2 Human activity affects the sustainability of ecosystems.

A pulp and paper mill produces paper, but it also produces pollution.

Skills You Will Use

In this chapter, you will:

- plan and carry out investigations into how using fertilizer affects water quality and the fertility of soil and explain how fertilizer use affects the survival of a terrestrial and an aquatic ecosystem
- interpret data from undisturbed and disturbed ecosystems, communicate the results graphically, extrapolate from the data, and infer the importance of biodiversity for sustainable ecosystems
- analyze the effect of human activity on populations in ecosystems by interpreting data and generating graphs

Concepts You Will Learn

In this chapter, you will:

- identify human activities that can upset the balance of ecosystems and affect their survival

Why It Is Important

Humans need ecosystems. Human activities have harmed ecosystems in many ways. If we know what factors lead to a decrease in biodiversity in ecosystems, we can take steps to undo or lessen the damage we have done to them. We also need tools to assess the damage that we have done to ecosystems. If we know what causes soil and water quality to be reduced, we can take steps to fix the damage or prevent further damage to ecosystems.

Before Reading

Thinking Literacy

Asking Questions of the Text and of Ourselves

Good readers do not read passively. They think as they read and evaluate the information, often asking questions about the different ideas in the text. They also question their own and others' actions and decisions that may have contributed to a particular situation. Skim the subheadings in chapter 2, and turn them into questions that begin with "How can we...?" or "How do we...?"

Key Terms

• acid rain • bioaccumulation • biological oxygen demand
• biomagnification • clearcutting • eutrophication
• habitat change • heavy metals • invasive species
• overexploitation • pesticide • urban sprawl

2.1 Human Use of Ecosystems

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

- All human societies depend on sustainable ecosystems characterized by maximum biodiversity.
- Managing the world's ecosystems means achieving sustainable use, preventing sudden irreversible changes to ecosystems, and addressing the impact of poverty on society and sustainability.
- Habitat change, overexploitation, pollution, invasive species, and climate change are the main factors influencing loss of biodiversity.

Figure 2.1 These stone statues are roughly 4 m high, and each has a mass of over 11 tonnes. No one knows exactly how the Easter Islanders moved these statues from the quarries across the island to the coast, where they currently sit.

A Lesson in Sustainability

In 1722, Dutch sailors arrived on Easter Island, a 165-km^2 island in the Pacific Ocean. They found an island with no trees and little significant plant life. There were also no domestic animals. The few people on the island were so desperate for food that they had resorted to cannibalism. The mystery of what happened on the island has only recently been solved after scientists discovered that Easter Island had once been covered with large palm trees.

Hundreds of years ago, a small group of Polynesians migrated from a nearby island to Easter Island in large sea-going canoes. They brought chickens, rats, dogs, and some crop plants with them. When they arrived, the island was covered with palm trees. The island's climate proved to be too cool to grow their crops, but its coasts were rich with sea life: porpoises, fish, turtles, and nesting birds. Within five or six centuries, the population grew to 10 000. With more people, they needed more resources. They hunted all the animals that were close to shore, and they had to venture farther out to sea to find food. They also cut down the palm trees to use for fuel faster than the trees could grow back. To complicate matters, the rats they brought with them ate both the seeds and saplings of young trees.

Eventually, the last tree was cut down. Due to the lack of wood, the islanders no longer had working canoes, and food became very scarce. The islanders ate all the dogs, rats, chickens, and nearly all the nesting birds. By the time the Europeans arrived, there were only a few small communities living in caves. The islanders' only legacy was their stone statues (Figure 2.1).

Because of unrestricted population growth, too high a demand on their resources, and no long-term plan to use their resources wisely, the result was an ecological disaster, which caused the population to crash. Easter Island shows what can happen when resources are not used in a sustainable way.

Figure 2.2 Modern-day Easter Island

A11 *Quick Lab*

Managing Resources

Purpose

To manage a resource, candy, in a sustainable way

Materials & Equipment

- 100 small candies
- 1 paper napkin or piece of paper towel

CAUTION: Do not eat anything in the lab.

Procedure

1. In small groups, arrange yourselves so that you are facing each other with 16 candies in a pile on a paper napkin in the middle of your group. Each group member plays once per round. Work out a group agreement on the order of play.
2. The candies represent your resources. Your goal is to manage them as you see fit, either as individuals or as a group.
3. Each turn, a player will have an opportunity to remove candies from the pile. (Do not eat any of the candies.)
   - To survive, each group member must take at least one candy per turn.
   - During his or her turn, each group member may take as many candies from the resource pile as he or she wishes.
4. After each round, count the number of candies left in the resource pile and add the same number of candies to the pile. For example, if there are 10 candies left in the pile, add 10 more to the pile.
5. Stop after three rounds. Assess what has happened as a result of the game play so far.
6. Restart the simulation several times, trying out different strategies for managing the candies. Note the results.

Questions

7. Decide on a set of rules that would result in the best sustainability for the group with the least amount of restrictions on the behaviour of individuals.
8. In what situations would a one-time renewal of candy resources lead to sustainable availability of candies in the long term?

Human Impacts and Biodiversity

Human well-being depends upon ecosystems. Ecosystems provide humans with many services. Ecosystems supply food, fuel, natural resources, and water. Ecosystems cycle nutrients and decompose wastes. They regulate climate. The animals they contain help pollinate crops and disperse seeds. Ecosystems also provide humans with cultural and recreational opportunities (Figure 2.3).

Figure 2.3 Enjoying nature contributes to the well-being of humans.

All the species contained in ecosystems contribute to these services. So we all have a vital interest in maintaining biodiversity, which is the types and numbers of organisms in an ecosystem. To maintain biodiversity, we have to use ecosystems in a sustainable way. **Sustainable use** of an ecosystem means using an ecosystem's resources in a way that meets our current needs without compromising the ability of future generations to meet their needs.

So far, we have referred to biodiversity as the variety of species on Earth. But the term also refers to other levels of biodiversity. There is diversity within a species. For example, members of a human family may all look similar, yet each individual is unique and is different from every other member. Differences in individuals can help keep a population healthy. For example, in a wolf pack some wolves may be better able to resist certain diseases than other members, and some may be better than others at tolerating a lack of water (Figure 2.4). These differences among individuals of the same species are called genetic differences or **genetic diversity**. Lack of genetic diversity in a population can be a real threat to its survival and can even lead to extinction. **Extinction** is the death of every member of a species. Reducing the sizes of populations can reduce genetic diversity in a population, putting the whole population at risk.

Figure 2.4 These wolf pups may look similar, but each one has slight differences that may influence its survival.

Biodiversity also refers to the variety of ecosystems found on Earth. This includes human-made ecosystems, such as farms, as well as the variety of naturally occurring ecosystems. Because different ecosystems provide different services, it is vital that we maintain as many types of ecosystems as possible.

Human activity has caused all levels of biodiversity to decrease at an unprecedented rate. The five major causes of this are:

- habitat change
- overexploitation
- pollution
- invasive species
- climate change

Habitat Change

Habitat change is the process by which humans alter a habitat enough so that the native species can no longer live there. **Native species** are species that normally live in that habitat. If their habitat changes, they either die or move to another habitat. Throughout the biosphere, habitat change is the most common cause of declines in the populations of many species.

Humans change habitats for many different purposes. We clear land for things such as agriculture, forestry, and urban development (Figure 2.5). Habitat change has been severe in the world's tropical rainforests. Currently, only 9 million square kilometres are left of the 16 million square kilometres that originally existed.

Figure 2.5 This tropical rainforest in Brazil is being cleared in order to create pasture for cattle.

During Reading — Thinking Literacy

Making Inferences

By asking the question "Why?" you can often make inferences or calculated guesses about the factors that affect biodiversity. As you read about each factor, ask the question "Why?" and make note of your answers. Draw conclusions about how we might lessen the effect of these factors.

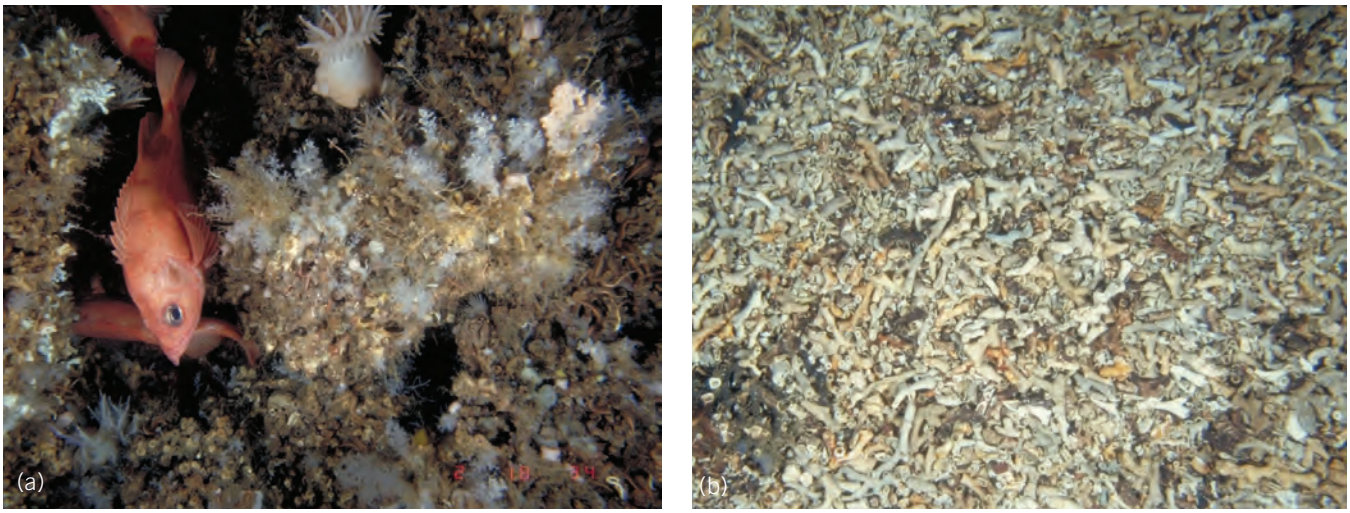


Figure 2.6 (a) A redfish in an intact ocean reef (b) After a bottom trawler has passed, a reef has been reduced to rubble.

