2.4 Ecosystem Services

Key Terms
ecosystem services
desertification
watershed
connectivity
ecotourism

The concepts of *niche* and *carrying capacity* include the idea of services. **Ecosystem services** are the benefits experienced by organisms, including humans, that are provided by sustainable ecosystems. Ecosystem services are the natural result of all the activities that occur in the biosphere. They include

- the provision of food and clean water
- the cycling of nutrients
- the conversion of atmospheric carbon into biomass (which influences climate and weather)
- the pollination of crops and natural vegetation
- the balance of processes such as growth and decomposition
- the provision of beauty and spirituality

Ecosystem services allow ecosystems to function, which is a requirement of sustainability.

ecosystem services the benefits experienced by organisms, including humans, that are provided by sustainable ecosystems

The Ecosystem Services Provided by Forests

In the past, the value of a forest was measured in dollars, based on the value of the trees that could be harvested for building or paper products. This value is still important. The forest industry in Canada is responsible for billions of dollars' worth of economic activities each year from logging operations and the manufacture of wood and paper products. The forest industry is particularly important in northern Ontario, where many communities are economically dependent on logging. A supply of trees, harvested in a sustainable manner, is needed to maintain the economic activities of these communities. Forests also perform many other ecosystems services, such as influencing climate—shown in **Figure 2.20**—reducing erosion in watersheds, and providing a habitat for thousands of species. In Chapter 3, you will read that tropical rainforests, in particular, are home to millions of species of insects, birds, plants, and other organisms.

Figure 2.20 Rain clouds form over forests, which help keep the climate cooler and wetter than it would be without the forest.

The Influence of Forests on Climate

Trees extract huge amounts of water from the soil. On hot days, much of this water escapes through the stomata, adding water vapour to the atmosphere. This helps to reduce temperatures and form rain clouds, as shown in **Figure 2.20**. More than half of the moisture above tropical forests comes from the trees.

When large forested areas are cleared, the local annual precipitation drops and the climate gets hotter and drier. The clearing of large forested areas is one factor that can lead to the desertification of an area. **Desertification** is the change of non-desert land into a desert.

desertification the change of non-desert land into a desert; desertification may result from climate change and unsustainable farming or water use

watershed an area of land over which the run-off drains into a body of water

Areas of Ontario have suffered from desertification in the past. When European settlers came to Norfolk County in southern Ontario, they cut down trees for lumber and cleared the land for agriculture. This led to desert-like conditions. Severe droughts and erosion forced the settlers to abandon their farms. In 1908, the St. Williams Forestry Station was created and more than 300 000 trees were planted. The area is now reforested and has become a model for restoring forests.

Forests and Watersheds

Forests can also benefit local watersheds. A **watershed** is an area of land that run-off drains over, into a body of water. Studies have compared run-off over watersheds that have been cleared of trees with run-off over watersheds that still have trees. These studies have shown that run-off increases by 30 to 40 percent in cleared areas. This means that soils in cut areas are less likely to retain rainwater and meltwater, and that the amount of erosion increases. In cleared areas, there is also an increased loss of nutrients, such as nitrogen, that are in limited supply.

The graph in **Figure 2.21** shows that the amount of nitrogen in run-off from a cleared watershed was 60 percent higher than the amount of nitrogen in run-off from an uncut watershed. Recall, from Chapter 1, that an excess of nutrients in water, or eutrophication, can lead to an overgrowth of algae that can affect an entire ecosystem.

Sense of Value

Other ecosystem services of forests include producing oxygen and removing pollutants from the air. In 50 years, a single tree can produce about $30 000 worth of oxygen and remove pollutants that would cost about $60 000 if humans were to try to remove them from the air.

