle wave action.
5. Use the technology you researched to clean up biotic and abiotic elements in your mini-ecosystem.
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 report or computer slide show presentation on the success of your clean-up operation. Or present your findings to the class in a form suggested by your teacher.

Key Concept Review

1. Describe two ways in which human activity has had an impact on abiotic elements. How could these impacts affect the environment?
2. How does recycling help solve some of the problems caused by the amount of waste produced by human activities?
3. How could teens discard unwanted electronic equipment without having much or any impact on the environment?
4. Explain why some environmental changes caused by humans cannot be dealt with by the process of succession.


Connect Your Understanding

5. Describe three ways in which your activities affect the environment. Are these effects positive or negative?

Practise Your Skills

6. Why is it important to consider opinions from a variety of perspectives when evaluating information to make a decision?



For more questions, go to ScienceSource. 

A43 Thinking about Science and the Environment




Limiting Factors and Human Communities

In Chapter 2, you read about limiting factors on populations. These included predators and the supply of resources such as water, food, and suitable habitat.

In 1900, the world's human population was estimated to be 1.7 billion. In 2000, it was estimated to be 6.1 billion.

What to Do

1. Use the Internet to find out what the estimated population of the world is now and what the population is projected to be 10 years from now. 

Consider This

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

1. Do you think limiting factors could affect the world's human population? Explain your reasoning.
2. Which limiting factor do you think is most likely to have an impact on the world's population? Explain your reasoning.
3. What do you think the world's populations could do to protect themselves from the impact of limiting factors?

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

- Decisions to change human activities and technologies to benefit the environment have measurable costs and benefits.
- Human communities can manage their waste products in order to cycle matter.
- Technology and practices to clean the air and water, reduce waste, and reduce energy needs already exist.



Figure 3.15 “Smog warnings” are issued during the summer months when the air quality is poor enough to cause health problems.

On hot, sunny days between May and September, air pollution in Ontario is often visible on the horizon and is sometimes a problem for people with breathing difficulties. Air pollution is most obvious in big cities (Figure 3.15).

People all over Ontario can help reduce the province’s “smog days” by driving well-tuned vehicles, driving less or car pooling, taking public transit, or reducing the use of air conditioning. People often make these kinds of choices by comparing the benefits with the costs in terms of money or convenience.

A44 Starting Point

Skills **A** **C**



Too Much Phosphorus in the Water

In the mid-1960s, North American lakes and rivers were turning green. Algae were so dense that sunlight could not penetrate the water, and, as the increased amounts of algae died, oxygen was consumed by decomposers. This left very little oxygen for the rest of the ecosystem. The problem was caused by phosphates in laundry detergent. They remained in treated waste water being cycled back to freshwater ecosystems and acted as a fertilizer, fuelling growth.

While the soap industry spent millions on research for another chemical and asked for

more time, consumers demanded phosphate-reduced detergent be made available immediately. They got their wish, and the popular environmental movement got its start.

Consider This

1. If you knew you were using a product that was destroying a local ecosystem, would you stop using it? Why or why not?
2. If the replacement for the product cost more than the original one, would you pay the extra money? Explain your reasoning.

Choosing Sustainable Communities

A sustainable human community is one that more closely models an ecosystem. Energy comes from renewable resources, and waste products are broken down into elements that can be re-used. Changing the way communities work in order to become more sustainable benefits the health of people as well as ecosystems. Adopting sustainable practices such as recycling may involve spending money or perhaps making a personal effort to do some things in a less convenient way.

Can communities change? Before 2004, residents of the town of Markham, Ontario were putting 35 percent of their solid waste into blue boxes or leaf and yard waste composting. The other 65 percent was going to landfill. In 2004, the town announced that 70 percent of Markham's solid waste would be diverted from landfill through recycling by 2007. More recycling programs, including a green bin organic waste program, were set up, and by the end of 2007, the town had achieved its goal (Figure 3.16).