Altering habitat may also lead to **habitat fragmentation**. Often, small areas within a large region are altered a bit at a time. This creates a patchwork of altered and original habitats. For example, southern Ontario was once covered in deciduous forest. Now, the original forest habitat is fragmented into small patches of forest interspersed among farms, suburban developments, and cities.

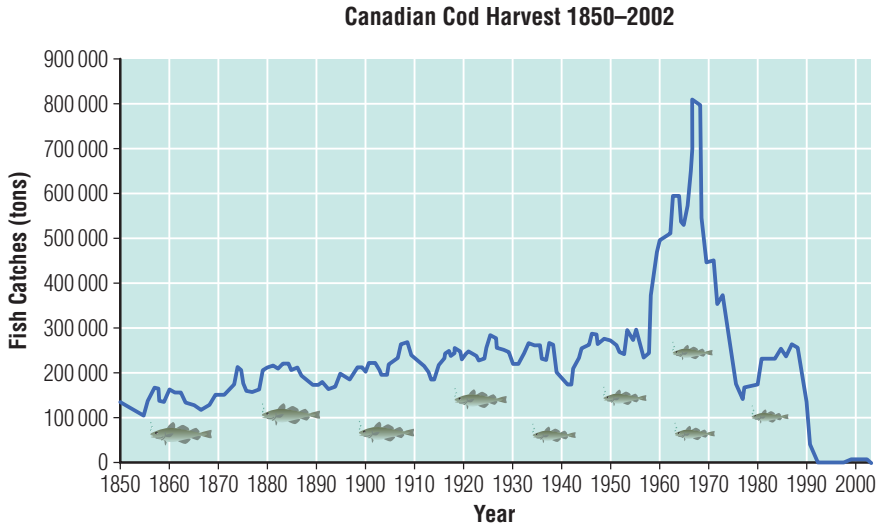
Habitat change also occurs in marine and coastal systems. For example, in a fishing method called bottom trawling, nets are dragged along the bottom of the oceans to catch shrimp and bottom-dwelling fish. This can completely disrupt the marine ecosystem by removing many producers from the food web as well as harming coral formations (Figure 2.6).

Figure 2.7 Catching cod in the 1940s

Overexploitation

Overexploitation of a resource means using a resource faster than it can be replaced. Overexploitation can often lead to extinction. A common example of overexploitation is overfishing. Around the world, many species of fish have been overfished, which has resulted in complete collapse of these populations of fish. Since the 1950s, humans have removed an estimated 90 percent of large fish from the sea. Overexploitation of the seas is one of the greatest environmental catastrophes in human history.

One example of overexploitation of a fish stock occurred in Atlantic Canada, where cod used to be abundant (Figure 2.7). Over the past century, the demand for cod grew and fishing technologies allowed more cod to be caught. Mature fish normally swim relatively close to the surface. When fishing fleets no longer caught



Source: Millennium Ecosystem Assessment

Figure 2.8 Cod were fished commercially for 500 years before the modern industrial fishing fleets wiped out much of the population.

fish at the surface, they fished deeper in the ocean, where the young fish are found. The fish on which cod fed were also located farther down. By fishing deeper, the industry was, in effect, collecting next year's cod harvest as well as the cod's food source. By the 1990s, the populations were so low that the cod fishery had to be closed. The cod populations have yet to recover (Figure 2.8).

Suggested STSE Activity
A12 Decision-Making Analysis on page 64

Overuse of Water

Around the world, fresh water is a precious resource. Canada has the world's largest supply of fresh water, and we are still working on ways to sustainably manage it. The consequences of water mismanagement are illustrated by the Aral Sea in central Asia (Figure 2.9).

The Aral Sea was once the fourth-largest lake in the world. It is called a sea because it is so large, but it is a freshwater ecosystem. The government of what was then the Soviet Union decided to grow cotton and rice in the region. To irrigate the crops, water was diverted from the two rivers that flowed into the lake. Slowly, the lake's water level dropped (Figure 2.10 on the following page). Dropping water levels split the lake in two, creating the North Aral Sea and the South Aral Sea. The water drop affected the ecosystem in the lake, including the fish. Many people relied on fishing for jobs. But as the water level dropped, the fish disappeared. As a result, the lake's commercial fishery no longer exists. Despite the slow shrinkage of the sea, the rivers are still being diverted for irrigation. However, the Kazakh government has increased water flow into the lake, and the North Aral Sea level is slowly rising.

Figure 2.9 The Aral Sea borders Kazakhstan and Uzbekistan.

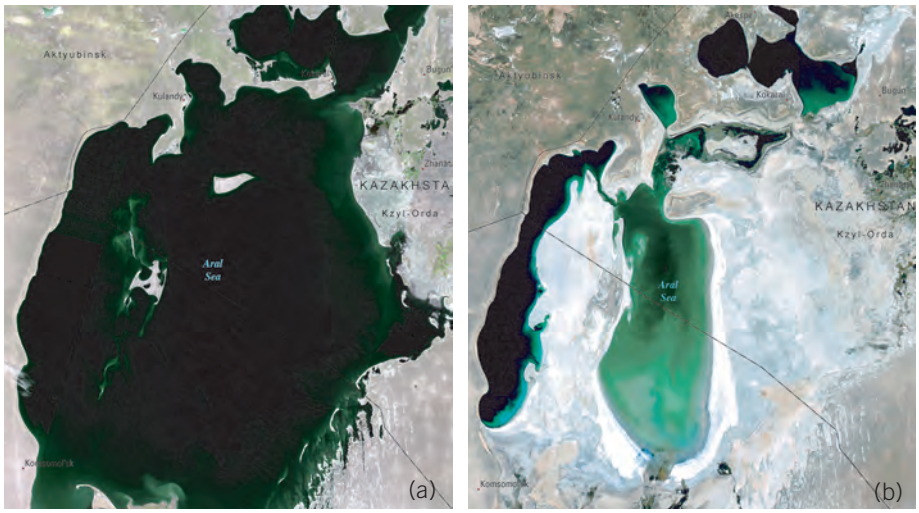


Figure 2.10 (a) The Aral Sea was already shrinking in 1985. (b) By 2007, it was less than 10 percent of its original size.

Pollution

Pollution is any substance added to the environment that produces a condition that is harmful to organisms. One example of pollution is solid waste that cannot be recycled. The garbage you put out on the curb or take to the landfill is solid waste. Currently, most garbage goes to landfills, where it is prevented from entering the environment. Garbage that does not enter the landfill and litter contaminate ecosystems.

Another form of pollution is air pollution. One of the most important pollutants worldwide is human-produced carbon dioxide gas. Automobiles, airplanes, power plants, and factories all emit carbon dioxide. Increased levels of carbon dioxide have caused global temperatures to rise. This, in turn, is accelerating global climate change.

Water can become polluted very easily. Pollution can enter water sources in different ways (Figure 2.11). **Point source pollution** enters a body of water at a specific place from an identifiable source. Oil spills from tankers, waste water from pulp and paper mills, and partly treated waste water released from a sewage treatment plant are examples of point-source pollution. **Non-point source pollution** enters bodies of water indirectly when water from rain or snow travels over land and picks up pollutants from many different sources before entering a stream or a lake. Fertilizer and pesticide run-off from farms and salt run-off from roads are both examples of non-point source pollution. Since all organisms need water, all organisms are exposed to the pollutants water contains. You will learn more about water pollution in the following section.