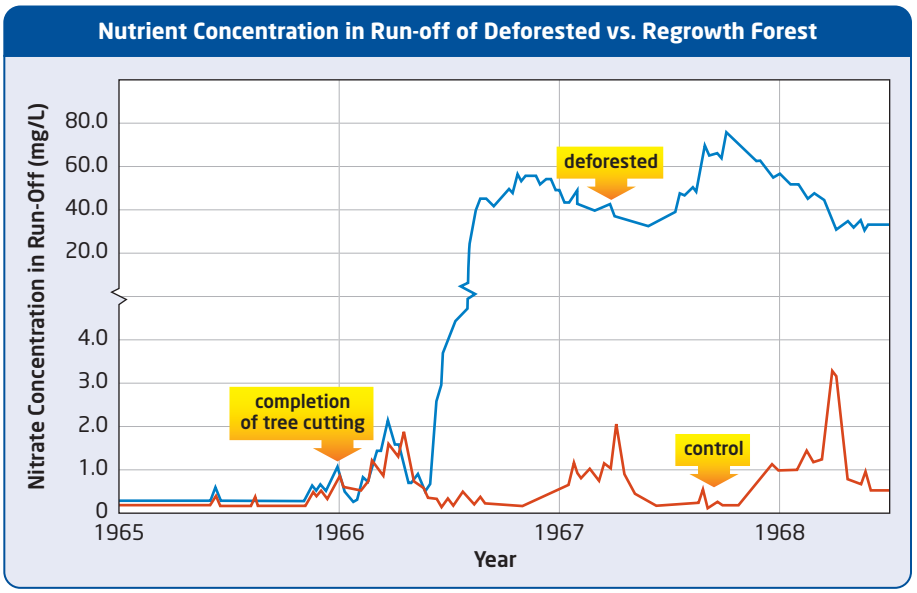


Figure 2.21 This graph compares the amount of nitrogen in run-off from a watershed that has been cleared to a watershed that is forested.

Learning Check

1. What are ecosystem services?
2. Briefly describe how forests can influence climate.
3. What are two negative outcomes of cutting down a forest?
4. Using data from **Figure 2.21**, explain one effect that cutting a forest has on a watershed.

Figure 2.22 Not all pollination is brought about by insects. Some plants rely on birds, bats, and other mammals to transfer pollen from one flower to another.

Insects and Ecosystem Services

Like many organisms, most plants reproduce through sexual reproduction. Male pollen from one flower fertilizes the female ovary in another flower of the same species in a process known as *cross-pollination*. The majority of plants rely on animals to move pollen from one flower to another. The most common pollinators are insects such as bees and beetles. Other organisms, such as the bat shown in **Figure 2.22**, are also important pollinators. Cross-pollination can also occur when pollen is transferred from one flower to another by wind. Sometimes pollination occurs through *self-pollination*, in which flowers can pollinate themselves or another flower from the same plant.

Pollination and the World's Vegetation

Many studies have confirmed that, for most plants, productivity is much greater when flowers are visited by pollinators. In wild species such as blueberries and raspberries, as well as in agricultural plants such as vegetables, livestock crops, and spices, fruit and seed production are much higher when plants are pollinated by insects. The graphs in **Figure 2.23** show two examples of plants that produced more seeds when they were cross-pollinated than when they self-pollinated. Cross-pollination by insects deserves the credit for perhaps one third of our food, a service that has been estimated at about $250 billion per year worldwide.

The best-known pollinators are honeybees. A recent phenomenon coined *colony collapse disorder* has concerned ecologists. The case study on the next page describes colony collapse disorder and its possible causes.