The Costs and Benefits of Recycling

Millions of dollars are spent building recycling plants, organizing the collection and sorting of materials, and educating citizens on their role. It can be a very costly process, and the benefits may not be visible immediately.

For example, in the early days of recycling, recycled paper was much more expensive than new paper. Now the recycling process is more efficient, and recycled paper products are affordable. The benefits of recycling paper include more than saving trees. When compared to the processing of wood pulp, less total energy and water are required in the manufacturing process, and fewer chemicals such as bleach are used. Paper recycling also reduces the amount of solid waste that goes into landfill (Figure 3.17).

Individuals must compare those benefits to the costs to themselves in terms of the amount of time they spend sorting materials for recycling and the taxes they pay to build and support recycling programs.



Figure 3.16 Materials to be recycled are picked up from homes and businesses.



Figure 3.17 Recycling programs for paper are now common in many schools and offices.



Figure 3.18 Disposable products may seem convenient, but their disposal costs money. Improper disposal affects the environment.

Beyond Recycling: Re-use and Reduce

“Re-use” and “reduce” are the other two ways to solve the challenge of modern waste disposal. Using containers, tools, and materials again rather than disposing of them and buying new ones saves money and reduces solid waste. Although it may be less convenient and cost time and personal energy, these options are better for the environment. For example, it takes time to rinse and re-use a water bottle made for repeated use instead of having a fresh “disposable” one available each day. However, there is a benefit to the environment of not manufacturing and then disposing of millions of plastic water bottles in landfill (Figure 3.18).

The processes and technology to recycle products such as electronics are not as advanced as they are for paper, glass, and metal. Using products for longer periods means continuing to use older models. Is that a cost consumers will accept to get the benefits of a healthy environment?

Reducing use of technologies that pollute or destroy ecosystems is another way to protect them. This may mean walking to school or riding a bike instead of being driven in a car. It may mean choosing products that do not require batteries. These are personal decisions that individuals can make after they compare the benefits of the technology to the cost of the impact on the health of the environment.

A45 *During Writing*

Thinking
Literacy

Considering Other Opinions

Talking about an issue with others gives you a chance to explain your opinions and to think about other opinions.

People depend on technology every day, but many activities using technology harm the environment. Who should be responsible for the negative effects on the environment, and what should they do about it? In your classroom, mark each corner to represent one of the following: technology users, technology makers, people who sell technology, and the government.

Take a few minutes to consider who you think is responsible for protecting the environment, and move to the corner that represents your choice. Discuss your ideas with the other people in your corner. Your group will then summarize and present the groups' opinion to the class.

As you listen to the other opinions, do they affect your thoughts in any way? Add any new ideas to your organizer. You are now ready to write a draft copy of your letter to the editor.

Choosing Sustainable Technologies

The technologies that can reduce the need for fossil fuels for transportation, heating, and powering industry exist and are being introduced into Ontario communities. There are many examples of the possibilities.

- In the hot summer months, some buildings in downtown Toronto are cooled by circulating cold water from Lake Ontario through their systems. This reduces energy consumption and carbon dioxide emissions.
- A wind farm near Shelburne, Ontario, generates enough electricity to power 20 000 homes (Figure 3.19).
- Electric cars are being built in Canada and elsewhere.
- Electronic equipment can be powered without batteries.
- New buildings are being designed with “green” roofs and solar panels, and older buildings are being remodelled to use more sustainable practices (Figure 3.20).

Evaluating Costs and Benefits

The development of new technologies costs money, and the financial costs of these changes can be calculated. But there are other costs — social and environmental costs — that are not as visible or easy to calculate. An example of a social cost of air pollution is an increase in respiratory illnesses.

Benefits can also be financial, social, or environmental. A financial benefit of reducing air pollution would be a reduction in healthcare costs. A social benefit would be fewer people whose lives are disrupted by illness.