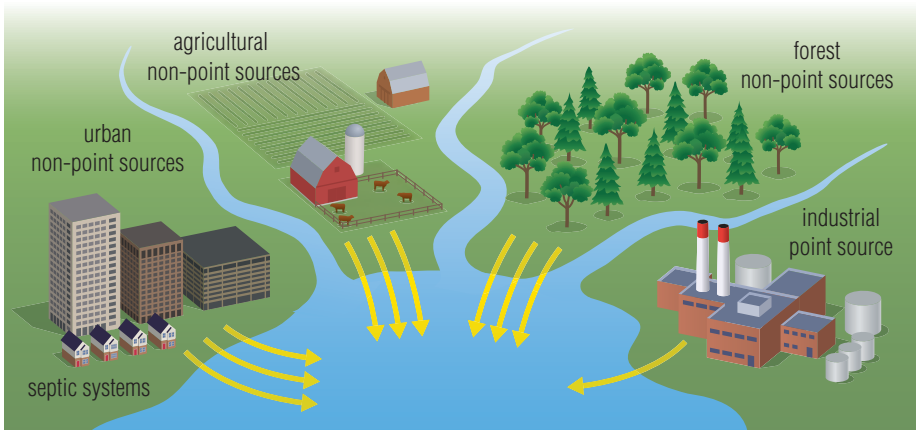


Figure 2.11 Point and non-point sources of pollution

Invasive Species

Increases in international travel and trade have introduced non-native species to all parts of the globe. For example, the Great Lakes are part of an important shipping route. While in these waters, foreign ships may release non-native species when they empty their ballast tanks. An **invasive species** is a non-native species that causes harm to the ecosystem into which it has been introduced. Invasive species tend to outcompete native species, often because they have no natural predators in the new ecosystem or they reproduce faster than native species. As a result, their populations increase rapidly while native species' populations decline (Figure 2.12). The dog-strangling vine is native to Eurasia and was introduced to North America as a garden plant (Figure 2.13). It has invaded sunny hillsides and ravines across southern Ontario. It grows in dense colonies and smothers small plants and tree seedlings, small shrubs, and saplings. It also affects monarch butterflies. The vine is a member of the milkweed family. Monarchs lay their eggs on native milkweed plants, but they will also lay them on the dog-strangling vine. However, the larvae cannot survive on the vine and die.

Figure 2.12 The eastern bluebird has suffered from the presence of starlings and sparrows. These two invasive species outcompete bluebirds for nest sites. In the past century, bluebird populations declined by 90 percent.

Suggested STSE Activity
A13 Decision-Making Analysis
Case Study on page 66

Figure 2.13 The dog-strangling vine has completely invaded the understorey of this tree plantation.

Climate Change

Climate change is a cause of loss of biodiversity around the world. **Climate** is the average weather conditions that occur in a region over a span of 30 years or more. When **climate change** occurs in a region, average temperatures may rise or fall, the amount of rainfall may increase or decrease, and even general wind directions may change. If species are to survive through periods of climate change, individuals must be able to adapt to the new conditions. However, climate change is currently being driven by a process called **global warming**, which is an increase in Earth's average temperature, caused partly by an increase in carbon dioxide in the atmosphere. Over the past two centuries, the amount of carbon dioxide in the atmosphere has increased, largely due to human activities that burn fossil fuels. Global warming has caused relatively rapid climate change. For example, the Arctic is warming faster than at any time in recorded history. The ice packs are shrinking and breaking up. Species that depend on ice packs, such as seals and polar bears, are losing their habitat (Figure 2.14). As a result, their populations are declining.

Frigure 2.14 Walruses in the eastern Arctic rely on ice floes. They haul themselves onto the ice to rest.

Learning Checkpoint

1. List three levels of biodiversity.
2. What is the difference between habitat change and habitat fragmentation?
3. What resources have been overexploited?
4. (a) Name an invasive species in Ontario.
   (b) Explain how this species has affected native species.

Human Impacts on Ontario Ecosystems

People in Ontario use the land and water for a variety of different purposes: farming, housing, industry, recreation, mining, logging, and a whole host of other uses. Each human activity affects the land and local biodiversity in different ways. By knowing how a human activity affects the ecosystem, steps can be taken to help lessen these effects.

A Freshwater Ecosystem

The thriving cottage and recreational industries in Ontario put a great deal of stress on the lake ecosystems. Figure 2.15 shows some of the sources of stress on a typical lake in cottage country. Table 2.1 summarizes the effects of these stresses.

Figure 2.15 A typical lake in the heart of Ontario's cottage country

Table 2.1 Stresses on Lakes and Their Effects

Stress	Effects
Motor boats	Oil leaks can easily contaminate lake water. Oil reduces the water's oxygen level and so affects the health of fish and other lake organisms.
Sewage	Sewage leaking from septic tanks can increase the nitrogen content of the water. This contamination eventually reduces the biodiversity of aquatic organisms.
Docks	Building docks can disturb fish spawning grounds and disturbs floating and submerged aquatic vegetation.
Boat wakes	Waves disturb aquatic and terrestrial vegetation along the shoreline and nesting sites of loons and other birds.
Beaches	Removal of aquatic and terrestrial vegetation along the shoreline means loss of habitat for other organisms.
Clearing shoreline	When shoreline vegetation is cut down, fish lose the shade and cover the vegetation provides.

These stresses affect the sustainability and biodiversity of a freshwater ecosystem. For example, some animals, such as loons, are affected by waves from boat wakes. They will move to other less disturbed habitat. The fish populations decline due to the pollution.

Figure 2.16 The escarpment area marked on the map contains natural areas, farmland, subdivisions, and parks.

A Suburban Terrestrial Ecosystem

The Niagara Escarpment is a long cliff that forms the boundary between two flat regions, each with a different elevation. The escarpment stretches 725 km from the western end of Lake Erie, northwest to the tip of the Bruce Peninsula (Figure 2.16). Most famously, it forms the ledge that makes Niagara Falls so impressive. Along its length are forests and other wildlife habitats, and the headwaters for five major rivers flow from its slopes (Figure 2.17). Among its forests are cedar trees that are over 1000 years old.

The Niagara Escarpment also runs through the Golden Horseshoe, one of the most heavily populated areas in Canada. Cities such as Hamilton are built on the edge of the escarpment. As the population of southern Ontario grew, so did the demand for land for housing developments, industry, farmland, vineyards, and rock quarries. Some parts of the escarpment gradually fell victim to urban sprawl. **Urban sprawl** is the unplanned, disorganized growth of urban and suburban development into the surrounding countryside. Urban sprawl has affected local biodiversity through habitat change and habitat fragmentation. The remaining undisturbed forest on the escarpment is now in smaller, disconnected sections. A smaller, fragmented habitat leads to a loss of biodiversity.

The Ontario government recognized that the escarpment's ecosystems were threatened, so it created the Niagara Escarpment Plan. It is a land-use plan that focusses on environmental protection. It has guidelines on how land in the escarpment area can be developed.

Figure 2.17 Bruce Peninsula National Park is one of the protected areas on the Niagara Escarpment.

A Forest Ecosystem

Boreal forest covers most of Ontario's land area. Commercial logging is a major industry in northern Ontario. Logging companies often use **clearcutting** to remove trees. Clearcutting removes all the trees in an area at one time, regardless of size. When forestry companies clear-cut forests, they break large areas of forest into smaller fragments (Figure 2.18), which can threaten local biodiversity. Some species, such as wolves, require very large areas of forest to hunt moose and other prey. Fragmenting their habitat makes it difficult to find food.

Figure 2.18 Logging companies clear-cut relatively small sections of forest, leaving other patches still standing.

Fragmentation is a serious problem in Ontario. About 30 percent of northern Ontario's boreal forests are within three kilometres of a road. This increases animal deaths through road kill, habitat destruction, altered water flow, and soil degradation.

Ontario has adopted certain measures to ensure a sustainable forestry industry. Companies have to plant new trees in an area that has been clear-cut. Also, they are not allowed to cut down more trees than they can replant in the same year. Logging companies have started to use more sustainable logging practices, such as leaving the forest in place around bodies of water. This reduces changes in water flow that can result from logging.

Take It Further

Overexploitation of water happens in North America. Find out about the state of the Ogallala Aquifer. Begin your research at ***ScienceSource***.

Learning Checkpoint

1. (a) What are three stresses put on a freshwater lake in Ontario?
   (b) Describe the effects of these stresses.
2. Explain how urban sprawl affects the Niagara Escarpment.
3. What is clearcutting?
4. What is the major effect that clearcutting has on the boreal forest ecosystem?

A12 STSE *Decision-Making Analysis* Skills References 4, 9

SKILLS YOU WILL USE

- Defining and clarifying the research problem
- Justifying conclusions

Wild Fish Versus Farmed Fish

Issue

Fish stocks around the globe have been drastically reduced due to unsustainable fishing practices. Many countries are turning to fish farms, also known as aquaculture, in which the fish are housed in underwater cages and farmed. However, some kinds of fish farming are very controversial because diseases among farmed fish sometimes infect wild stocks. Also, farmed fish that escape can become invasive species or interbreed with wild stocks, potentially weakening the wild stocks.

Fishing wild species almost always results in by-catch, which is unintentionally catching fish species other than the target fish species. Sometimes, the fish populations most threatened by fishing wild stocks are not even the intended catch. This leaves a very important question: which is more sustainable, aquaculture, wild stock fishing, or a mixture of both?

Background Information

Making management decisions about fishing depends on knowledge of wild fish populations. If wild stocks are threatened by overexploitation, banning fishing is a sound decision. However, how do we know if a fish population is threatened?