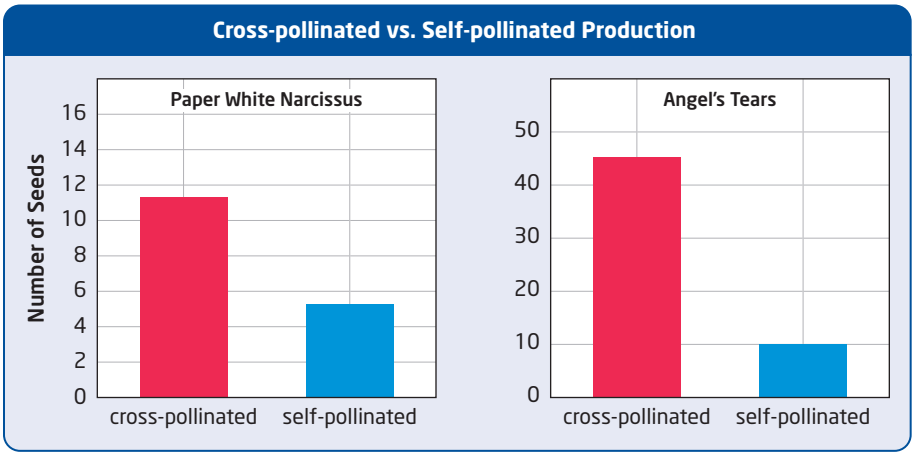


Figure 2.23 Laboratory studies show that plants that are cross-pollinated are more successful in producing fruit and seeds. In nature, cross-pollination usually occurs when animals move pollen from one flower to another.

Insects and Decomposition

Section 2.2 reviewed four important relationships among living organisms: predation, competition, mutualism, and parasitism. Decomposition is a fifth important ecological relationship. It is also an ecosystem service. Decomposition is the breakdown of organic wastes and dead organisms. It differs from the other relationships in one important way: it occurs between a living organism and a dead organism. All living things die eventually. Locked up in their dead bodies are nutrients and energy that must be recycled.

Insects are one of three main groups of organisms that serve as decomposers in ecosystems. The other two groups are bacteria and fungi. Decomposer insects, such as beetles, flies, wasps, and ants, feed off dead plants, animals, or animal feces. The burying beetles in **Figure 2.24** are one example of an insect that is a decomposer. Decomposition is an important part of the nutrient cycles discussed in Chapter 1. Nutrients are returned to the soil, water, and air as dead organisms decay.

STSE Case Study

Why Are Honeybees Disappearing?

Why are honeybees mysteriously disappearing from North American beehives? Beekeepers are finding that many of their hives are empty or contain only frail young worker bees and the queen. Mature worker bees have left the hives and disappeared. The bees that remain cannot maintain the hives alone. This is known as colony collapse disorder.

About 15 percent of the commercial bee colonies in Canada are lost each winter. In the winter of 2008, 35 percent of the colonies were lost. Honeybees and other pollinators are critical for many fruit and vegetable crops. The value of crop pollination services is estimated to be at least $1.2 billion per year in Canada.

Many scientists and beekeepers think that the decline of honeybees is due to a combination of factors, including parasites, pesticide use, and beekeeping practices. More research is needed to determine why honeybees are disappearing and to save these important pollinators.

In a healthy beehive, worker bees cover most of the combs. As a result of colony collapse disorder, only a few weak worker bees remain in the unhealthy hive.

When burying beetles find the body of a small animal, such as a mouse, they quickly dig soil out from under the body.

The body sinks below the surface and the beetles then cover the body to help prevent flies from laying eggs.

The adult beetles lay eggs on the decaying body, then use it to feed their growing larvae.

Figure 2.24 Burying beetles are among the countless organisms whose niches bring about the decomposition of dead bodies and other waste.

What Happened to the Bees?

Scientists hypothesize that one or several factors may be to blame:

- Pesticides may affect the ability of honeybees to find their way back to their hives. As a result, the bees leave their hives and never return.
- Radiation from cellphones may interfere with the ability of honeybees to navigate. In one study, researchers found that when cellphones were placed near hives, the bees stayed away.
- A parasite called the *Varroa destructor* mite attaches itself to the outside of honeybees and feeds off their fluids. Another mite, called the honeybee tracheal mite, attaches to the tracheas of honeybees and suffocates them.
- Transportation of colonies over long distances can affect honeybees. Confinement or the temperature and vibrations on trucks may disrupt the bees' life cycle.

Varroa destructor mites attach to the outside of honeybee larvae. They feed on body fluids from the bees and weaken the bees as they mature into adults.