The environmental costs of development or pollution — loss of habitat, fresh water, and clean air — are not paid directly by humans. However, the connections among all living things are becoming more clear. You have learned that all living things, including humans, depend on each other for survival. The benefits of a healthy environment are benefits for all living things. Can these benefits be calculated?

Assessing both costs and benefits of new technologies and ways of doing things is an important part of looking at the impact of human activity and technology on the environment. Your use of sustainable technologies will help improve and maintain a healthy environment for all.



Figure 3.19 Wind farms can contribute to the supply of electricity in Ontario.



Figure 3.20 A “green” roof includes soil and plants that absorb water as well as heat in the summer to keep the building cooler.

Suggested Activity •
A46 Decision-Making Analysis on page 78

Take It Further

There are many groups of ordinary people working together to build sustainable communities and preserve the environment. Choose one group and find out what their objective is and what their members are doing. Begin your research at ScienceSource.

- Gathering Information
- Stating a Conclusion

What kind of car will you be driving?

The Issue

The supply of oil to make the gasoline that powers conventional car engines is large but limited. Populations in India and China are becoming rich enough to buy their own cars, and the demand for this oil-based fuel will continue to increase. In addition, the exhaust from these engines is damaging the air quality in communities around the world.

All of these factors suggest that alternatives to conventional vehicles and car engines must be developed and on the road in the coming years (Figure 3.21).

Background Information

- In order to find out how cars of the future might be powered, you need more information. Working in groups of three, identify three alternatives to a conventional car engine that uses gasoline for fuel.
- Have each group member choose one of the alternatives, and use the guidelines below to focus your research. Record the process, results, and sources of your research with notes, diagrams, or tables. Use your judgement to choose the best methods for recording your data and information.
 - What mechanism powers the vehicle?
 - What kind of fuel does the vehicle use?
 - What are the by-products or emissions from the vehicle's operation?
 - How well does the vehicle perform?
 - What is the potential cost of the vehicle and its fuel?
 - How easy will it be to refuel the vehicle?

- What social changes (if any) might be necessary in order to make the vehicle successful? For example, gas stations are a feature of all communities. If the alternative vehicles do not use gasoline, what will happen to the gas stations?
 - What would be the benefit of using this new kind of car? Include financial benefits as well as any environmental benefits.
- Share your information with other members of your group. Consult with other groups as well. You may have gathered information that they can benefit from, and they may have done the same for you.

Analyze and Evaluate

1. What criteria will you use when you evaluate the cars of the future?
2. Which alternative do you think is most likely to be accepted? Explain your reasoning using a comparison of the costs and benefits of making the change.

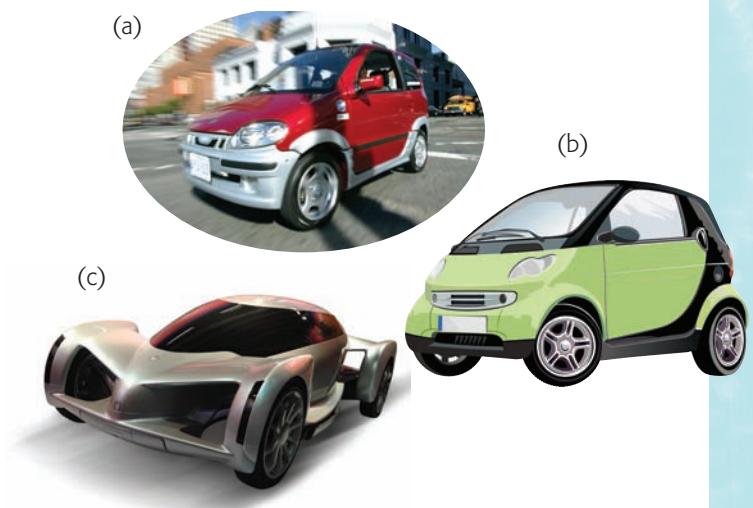


Figure 3.21 (a) ZENN (zero emissions, no noise) car
(b) Smart car
(c) Energy-efficient design

- Asking questions
- Organizing information

What do you want to do today?