Gathering data on fish and other species from marine and freshwater ecosystems is challenging. One method is to keep track of the total mass, or tonnage, of fish caught in commercial fisheries. However, relying solely on this data has often meant that by the time enough data were gathered and analyzed, the fish population was already in an advanced stage of collapse. Around the world, stocks of many different species have collapsed. This has happened time and time again across the globe in the last half century, mainly due to the introduction of large factory fishing fleets.

Even so, a great deal of valuable information can be inferred from the data obtained through fisheries.

Data from harvests of three species of wild stocks are presented in Table 2.2. These numbers are actual data taken from Fisheries and Oceans Statistical Services archives. The numbers represent the total mass of fish caught in Canada. Table 2.3 on the next page shows data on farmed salmon and trout.

Table 2.2 Wild Fish Harvests 1985–2006 (tonnes)

Year	Cod	Redfish	Herring
2006	28 266	32 525	182 194
2005	27 693	34 273	192 041
2004	26 049	32 431	207 235
2003	23 573	36 268	229 613
2002	36 434	36 898	219 648
2001	40 913	41 583	224 914
2000	46 888	44 306	233 785
1999	56 314	43 683	214 679
1998	39 201	47 691	216 836
1997	31 418	39 277	218 525
1996	16 447	45 200	211 568
1995	14 661	39 624	220 472
1994	26 270	75 070	247 777
1993	84 767	109 329	242 968
1992	198 078	125 103	251 433
1991	321 833	116 109	256 485
1990	401 257	109 164	301 328
1989	435 373	100 604	270 035
1988	479 141	104 828	310 283
1987	471 897	104 774	284 626
1986	478 730	104 320	203 086
1985	492 767	89 283	219 167

Table 2.3 Aquaculture Harvests 1986–2006 (tonnes)

Year	Salmon	Trout
2006	118 058	5 033
2005	98 369	4 878
2004	90 646	4 858
2003	99 961	5 253
2002	126 321	6 833
2001	105 606	6 513
2000	82 195	6 514
1999	72 890	6 574
1998	58 618	6 022
1997	57 775	5 930
1996	45 624	6 615
1995	42 515	4 429
1994	36 083	4 004
1993	36 670	3 718
1992	30 325	3 511
1991	34 109	2 839
1990	?	4 497
1989	?	3 614
1988	?	3 259
1987	?	2 842
1986	?	2 167

Analyze and Evaluate

1. Create a line graph for each wild species listed in Table 2.2. Graph the data for all three species on one graph. Choose the vertical scale (tonnes of fish harvested) carefully so that all the data fit on the graph. Use a different coloured pencil for each species. Be sure to put a legend and title on your graph.
2. Create a second line graph for the farmed species in Table 2.3. The vertical scale will probably be different than the one on the first graph because the numbers are much smaller. Use a different coloured pencil for each species, and add a legend and a title.
3. Describe any trends you see in the wild fish data.
4. Some wild fish populations change more drastically than others. Suggest reasons for this.
5. What inferences can you draw about sustainability of the wild stocks over time?
6. Describe any trends you see in the farmed fish data.
7. What do the data from the farmed fish stocks suggest about the sustainability of aquaculture?
8. Fish harvest data alone do not give enough information to decide which kind of fishing method is more sustainable. Working in small groups, choose one of the two fishing methods to investigate. Research the pros and cons of your chosen method. Consider the costs and benefits to society and to the environment.
9. Summarize your findings, and present a brief list of the costs and benefits of your method to the class.
10. As a class, discuss the issue and try to reach a consensus as to the most sustainable way to use wild fish and farmed fish.

Skill Practice

11. Justify any conclusions you drew from the discussion.

CASE STUDY

A13 STSE *Decision-Making Analysis* Skills Reference 4

SKILLS YOU WILL USE

- Gathering information
- Summarizing information

Invasive Species

Issue

When people mention dangerous fish, sharks, piranhas, and barracudas probably come to mind. By comparison, the round goby seems harmless (Figure 2.19). However, this fish and other invasive species cost the Ontario economy hundreds of millions of dollars. How could human activities be modified to minimize or prevent the introduction of non-native organisms to the environment?

Background Information

Native to eastern Europe, the round goby arrived in North America in the ballast tanks of a ship. When the ship dumped its ballast water in Lake St. Clair, it released a number of invasive species into the Great Lakes, including the round goby.

The round goby arrived in North America without the predators and parasites that are associated with it in its natural habitat, and the exotic invader was free to reproduce as fast as it could. The round goby is highly territorial and able to outcompete many native fish, including mottled sculpin and native logperch, causing declines in these populations.

This fish is relatively small, growing to an average length of 18 cm in the Great Lakes. It prefers the rocky and sandy lake bottoms that are typical of the Great Lakes. In addition to displacing a number of native fish, the round goby is also a voracious predator of another invasive species, the zebra mussel. Zebra mussels often have very high levels of contaminants in their tissues. These become concentrated in the round goby. Any animals that eat the round goby are likely to have much higher levels of contaminants in their tissues as well.

Other invasive species, including the Eurasian ruffe, spiny water flea, zebra mussel, and purple loosestrife, have also been introduced to the Great Lakes through ballast water.

Figure 2.19 The round goby is a relatively small fish and is considered very aggressive.

Analyze and Evaluate

1. ***ScienceSource*** Use the Internet to research how human activities have contributed to the introduction of so many invasive species in the Great Lakes. Identify how the invasive species and native species interact. Also research how the environment and human society have been affected by the invasive species.
2. Draw a concept map to show the social, economic, and environmental consequences of these interactions.
3. Analyze your research, and describe the effects invasive species have on society, the economy, and the environment.
4. Write a proposal to the Ministry of Natural Resources recommending which human activities should be discontinued in the Great Lakes to reduce the introduction of non-native species. Alternatively, you may propose potential solutions to reduce the introduction of invasive organisms to the Great Lakes.
5. **Web 2.0** Develop your proposal as a Wiki, a presentation, a video, or a podcast. For support, go to ***ScienceSource***.

Skill Practice

6. Summarize the information you found in a brochure for the public to educate them about the issue.

2.1 CHECK and REFLECT

Key Concept Review

1. List five services that we rely on ecosystems to provide.
2. Describe three levels of biodiversity.
3. What is extinction, and how is it related to biodiversity?
4. Give two examples of how overexploitation of a resource has harmed ecosystems.

Connect Your Understanding

5. Suppose a non-native species of beetle is introduced into a forest. How would you know if the beetle was becoming an invasive species?
6. Rhinoceros horns are valued in certain countries and are used to make dagger handles. This has led to the illegal hunting of rhinoceros in all parts of Africa. Rhino populations are low and still declining.
   (a) What is the factor that is affecting the rhino population?
   (b) What is a possibility if the current trend is not reversed?
7. Identify the misconception in each of the following statements. Rewrite each sentence so that it is no longer misleading.
   (a) Not all species are important, so some have to be sacrificed.
   (b) If an ecosystem appears to have a lot of one particular species, then it must be healthy.
   (c) Biodiversity is unimportant to humans.
   (d) A large, smelly swamp is a nuisance to humans and not ecologically valuable.
8. Easter Island represents an unsustainable use of ecosystems. You have learned that five factors can affect the sustainability of ecosystems. Did all of these factors contribute to the islanders' demise? Justify your answer.
9. What are three negative ecological consequences of logging within the boreal forest ecosystem?
10. Explain the possible threats to biodiversity shown in the photograph below.

Question 10

Reflection

11. Ecosystems provide things that directly affect you. Do you take these things for granted? Give an example of how an ecosystem specifically helps you. Which value related to the preservation of biodiversity do you hold most important?

For more questions, go to *ScienceSource*.

2.2 Assessing the Impact of Human Activities on Ecosystems

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

- Different soils have different characteristics that can be assessed. Human activities can have long-lasting effects on soil.
- Water can be tested for the presence of pollutants such as heavy metals, pesticides, and fertilizers.
- Human activities have affected Ontario's terrestrial and aquatic ecosystems in many ways.

Figure 2.20 The amount of plastic in the world's oceans exceeds 100 million tonnes. Most of us usually encounter this plastic pollution only when it washes ashore as it has done here on Hawaii.

Great Pacific Garbage Patch

The world's oceans are so big, it is easy to think that tossing garbage into them will not really affect the environment. Evidence suggests that the opposite is true. There are great circular ocean currents, called gyres, that swirl floating debris to their centres, and the debris stays there.

The North Pacific Ocean has two large gyres, each thousands of kilometres across. People passing through them in sailboats have reported constant encounters with floating garbage. This does not mean, however, that there is an "island of floating junk" that you could bump into or photograph from space.

It might be better for the environment if there actually were such an island. At least we could travel to it and clean it up. In reality, enormous amounts of garbage, mostly plastic, are spread out over thousands of square kilometres of ocean. These items float on or just beneath the surface. Occasionally, the North Pacific gyre brushes past the Hawaiian Islands and deposits mounds of plastic from across the world onto Hawaii's beaches (Figure 2.20).