Your Turn

1. What two parasites are named in the case study as being potential factors in the decline of honeybees? Conduct research to find out how one of these parasites was introduced to North America. Write a brief explanation. What attempts have been made to eliminate this mite?
2. Honeybees were introduced to North America by European settlers. Identify one species, native to Canada, whose pollination of plants is important. Identify the plant species it pollinates. Write a short paragraph about the ecosystem in which the species lives.
3. Some taxpayers are concerned that the Ontario government is compensating beekeepers for their losses and providing them with funds to help them rebuild their colonies. Write a letter to the editor of your local newspaper, explaining why honeybees are important in Ontario and why the government should continue to support beekeepers.

The Role of Migratory Birds

Some insects are considered to be pests of crops and forests. Other insects, such as mosquitoes, can carry and spread disease. The complete elimination of these species would have very negative consequences for ecosystems, but the regulation of their numbers is desirable.

Some organisms, known as *aerial insectivores*, consume flying insects. Unfortunately, the populations of many aerial insectivore birds that breed in Canada have declined since the 1980s, as shown in **Figure 2.25**. As in the case of honeybees, there are many ideas about the cause of their decline, but no firm answers. A complication is that all aerial insectivores leave Canada for the winter. Scientists are uncertain whether the challenges that the birds are experiencing exist here in the spring or summer or elsewhere at other times of year. The use of distant parts of Earth by many migratory species underscores the importance of having sustainable practices everywhere. Habitat destruction or poorly regulated insecticide use in the tropics, thousands of kilometres away, could be contributing to the losses of aerial insectivores here.

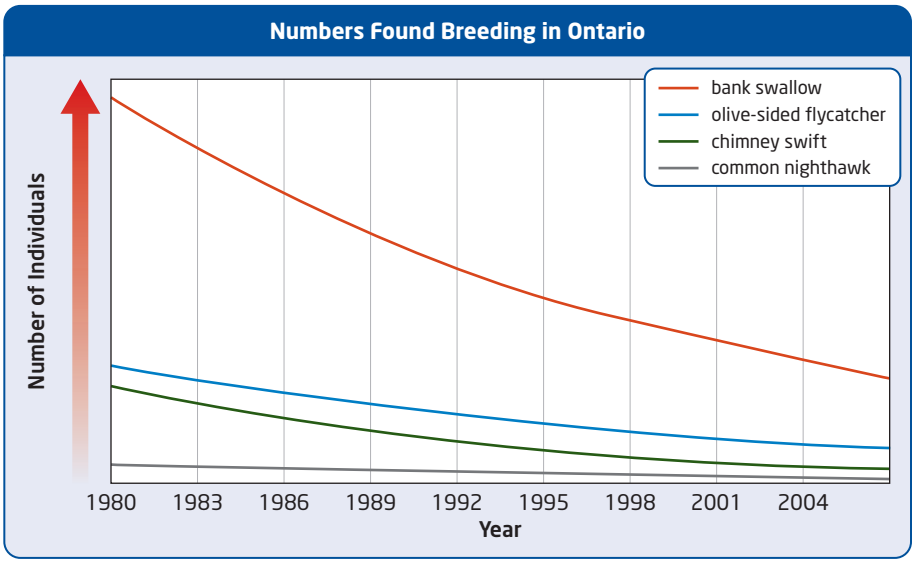


Figure 2.25 Species of birds that eat flying insects have generally been declining in Canada since 1980. These four species, from four different bird families, all spend the winter in South America.

Learning Check

5. What are two ecosystem services that insects provide?
6. List three possible causes of colony collapse disorder.
7. What ecosystem service do aerial insectivores provide?
8. Describe what the graph in **Figure 2.25** shows.

Coffee Plantations and Canadian Birds

Many songbirds that occupy Canadian woodlands during the summer seek out forest habitats in the tropics during the winter. One tropical ecosystem that many Canadian songbirds find sustaining during the winter is an ecosystem in which coffee is grown.

Coffee can be grown in sunlight or in shade, as shown in **Figure 2.26**. Most mass-marketed coffee is grown in an unsustainable way. Forests are cleared, pesticides and fertilizers are applied, and a sun-tolerant coffee plant is grown in a monoculture. A monoculture is an area of land in which the plants are all the same species. A smaller percentage of coffee is shade-grown coffee. Shade-grown coffee has lower yields than sun-tolerant coffee, but it is grown in natural landscapes that include the shade of overhanging trees.