Issue

Human activities and technologies have an effect on the environment. Often there are choices available that will have a limited impact on the environment and can help protect ecosystems.

Background Information

Consumers are found in every ecosystem on Earth. In addition, human consumers are often found in malls and shopping centres in North America, as well as online.

Shopping for and buying items is an important part of the economy. Human consumption includes getting the weekly groceries, buying the latest fashion, getting a haircut, or going to a restaurant for a quick snack. Packaging, plastic bags, emissions from cars driving to the mall, throw-away dishes, and basements full of objects that are not used anymore are all results of these human activities.

The products we buy are made from resources that come from Earth. Energy is used to manufacture, package, and transport them to markets. More energy is used to light and power stores and malls. Considerable waste is generated after products have been used. What impact do these activities have on the environment? As we begin to understand about the environmental impact of our consumption, what are we willing to do to change that impact?

Analyze and Evaluate

1. Consider one of the activities listed below and how it affects the environment:
 - (a) visiting a fast food restaurant for a meal with your friends
 - (b) the family's grocery shopping

- (c) going to the mall to pick up something new to wear or play with
- (d) another activity that you participate in that has an impact on the environment (check with your teacher to ensure it is applicable)

2. Use the chart below to analyze the impact of your chosen activity on the environment.

Benefit to you (+)	Cost to the environment (–)	Options

In this activity, benefits (+) are things that are good for you, the consumer. Costs (–) are things that are not good for the environment. In the Options column, list ways you could reduce the negative impact of the costs but still get the benefit of the activity.

3. Once you have filled in information on the activity you chose, find two classmates and compare the benefits, costs, and options you each listed.
4. Discuss with your small group any other questions, concerns, or related information you have about your activity. Record these on the back of your chart.
5. Work as a group to develop a creative way to share your findings with the rest of the class, (speech, computer slide show, editorial, or video report) or suggest ways to balance the benefits and costs of some common activities at an Environmental Action Fair. Your teacher will tell you the date by which you must be ready to present.

Key Concept Review

1. Describe how financial costs can influence choices people make about actions that affect ecosystems.
2. Describe how wind farms can help protect the environment. Are there any potential negative impacts?
3. Describe two examples of new technology and ways of thinking that can make a positive difference to the environment.


Connect Your Understanding

4. Give an example of a social cost and a social benefit of preserving a meadow instead of building a new arena.

5. How are social and environmental costs different from financial costs? Are they similar in any way?

Practise Your Skills

6. Design a poster to promote one of the following:
 - (a) walking to school
 - (b) having a “no waste” lunch
 - (c) not leaving a car running
7. Use a chart to show the financial, social, and environmental costs associated with building a new shopping centre.

For more questions, go to ScienceSource. 

A48 Thinking about Science and the Environment



Positive Actions for the Environment

Residents of Brighton, a town of about 5000 people near Lake Ontario, built a marsh in an old cornfield. It is for treating waste from the town's sewage treatment facilities. The plan is to construct wetlands that treat waste water, while re-establishing a diverse ecosystem.

In northern Quebec, a protected area that includes the areas drained by the rivière du Vieux Comptoir, the mouth of the river, and the James Bay area where the river flows into is being created. The local Cree people will share their knowledge of the land and the bay and assist in managing the area.

What to Do

1. Discuss with a classmate how the two projects each combine human activity and protection of ecosystems.
2. Look in the newspapers and online for other examples of human activities that preserve or maintain a healthy environment.

Consider This

3. In what other ways do human communities maintain the health of ecosystems while they are growing and expanding?



Rewilding

Imagine driving through western Canada and the United States and taking time out to see the wild elephants, lions, camels, and cheetahs there. How could this be? The idea is called rewilding, and people are talking about it.