The Impact of Human Pollution

The United Nations Environment Programme (UNEP) estimates that plastic debris kills more than a million sea birds every year. Sea birds, sea turtles, and other animals mistake bits of plastic for food items. Plastic pieces can last for over 50 years in the ocean, and because they are not digested when eaten, they can go on killing animals. The animals die from eating plastic items, and their remains decompose. The plastic items, however, do not. They stay in the environment and can be eaten by other animals. UNEP reports that cigarette lighters, syringes, and toothbrushes are just some of the items that have been found in the stomachs of dead sea birds (Figure 2.21).

Figure 2.21 This albatross chick died from plastic consumption.

A14 *Quick Lab*

If Earth Were an Apple

Purpose

To create a model that demonstrates the amount of land on Earth that is available to grow food

Materials & Equipment

- apple
- cutting board
- knife

CAUTION: Do not eat anything in the lab.

Procedure

1. With a partner, estimate what fraction of Earth's surface is available to grow food for the world's human population. Record your estimate.
2. Obtain an apple, and place it on the cutting board. The apple represents Earth.
3. Cut the apple into four quarters. Three of the quarters represent the oceans of the world. Place them in the discard pile.
4. Cut the remaining quarter in half. One piece represents the land area that is uninhabitable: polar areas, deserts, swamps, and high mountains. Discard one piece. The remaining eighth represents the land area where people live.
5. Cut the eighth into four equal pieces. Three of these represent the areas unable to produce food because they are too wet, too stony, too cold, too steep, or have poor soil. They also represent cities, suburbs, highways, malls, schools, parks, industrial areas, parking lots, and many other places where people live and work but do not grow food. Put them in the discard pile.
6. Carefully peel the 1/32nd slice of Earth. This tiny bit of peel represents the surface of Earth's crust upon which humankind depends to grow food. It is less than 2 m deep and is a quite fixed amount of food-producing land.

Question

7. Think about your model and the information in step 6. What does this mean for humans and the amount of space on Earth to grow food?

Acid Rain and Ontario's Ecosystems

Emissions from a variety of human activities contain pollutants that enter the atmosphere and can have wide-ranging effects on the environment. In Canada, emissions come from mining and refining metals, electrical power generation, oil and gas operations, and automobiles. Nitrogen- and sulphur-containing substances are two of the most common pollutants in emissions (Figure 2.22).

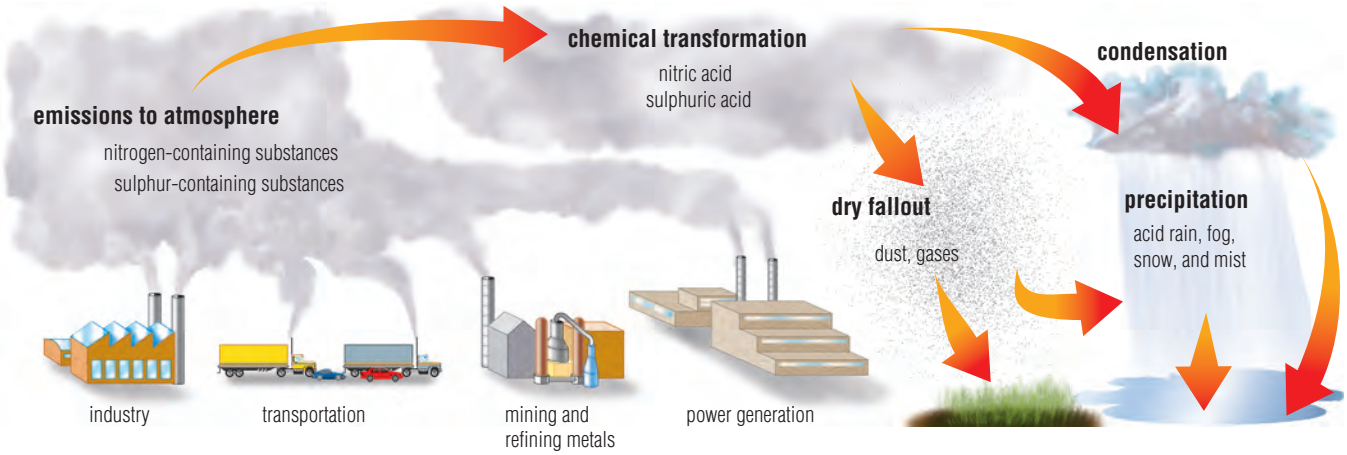


Figure 2.22 The steps involved in forming acid rain

Once these substances are released into the air, they combine with water vapour in the air and form acids. An acid is a common type of chemical. Some acids are safe for the environment. You even consume them in foods such as orange juice and salad dressing. However, many acids are not safe and can damage ecosystems. The acids formed in the air by emissions fall as **acid rain**. Acid rain affects soils, vegetation, lakes, rivers, and terrestrial and aquatic animals.

Effects of Acid Rain

Acid rain damages the waxy coating that protects leaves from infection. When acid rain seeps into soil, it burns the skin of earthworms. It increases the acidity of the soil and affects plant roots' ability to absorb nutrients. Acid rain also makes bodies of water more acidic. Shellfish are the most sensitive because the acid in the water dissolves their shells. When lakes become acidic enough, no organisms can survive in them. These lakes have clear blue water but contain no life.

When scientists discovered how acid rain was caused and its wide-ranging effects, governments put limits on emissions. In response, the mining industry installed scrubbers, which remove a large proportion of the damaging chemicals from the emissions before they are released. As a result, acid rain has been reduced. However, it has not been eliminated completely. Countries that have not implemented these changes continue to produce emissions that cause acid rain. The wind carries these emissions to other countries (Figure 2.23). Acid rain is an international problem, not just a Canadian one.

Figure 2.23 The trees in this forest have been damaged by acid precipitation. The pollutants that caused the acid rain probably entered the atmosphere far from this forest.

Assessing Impacts on Ecosystems

When we examine pollutants, such as acid rain, in ecosystems, we have to have ways of assessing their effects on soils and water. Understanding the effects of human activities on soils and water, and the organisms that depend on them, helps us to find ways to prevent harm to ecosystems. It also helps us to find ways to improve the health of ecosystems that have been damaged by human activities.

Assessing Soils

Soil and water are essential to all ecosystems. Soils are much more than just dirt. They are bursting with life. The condition of a soil indicates the health of any ecosystem that depends on it, as well as the effects human activities have on it.

To assess the condition of a soil, it is helpful to know what **soil** is. Soil is a loose covering on the ground containing a mixture of organic matter, minerals, and moisture. Soil quality includes soil profile, soil type, and acidity.

Soil Profile

Soil is made up of distinct layers, as shown in Figure 2.24.

- **Topsoil** is the uppermost layer in soil. It is composed chiefly of humus, which is decaying organic matter. It also contains rock particles and organisms such as bacteria, fungi, insects, and worms.
- **Subsoil** is the layer below topsoil. It is very compact and has little or no organic matter except roots of very large trees and bacteria.
- **Bedrock** forms the bottom of the soil profile. It is solid rock, and water cannot pass through it. Water travels down through the upper layers and is trapped above the bedrock. The bottom of the subsoil gets saturated like a sponge sitting in water. The top surface of the ground water is called the water table.

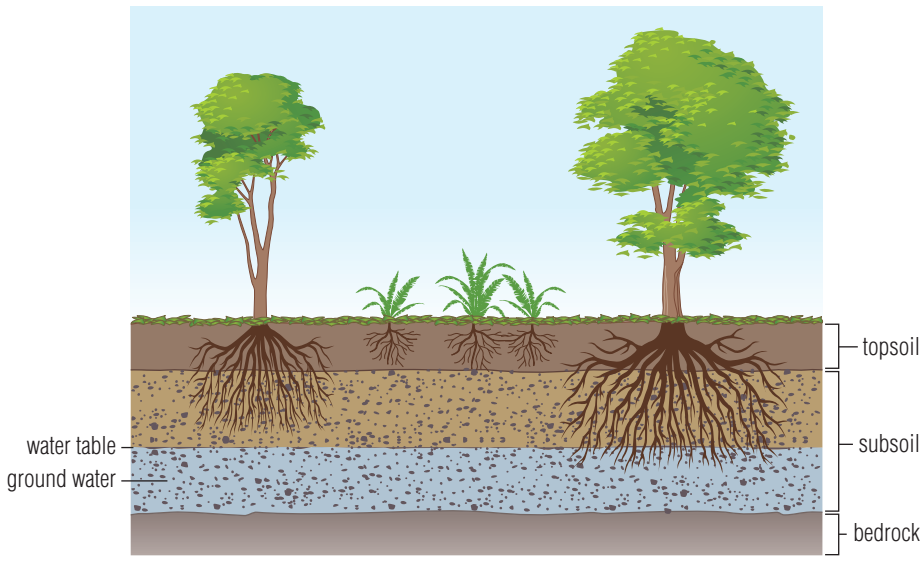


Figure 2.24 Soil is composed of subsoil, topsoil, and bedrock.