These shade-grown operations, often managed by indigenous peoples, provide sustainable ecosystems for many Canadian songbirds during the winter. This is sustainable use because it serves human needs—the growth of coffee beans—as well as the requirements of the songbirds. For shade-grown operations to succeed commercially, coffee consumers need to know the difference and to demand shade-grown brands.

Study Toolkit

Making Connections to Visuals How do the photographs in **Figure 2.26** help you understand the difference between sun-grown coffee and shade-grown coffee?

Go to **scienceontario** to find out more

Figure 2.26 **A** When coffee is grown in sunlight, it becomes a monoculture. The diversity of living things decreases. **B** When coffee is grown naturally in shade, it is part of an ecosystem that supports many other species of plants and animals.

connectivity the collection of links and relationships between ecosystems that are separated geographically

ecotourism a form of tourism that is sensitive to the health of an ecosystem and involves recreational activities provided by sustainable ecosystems

International Co-operation for Ecological Connectivity

The concept of linked ecosystems, which have to be sustainable together, is known as **connectivity**. In 1916, Canada and the United States recognized this concept when they negotiated a formal agreement designed to protect birds that moved across their shared border. More recently, conservation initiatives have spread farther. Biologists at Bird Studies Canada, an organization dedicated to the welfare of Canadian birds, have developed an international program that uses financial resources and expertise to foster stewardship and bird research in tropical regions of North and South America.

Recreational Opportunities as Ecosystem Services

Ecotourism is a nature-based, sustainable form of tourism that is now a multibillion-dollar industry worldwide. Some tourists plan coastal holidays that include boat trips to view whales, dolphins, and sea birds. Other tourists plan holidays and weekend events to watch birds fly back and forth annually between breeding grounds in Canada and wintering grounds farther south. There are many other ways in which Canadians and visitors to Canada can get recreational enjoyment from sustainable ecosystems. Hiking, snowshoeing, shown in **Figure 2.27**, fishing, and kayaking are just a few examples.

Figure 2.27 Snowshoeing is one of many outdoor activities people participate in as ecotourists.

Activity 2-4

Ecotourism and Monarch Butterflies

Every year, millions of monarch butterflies migrate over 3000 km from Canada and the United States to spend the winter in central Mexico. These butterflies stay in fir-tree forests at high altitudes in the mountains of the Mexican states of Michoacan and Mexico. Recently, the Mexican government has encouraged ecotourism to this area.

Procedure

Use the Internet to research monarch butterflies and ecotourism to this area. Find answers to the following questions:

a. How many people visit this area each year?

b. What has the Mexican government done to encourage ecotourism in this area?

c. How could illegal logging in the fir-tree forests affect ecotourism in this area?

Questions

1. Why is it important to ecosystems in Canada that the butterflies have a sustainable ecosystem in which to spend the winter?
2. List some possible ways that ecotourism could negatively affect the butterflies.
3. Make a pamphlet that promotes ecotourism to this area of the world.

Beauty and Spirituality in Sustainable Ecosystems

Canada's indigenous peoples have had a long, rich, and complex spirituality tied closely to the ecosystems they occupy. In the Queen Charlotte Islands on Canada's west coast, for example, the Haida people used tall rainforest trees to construct totem poles, which were both artistic and sacred. Many Aboriginal peoples continue these spiritual traditions that are connected to nature.

Many other Canadians also find ecosystems sustaining, not only in the sense of the services they provide but also in a spiritual sense. The rugged and wild north inspired the artists in Canada's renowned Group of Seven. One of their paintings is shown in **Figure 2.28**. It is vital that we study ecosystems scientifically, but artistic expressions of ecosystems provide another perspective that is also meaningful.

Figure 2.28 Lawren Harris' *Above Lake Superior* is one example of art inspired by the landscape.

Making a Difference

Allyson Parker got her first pair of binoculars when she was 8 and has been bird-watching ever since. She has volunteered as an interpreter at Presqu'ile Provincial Park Waterfowl Festival, educating the public about waterfowl species, since she was 11. She also volunteers as a bird bander at the Prince Edward Point Bird Observatory.