Some scientists argue that most of the large mammals living in Africa and Asia face extinction. Rather than just letting them die, why not introduce some of these species to the wide-open spaces of North America? There, free from human population pressure and habitat destruction, they could survive and prosper.

It may not be as crazy as it sounds. For one thing, 20 000 years ago North America was home to a variety of similar animals. There were camels, lions, cheetahs, the elephant-like mammoths, and the mastodons. Where there's a history, there's at least the likelihood of a suitable habitat.

There's enough land available to make such a project at least thinkable. In fact, the North American habitat could benefit: camels and elephants, by grazing on woody plants, would help restore the American grasslands to their former glory. The now-extinct American cheetah likely preyed on the pronghorn, prompting its evolution as one of the fastest animals on Earth. Maybe African cheetahs would resume the hunt that has been suspended for many thousands of years.

One of the prime motivations for rewilding is that large animals, whether carnivores or herbivores, exert a disproportionately large influence on their habitats. Predators like lions cull their herbivore prey, leave carcasses for

scavengers and are host to a variety of ticks, lice, and other invertebrates that in turn are fed on by others.

Obviously there are huge political and biological problems with the idea. Even if the American west is relatively under-populated, most of the land is still in private hands. And who in Africa would want to allow this program? It would be like admitting that their conservation efforts have failed. And we are living in a different time, a different climate, a different world: replacement species might not be so well-suited to the habitat into which they are being introduced. Sure there were cheetahs in North America in the past, but we have no idea how modern cheetahs would do.

Maybe in the end the value of this idea would be to encourage more adventurous thinking about conservation and biodiversity and to concentrate on those endangered species we already have.



Figure 3.22 Rewilding means these animals could live in North America.

Key Concept Review

1. Explain how ecosystems change naturally. Use specific examples. **K**
2. How do catastrophic events in nature affect the balance of biotic and abiotic elements in an ecosystem? **K**
3. List three impacts human activities have on water. **K**
4. Suggest a strategy a community could use to divert waste from landfills. **K**
5. Write a poem or a rap verse to explain how reducing, re-using, and recycling materials can benefit the environment. **K**

Connect Your Understanding

6. Describe how you would decide which of the drink containers shown in the photos below is better for the environment. **A**




7. Draw an eight-panel cartoon that would explain why it is important to reduce the use of resources that come from Earth. **C**
8. Design a poster to promote an alternative energy source. Be sure to explain the benefits of this new technology. **C**
9. What are the benefits of a forest fire in a forest ecosystem? **A**
10. Ancient civilizations in Egypt were based on the Nile River. Each year the Nile would flood its banks and add fertile sediment to the local soil. How would this help the farmers who lived near the river? **A**

After Writing

Thinking Literacy



Reflect and Evaluate

Review your letter to the editor, and then discuss with a partner the ideas presented in each of your letters. Have facts and opinions been clearly expressed? Have the concepts of change in ecosystems and our role as stewards of the environment been communicated? At the beginning of this chapter, you examined several examples of letters to the editor. Do your letters include the characteristics you saw in these examples?

11. Write a letter to the local council describing how recreational development may alter the environment shown in the photo below. Make it clear whether you support or oppose the development and explain why. 



Practise Your Skills

12. Explain the steps you would follow to analyze the impact of a particular human activity on the environment. 
13. Design a computer slide-show presentation to teach primary students about reducing, re-using, and recycling materials. 

Unit Task Link

Some human activities in the developed world must change in order to preserve ecosystems. Make a list of the top five activities that you believe must change in order to protect the environment. Indicate whether the change is related to reducing, re-using, or recycling.

A49 Thinking about Science and the Environment



Stewardship

You have been learning about how biotic and abiotic elements in ecosystems depend on each other for survival, and how ecosystems, when left alone, can sustain themselves.

This chapter has looked at how human activities can harm the ability of ecosystems to sustain themselves. It has raised questions about how human activities could be changed to protect the environment. You have read examples of how some communities have changed their activities.