Soil Types

Three main soil types are loam, clay, and sandy. Each supports different varieties of plants, but the most fertile, and the one generally preferred for agriculture, is loam.

- **Loam soil** has rock particles of many different sizes. This results in many pockets that can hold air or water, which keeps the soil loose enough that plants can grow into it easily (Figure 2.25). Loam also tends to have a lot of humus, and it drains well without drying out. The black soil of Holland Marsh, near Lake Simcoe, is loam (Figure 2.26).
- **Clay soil** contains particles that are extremely small and so pack tightly together. This prevents the formation of air pockets. Many plant roots do not grow well in clay soil. Clay tends to block root growth and trap water, making the soil excessively wet.
- **Sandy soil** contains sand particles, which are relatively large compared to clay particles. The presence of sand creates large spaces that permit root growth and air pockets. It also permits water to drain away quickly into the subsoil, carrying essential nutrients away from roots. This makes sandy soil much less fertile than loam. Many areas near the Great Lakes have sandy soil.

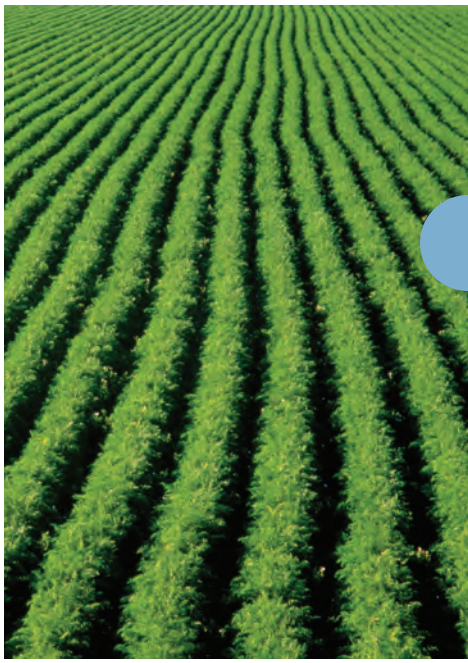


Figure 2.26 Farming in the Holland Marsh

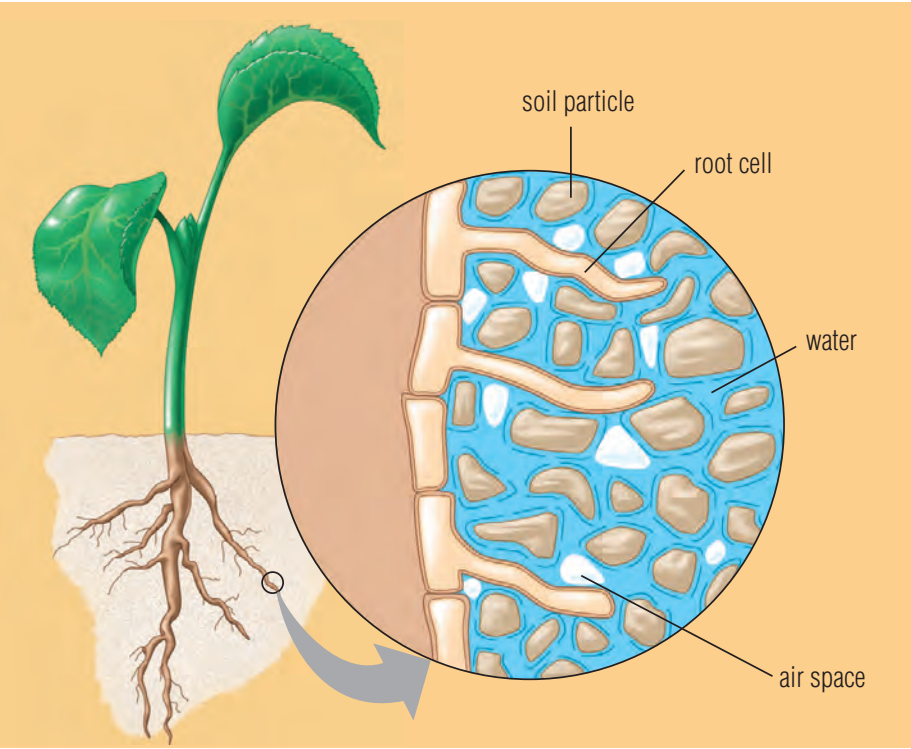


Figure 2.25 The areas between soil particles are filled with air spaces and water.

Acidity Levels

Acidity is an abiotic factor that is connected to the chemical environment of soil. Soils vary in their acidity. If you have ever sucked on a lemon, you know that it is extremely sour. This is caused by acid in the lemon juice. By contrast, a banana is not sour at all. However, even bananas are very slightly acidic.

Not all substances are acidic. For example, pure water is not. It is classified as neutral. To precisely assess acidity levels in soil, a special scale is used. It is called the pH scale (Figure 2.27). The pH of a soil can be measured by testing the moisture in the soil with specially treated strips of paper that change colour depending on the pH.

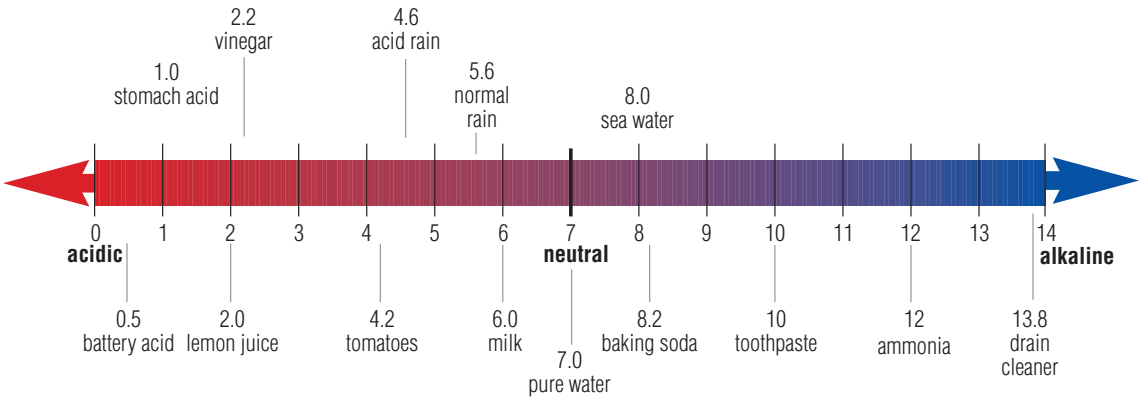


Figure 2.27 pH scale

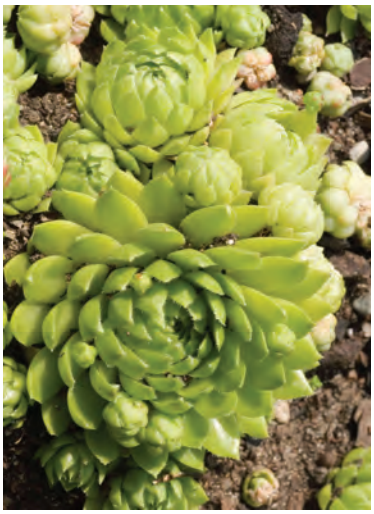


Figure 2.28 These hen-and-chicks plants require alkaline soil. Gardeners will often add limestone to soil to raise the pH.

The pH measurement of a substance can be classified as low, neutral, or high. If a soil has a low pH, it is acidic. If it has a high pH, it is called alkaline. If a soil has a pH that falls exactly between the two extremes, it is neutral. Most organisms, including plants, prefer a nearly neutral environment. Soil that is too acidic or too alkaline can damage the tissues of plants and animals or make it difficult for them to absorb nutrients. Some plants do require slightly acidic or basic pH levels and will grow only under the correct conditions (Figure 2.28).

Human Impacts on Soils

One of the most devastating effects of human activity on soil is **soil erosion**. Soil erosion is the loss of soil when water or wind washes or blows it away. The roots of plants normally hold the topsoil in place. When soil is ploughed, or tilled, the topsoil is

exposed to wind and water, which can erode it (Figure 2.29). Overgrazing by livestock animals, such as cows and sheep, can also erode the soil. If livestock eat too many of the plants' leaves, the plants die. Without plants to hold the soil in place, the soil erodes. Once the topsoil is gone, the land can no longer be used for grazing or growing crops.

Figure 2.29 Wind is eroding the soil as it is tilled to plant crops.

Plants draw nutrients from the soil and use them to build plant tissue. As you learned previously, when plants die, decomposers consume the dead plants and release some of the nutrients in the organic matter back into the soil. The nutrients can then be used again. If the same type of crop is grown in the same soil year after year, the nutrients in the soil get used up, and the crops no longer grow well in the soil.

Early in the history of agriculture, farmers learned that they had to rotate their crops. **Crop rotation** is the practice of planting a different type of crop in a particular field each year. For example, farmers will plant wheat or corn one year, and then plant soybeans or alfalfa in the same field the following year. This replenishes some of the nutrients in the soil, especially nitrogen.