Allyson's interests also include other wildlife and conservation issues. At her Cobourg high school, Allyson was president of the environment club, which introduced recycling programs and participated in the Great Canadian Shoreline Clean Up. In 2006, Allyson travelled to Antarctica after winning the Canadian Geographic Polar Bound Contest. After her trip, she shared her experience with other students.

Allyson's passion for birds has helped her make a difference. She believes that teaching and helping others feel passionate about nature is the best way to help the environment. Allyson is studying wildlife biology at the University of Guelph.

How could you help others in your community learn about wildlife?

Section 2.4 Review

Section Summary

- When a species occupies its niche, it provides ecosystem services for other organisms.
- Forests influence climate and play a vital role in the regulation of watersheds.
- Insects provide many ecosystem services, including pollination and decomposition.
- The health of migratory bird populations is dependent on the health of the ecosystems they visit during their migration.
- Ecological connectivity means that international co-operation is necessary to keep ecosystems sustainable.
- Visual beauty and spiritual appreciation are two services that ecosystems provide for humans.

Review Questions

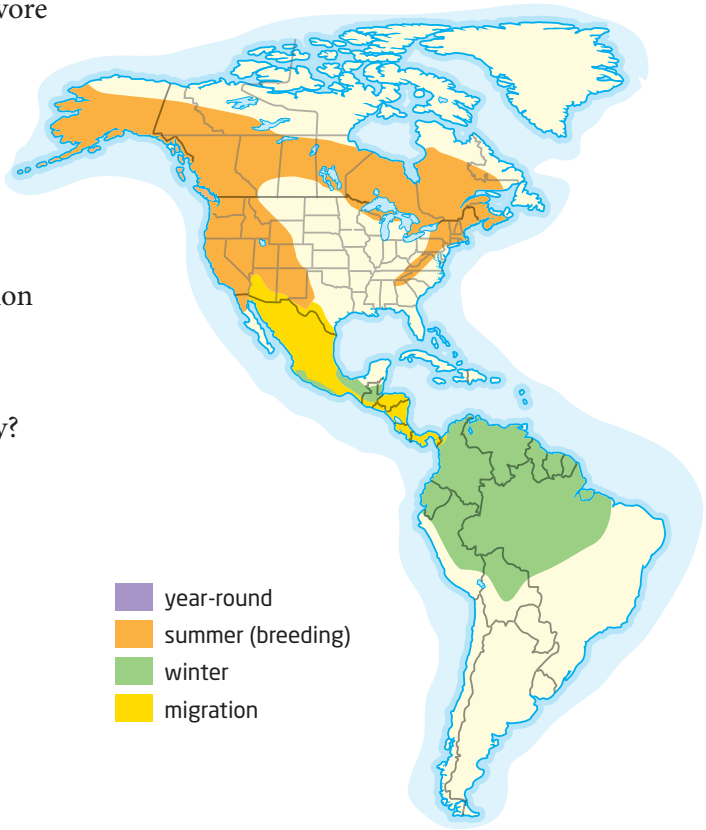
K/U **1.** Identify the ecosystem services that are provided by forests.

C **2.** 2006 was the International Year of Deserts and Desertification. Write two or three sentences explaining why it is important to focus attention on desertification.

K/U **3.** Explain the process of pollination. Give three examples of pollinators.

C **4.** Make a mini-poster that explains colony collapse disorder and its possible causes.

A **5.** The olive-sided flycatcher is an aerial insectivore whose population numbers have decreased in Canada since the 1980s. The map on the right shows the range of this species. What are some possible reasons for the decline in its population?



T/I **6.** Describe the results shown in the graph in **Figure 2.21**. Explain the impact of deforestation on the amount of nitrate retained in the soil.

A **7.** Do you think governments should manage ecological health by considering connectivity? What steps should governments take to recognize connectivity?

K/U **8.** Briefly describe one way that the Haida people expressed their reverence for the forest and sustainable ecosystems.