This unit began with a discussion of the term “steward.” When we plan our daily activities, should we consider our role as stewards of the environment? Why or why not?

Consider This

With a classmate or as a whole class, discuss the following:

1. Is protecting ecosystems an effective way to be a good steward of the environment?
2. How have some of the practices of Aboriginal peoples been good examples of stewardship of the environment?
3. How are sustainable activities related to being a good steward of the environment?
4. Make a list of five things you can do to be a good steward of the environment.

UNIT A Summary

1.0 Ecosystems are communities where biotic and abiotic elements interact.

KEY CONCEPTS

- Interaction of biotic and abiotic elements
- Role of producers
- Interactions of producers and consumers

CHAPTER SUMMARY

- Biotic elements (living things) have five basic needs: oxygen, water, food, energy, and habitat.
- Biotic elements interact with both living things and non-living (abiotic) elements to meet their basic needs.
- Plants are the only organisms that can use the Sun's energy to make food. All ecosystems include plants.
- All other organisms must consume other living things to get food.

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

KEY CONCEPTS

- Energy transfer in ecosystems
- Cycling matter
- Interactions and changes in ecosystems

CHAPTER SUMMARY

- Food chains and food webs show how the Sun's energy is transferred in ecosystems.
- At each step in a food chain, less energy is available to the next consumer.
- Matter moves continuously from non-living things to living things and back to non-living things in a cycle of constant change in ecosystems.
- The supply of resources in ecosystems is limited.
- A big change in the supply of resources disrupts interactions. Sometimes a big change threatens the survival of living things in an ecosystem.

3.0 We can change our actions and technologies to better protect the environment.

KEY CONCEPTS

- Succession, recovery, and renewal in ecosystems
- Human technologies and activities and their environmental impact
- Human communities and sustainability

CHAPTER SUMMARY

- Ecosystems change naturally in predictable ways known as succession.
- Ecosystems can recover from catastrophic natural changes.
- Many modern human activities and technologies have damaged abiotic and biotic elements in ecosystems. Ecosystems may take a very long time to recover.
- Human communities have the knowledge and technology to reduce the environmental impact of their activities.

Reduce the Size of Your Ecological Footprint



Getting Started

Earth, our habitat, has a total area of just over 50 billion hectares, but less than one-quarter of that area produces food and other resources. This means that just 12 billion hectares are available to provide the basic needs of all producers and consumers (including humans) on Earth. For six billion humans, this works out to two hectares each, which we must share with other living things.

You have learned that all living things must meet five basic needs in order to survive. You have also learned that there is a limited amount of resources available for living things to meet those basic needs. By assessing your lifestyle choices, you can find out whether you use resources equal to more or less than “your” two hectares of land. The amount of Earth required to support you is known as your “ecological footprint.”

Your Goal

You will score your activities to assess the size of your ecological footprint. Then you will review your lifestyle and find ways to make your footprint smaller.

What You Need to Know

You can calculate your Ecological Footprint using an Ecological Footprint Calculator (EFC). Your teacher will provide this. You will be scoring your activities in six categories: food, water, energy, transportation, shelter, and lifestyle.

Steps to Success

1. Use the EFC to calculate your ecological footprint. Which categories were high? Were any categories low? How did you compare with the rest of your classmates?
2. In pairs, examine your scores in each of the six categories. Identify changes (a minimum of two per category) you could make that would reduce your score.
3. As a class, share ideas on how everyone can reduce their ecological footprints. Include ideas for reducing activities and re-using or recycling items. How many of these changes are you willing to make? Why or why not?
4. Create an ecological footprint contract that will commit you to making at least one change in each category that will reduce your ecological footprint. Choose changes that are realistic and achievable.

How Did It Go?