Plants of the legume family, such as soybeans, peas, lentils, and alfalfa, have a symbiotic relationship with nitrogen-fixing bacteria (Figure 2.30). The bacteria supply nitrogen in a usable form directly to the plant. In return, the plant provides the bacteria with other nutrients. Nitrogen-fixing bacteria also live freely in the soil. By planting nitrogen-fixing plants, the nitrogen in the soil gets replenished. This reduces the need to add chemical fertilizers to the soil. If farmers do not rotate their crops, they have to supply nutrients to the soil by adding fertilizers.

Figure 2.30 The white bumps on the roots of this pea plant are called nodules. Each nodule contains millions of nitrogen-fixing bacteria.

Learning Checkpoint

1. What are the three layers of soil?
2. Describe how sandy soil is different from clay soil.
3. Explain why it is important to know the level of acidity in soil.
4. In what ways can farming contribute to soil erosion?
5. Describe how crop rotation helps restore nitrogen to the soil.

Assessing Water Quality

Water is critical to life, and every community in Ontario has some plan to manage its use and protect its quality. Being able to assess water quality and act responsibly to protect it is essential for sustainable ecosystems in Canada and around the world. Many different aspects of water are used to assess its quality.

Aquatic Organisms

Healthy aquatic ecosystems are full of organisms. These include ones that are easily recognizable, such as fish, large plants, and invertebrates. On the microscopic level, there are plankton, which are tiny plantlike and animal-like organisms, and bacteria and viruses.

Sometimes, the types and quantities of species present in the water can indicate that the water is unsafe. For example, certain bacteria can cause serious health problems if they are present in large enough numbers. In summer, lakes are closed for swimming because of temporary high levels of micro-organisms that can cause diseases such as ear infections and intestinal infections.

The presence or absence of some organisms can indicate that water is polluted. Indicator organisms include certain insects and insect larvae, shrimp, clams, and worms (Figure 2.31). Different organisms prefer different conditions. For example, some organisms can survive in polluted water, while others cannot.

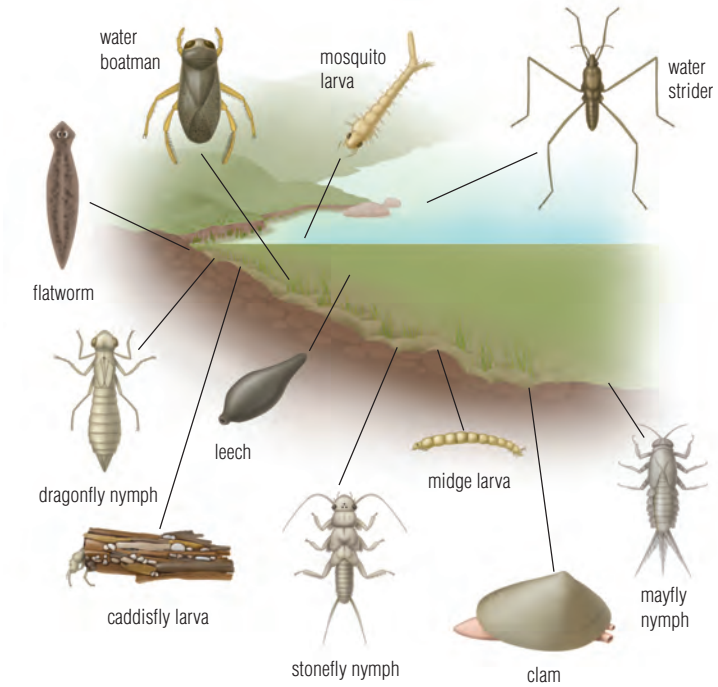


Figure 2.31 The number and types of aquatic organisms indicate water quality.

Oxygen

Just as terrestrial organisms need the oxygen in the air, aquatic organisms need the oxygen gas that is dissolved in the water.

- **Dissolved oxygen** measurements give the level of oxygen present in water. Table 2.4 shows the levels of dissolved oxygen needed by various organisms. If levels of oxygen drop below a certain level, fewer organisms are able to live in that body of water. For example, caddisfly larvae prefer water that has a high level of dissolved oxygen (Figure 2.32). If the oxygen level falls, the larvae will die.

Figure 2.32 A caddisfly larva

Table 2.4 Levels of Dissolved Oxygen Needed by Aquatic Organisms

Dissolved Oxygen (mg/L)	Aquatic Organisms
8	Large numbers of diverse species thrive.
6	Mayflies, stoneflies, and beetles start to disappear.
4	Freshwater shrimps, midge larvae, and worms can survive.
2	Midge larvae and some worms can survive.

- **Biological oxygen demand** (BOD) measures how quickly oxygen is used up by micro-organisms in a given body of water (Table 2.5). BOD is an effective test for certain types of water pollution. Polluted water can actually promote the growth of some micro-organisms, which feed off the pollution. These organisms use up oxygen, which means oxygen is removed from the water at a high rate. In addition to the possible toxic effects the pollution can have on an aquatic ecosystem, its presence results in low oxygen levels in the water. This can cause organisms to die.

Table 2.5 Typical BOD Values for Selected Water Samples

Water Sample	BOD Value (mg/L)
Clear lake water with few organisms	0–5
Clear lake water with many organisms	8–20
Slightly polluted lake water	20–100
Highly polluted lake water	100–10 000

Acidity

As with soil, most aquatic organisms prefer a neutral environment. If the acidity increases, the diversity of plants and animals that live in this water decreases. Most fish die if the water's pH falls to 4.5.

Phosphorus and Nitrogen

Fertilizers are applied to fields and gardens to supply plants with nutrients, such as the elements nitrogen and phosphorus. When the field or garden is watered, the water dissolves the fertilizer and this provides the nutrients to the plants. However, water from the garden then runs into local waters and streams and takes these nutrients with it. If the stream runs into a pond or lake, the high levels of nutrients in the water cause algae to grow rapidly. This process is called eutrophication. **Eutrophication** is the addition of nutrients to an aquatic ecosystem causing increased growth of plants such as algae (Figure 2.33). As the large amount of algae dies and decomposes, oxygen is depleted from the water. The resulting low amount of oxygen in the water may cause fish and other animals to die. Eutrophication is a huge problem in aquatic ecosystems in areas where chemical fertilizers are widely used.

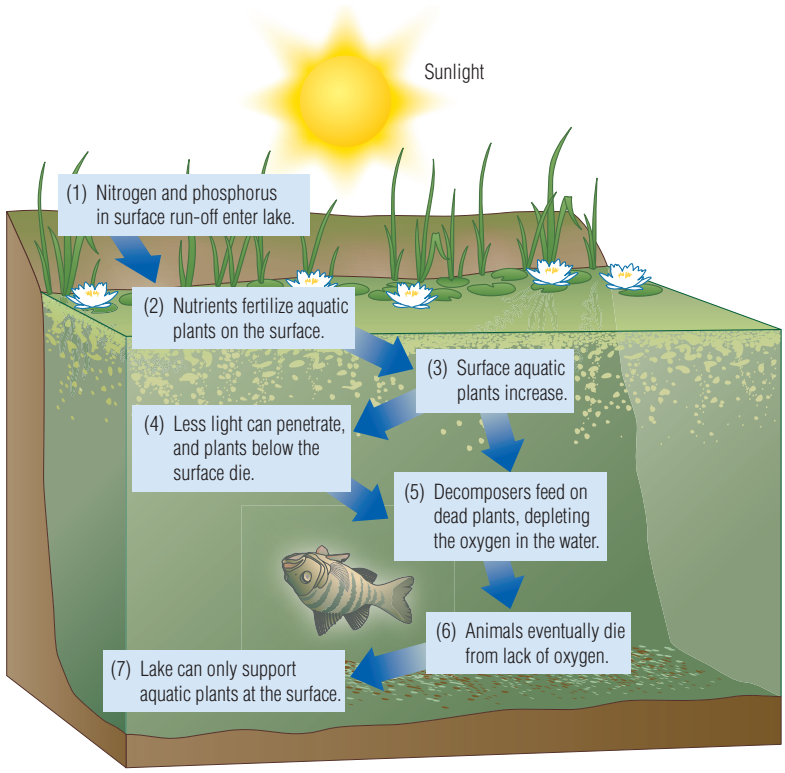


Figure 2.33 The steps in the process of eutrophication

Heavy Metals

Some kinds of metals cause illness if they are present in water in even very tiny amounts. Mercury belongs to a group of substances called **heavy metals**. They are called heavy metals because they have a density of 5 g/mL or higher. This means that they are five or more times heavier than an equal volume of water. Other heavy metals include copper, lead, and cadmium. There are many sources of heavy metals including batteries, which often contain cadmium, and compact fluorescent light bulbs, which contain mercury. Both of these kinds of devices must be disposed of responsibly.

Many industrial processes release heavy metals directly into the environment. For example, all coal-fired power plants, incinerators, and steel mills emit mercury from their smokestacks, because mercury is found naturally in coal. Mercury in the atmosphere usually settles in water. Algae absorb very tiny amounts of mercury from the water. Over time, mercury builds up in their tissues. The gradual build-up of a substance in an organism's body is called **bioaccumulation**. Unfortunately, this is not the end. The contaminated algae are consumed by zooplankton, and the mercury bioaccumulates in their tissues. In a process called **biomagnification**, the mercury becomes more and more concentrated in each link in the food chain as one animal eats many contaminated animals (Figure 2.34). Many predatory fish, including some salmon and trout, have levels of mercury high enough to be toxic if they are eaten by humans and other animals.