5. Use the EFC to recalculate your impact on the environment, assuming that you have made the changes described in your contract. How big is your footprint now? What would you have to do to reduce it to two hectares?
6. Do you think you can change your lifestyle to one that uses less of Earth’s resources? Write out each change in activities that will be necessary and how you could make it.
7. Create a poster, calendar, or diary to help you track your progress in reducing your ecological footprint. Challenge your classmates to find out who has been able to make the changes.

UNIT A Review

Key Terms Review

1. Create a mind map that shows your understanding of the terms listed below. You may want to add some words of your own to show how the terms are connected. **k**

- | | |
|---------------|------------------|
| • abiotic | • habitat |
| • biotic | • human impact |
| • climax | • interactions |
| community | • organic matter |
| • consumers | • producers |
| • decomposers | • succession |
| • energy | • sustainability |
| • food chains | |

2. Use the words listed below in a paragraph that explains how the Sun's energy is transferred through an ecosystem. **k**
carnivore, consumer, decomposer, herbivore, omnivore, producer
3. *Sustain* is the root word in *sustainability*. How does the meaning of *sustain* help you understand what the word *sustainability* means? **k**

Key Concept Review

1.0

4. Describe an ecosystem in your own words. Apply your definition to the following statements, and explain why each one is true or false. **k**
- (a) A schoolyard is an ecosystem.
(b) A puddle on the road is an ecosystem.
5. Explain why abiotic factors are essential to ecosystems everywhere. **k**
6. Describe three types of interactions that could take place in an ecosystem, and give an example of each. **k**
7. Ecosystems change both naturally and as a result of human activity. Give an example of each type of change, and explain how it could affect the ecosystem where the change is occurring. **k**
8. How can looking at the costs and benefits of an activity help evaluate the effect the activity has on the environment? **k**
9. Select an area near your school that has both biotic and abiotic elements. List three of each. Draw lines to show possible connections among the different elements. **k**
10. List three of the basic needs of living things, and explain their importance. **k**
11. How are producers and consumers similar? How are they different? Explain why producers are at the beginning of every food chain. **k**
12. Plants make their own food through photosynthesis. This is how they obtain the matter and energy they need to survive. **k**
- (a) What are the raw materials for photosynthesis?
(b) What are the products of photosynthesis?
(c) Give three reasons why plants are important for ecosystems.

- 13.** Look at the picture shown below. Identify four biotic elements that could be living in this location. **k**

(a) Explain how these biotic elements might be connected to one another.

(b) Explain how the biotic elements might be connected to the abiotic elements in the location.



(c) Would you expect to find scavengers and decomposers in an ecosystem like this? Why or why not?

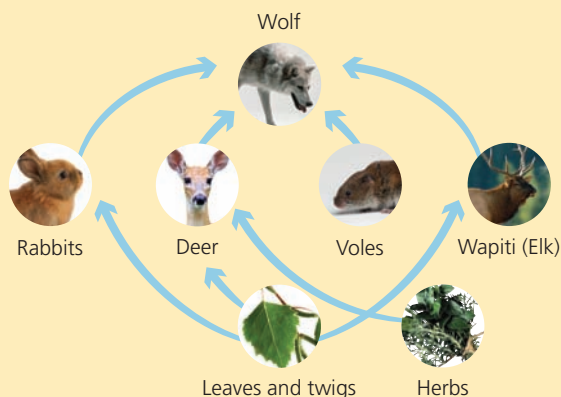
2.0

- 14.** In terms of the flow of energy through an ecosystem, what is the correct order for each of the following elements? **k**

(a) earthworm, rabbit, rose, Sun, wolf

(b) bacteria, otter, sea urchin, seaweed, Sun

- 15.** Study the diagram below.



(a) Identify at least three food chains. List them in the correct order. **k**

(b) Does a food web give a better picture of interactions in an ecosystem than a food chain does? Explain why or why not. **k**

- 16.** What would happen if the abiotic matter in the environment was not recycled? How do you know? **t**

- 17.** Compare the number of producers in an ecosystem to the number of herbivores. How do you think the number of carnivores compares with the number of herbivores? Give reasons to support your answer. **k**

- 18.** Explain the term *sustainability*. Give two examples of how an ecosystem in a natural setting is sustainable. **k**

- 19.** How might the introduction of a non-native plant or animal species affect an ecosystem? **k**

3.0

- 20.** Over the years following a forest fire, the plants and animals listed below appear in the area. In what order do you think they appear? Explain your answer. **k**

bear, birch tree, fireweed, grass, mouse

- 21.** How have humans affected a natural area in your community? Were these effects positive or negative? Explain your answer. **k**

UNIT A Review (continued)

- 22.** Use examples to demonstrate your understanding of the terms below. **k**

environmental benefit, environmental cost, financial benefit, financial cost, social benefit, social cost

- 23.** Explain how the following activities affect the balance of interactions in an ecosystem. **k**

- (a) cutting all the trees in a forest
- (b) running motorcycles and ATVs (all-terrain vehicles) through a wetland
- (c) spraying a pesticide to control insects on a lawn

Connect Your Understanding

- 24.** Whether they are started naturally or by people, forest fires change the ecosystem of a forest.

- (a) Name at least three other natural changes that can affect ecosystems. **t**
- (b) Choose one of the above natural changes. Describe how it might affect an ecosystem. **a**

- 25.** The photo on the right shows a huge pile of tires burning. Suggest three effects the event could have on the environment. For each, suggest ways the environment could recover. **t**



- 26.** Now that you have completed this unit, do you think you will make different decisions when choosing activities that will affect the environment? Why or why not? **a**

Practise Your Skills

- 27.** Look at the photo below and explain how the shore ecosystem will be affected by the oil spill. Use a series of diagrams to show how the area might change over the next 20 years. **t**



- 28.** Your school wants to start a recycling program. What information would you need in order to determine if this is a good idea? Design a survey as a first step in investigating the issue. **a**
- 29.** Make a four-by-four grid titled “Human Impacts.” At the top of each column, write the headings “Human activity,” “Air,” “Water,” and “Habitat.” In the “Human activity” column, write “build a golf course,” “restore wetland,” and “build housing development.” Write notes on the effect of each activity on the air, water, and habitat. **t**

30. Describe an environmental issue in your community. Design a poster or picture that illustrates the issue. Be sure your poster includes the causes and effects of the issue. **c**

31. Design an action plan to help the community deal with the issue you described in question 31. List the factors you would take into consideration. **a**

32. Create a chart to demonstrate the costs and benefits that need to be considered when making informed decisions about human impact on the environment. If you wish, use the issue from question 30. **a**

Revisit the Big Ideas

33. Identify which of the following statements are false. Reword the false statements to make them true. **k**

(a) Ecosystems can only be large.

(b) Ecosystems contain both biotic and abiotic elements.

(c) Only the stones and sand in a puddle are needed to make up an ecosystem.

34. Use the following examples to demonstrate how people can affect energy transfer and the cycling of matter in an ecosystem. **b**

(a) A developer fills in a wetland to build houses.

(b) A farmer ploughs up a grassland to plant a crop.

(c) A town changes the drainage system in an ecosystem to reduce flooding.

35. Identify one example of human impact on an ecosystem that you could help to reduce. Describe what you could do to reduce this impact. **a**

A50

Thinking about Science, Technology, Society, and the Environment



Can you go “carbon neutral”?

Going “carbon neutral” is a way of balancing an activity that omits carbon dioxide with one that removes carbon dioxide from the atmosphere. The amount of carbon dioxide emissions caused by one activity is calculated. Then activities that remove (or offset) the same amount of carbon emissions from the environment are undertaken or funded. Supporting renewable energy products or planting trees can all be carbon offsets.

Consider This

With a small group of your classmates, discuss the following statement:

Going carbon neutral will give people an excuse to not change their attitudes and actions toward the environment.