Health problems caused by heavy metals include kidney and lung disease, immune system disorders, cancer, sterility in men, and infertility in women.

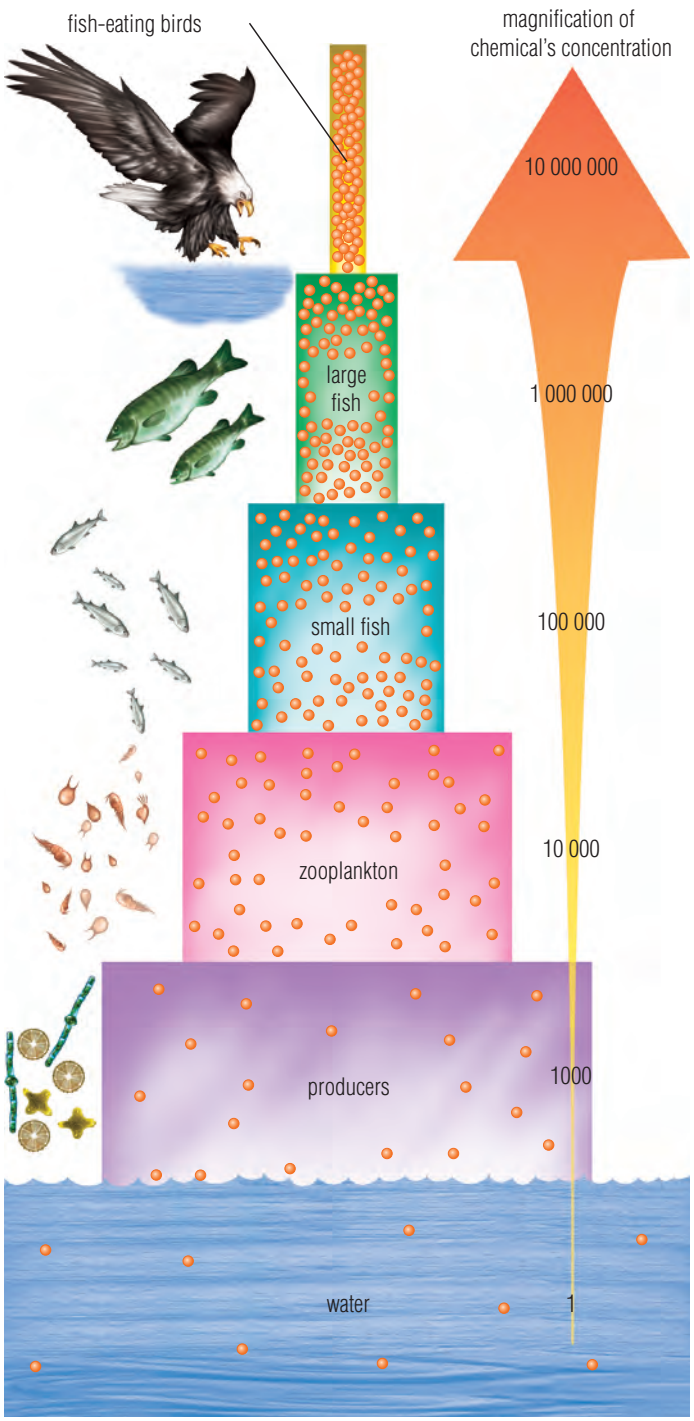


Figure 2.34 The steps involved in biomagnification

Take It Further

Aboriginal farmers developed a system of cultivation known as "the three sisters." Find out what crops made up the three sisters and what advantage each crop provided. Begin your research at *ScienceSource*.

Pesticides

Pesticides are chemicals that kill unwanted organisms, usually ones that attack crops and reduce their yield (Figure 2.35). Some pesticides last a long time in the environment, though in Canada these kinds are strictly controlled or banned. Just as heavy metals can biomagnify, so can some long-lasting pesticides. One such pesticide is DDT. Used in Canada until the 1970s, it built up in many top level predators, such as peregrine falcons. It made their eggshells so thin that few eggs hatched, and their populations declined. In Canada, the peregrine falcon almost became extinct due to DDT use. Modern pesticides are designed to last one growing season and then break down into less harmful substances.

DDT has not been banned worldwide because in some cases, its societal benefits outweigh its environmental risks. DDT is used responsibly in mosquito-infested parts of Africa in homes and on mosquito nets. This saves millions of lives by combatting an often lethal disease called malaria, which is carried by mosquitoes.

Figure 2.35 Pesticides help reduce the amount of crops lost to pests. However, in addition to killing the pest species, pesticides can also kill other non-target species. This can reduce local biodiversity.

During Reading

Thinking Literacy

Drawing Conclusions

When we ask questions, we can analyze ideas and draw conclusions. Use a three-column chart to help you draw conclusions from the reading you have done about human interactions with ecosystems. Label the first column "I read" and record a phrase or sentence from the text. Label the second column "I asked" and write down your question(s). Label the final column "Therefore" and record your conclusion.

Learning Checkpoint

1. How does the presence of certain bacteria affect water quality?
2. Explain what biological oxygen demand is.
3. Explain why the presence of nitrogen and phosphorus in water can threaten ecosystems.
4. Give an example of a heavy metal.
5. Explain the process of biomagnification.

A15 STSE Science, Technology, Society, and the Environment

Increasing Biodiversity in Your Community

To achieve sustainability, we have to maintain all levels of biodiversity: genetic, species, and ecosystem diversity. But we must remain part of our ecosystems to exist, so we have to find ways to balance human needs with maintaining biodiversity.

1. Working in groups, think of an area in or near your community where biodiversity could be increased. In a city, this could be a city park, a waterway running through a densely populated area, or a vacant lot. In a rural farming community, it could be an undeveloped patch of land between cultivated areas. In a community located within a forest, it might be the entire area surrounding the community.
2. Brainstorm ways to increase biodiversity in your chosen area. Try to be as practical as possible.
   - How will you lessen or eliminate the effects that pollution, invasive species, and habitat change have had in the area?
   - How could you improve the water quality and soil quality?
   - What species do you want to introduce into your area? How will their needs be met?
   - How will human needs be met? Will humans use the area? If so, how will any possible impacts on the biodiversity be minimized?
3. Present your action plan to the class. Be prepared to answer any questions.

A16 Skill Builder Activity

Extrapolation

Extrapolation is the process of estimating the value of a measurement beyond the known or measured values of a set of data. To make predictions about what may happen in the future, scientists extrapolate from existing data. For example, you can estimate how tall you will be next year based on your height measurements over the last five years.

Use Figure 2.36 to answer the following questions.

1. By how much did the world's population increase from 1980 to 2000?
2. Extrapolate to predict the world's population in 2020.
3. What assumptions did you make when you extrapolated from the data?

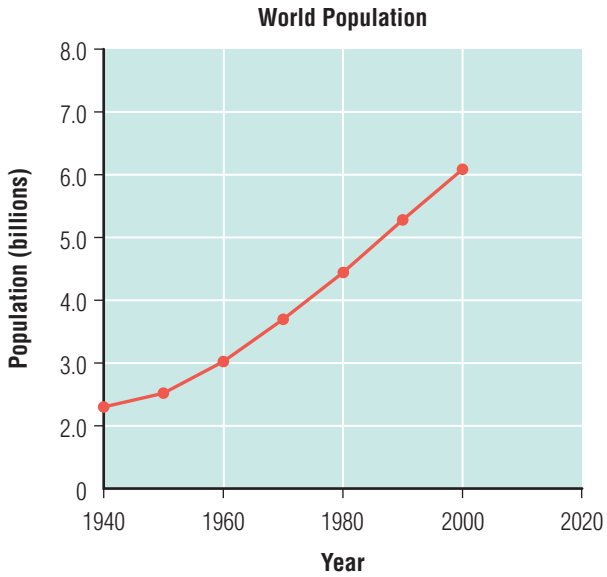


Figure 2.36

DI Key Activity

A17 Design a Lab

Skills References 2, 6, 9

SKILLS YOU WILL USE

- Developing a hypothesis
- Evaluating whether data support a hypothesis

Testing the Effects of Fertilizer on Soil and Aquatic Ecosystems

Part A — Fertilizer and Soil Fertility

Question

How does using fertilizer affect the fertility of soil?

Design and Conduct Your Investigation

1. Create a hypothesis to explain how fertilizer could affect soil fertility. For example, adding fertilizer increases soil fertility.
2. Once you have developed your hypothesis, think about how you can test it. Consider the following questions.
   - How will you measure fertility?
   - There are many different types of fertilizer. What type of fertilizer will you use, and how much should you use? How often will you apply it?
   - What kind of plants should you use? For example, will you grow plants from seeds, or will you use seedlings?
   - What aspect of a plant will you measure (for example, plan height, leaf colour)?
   - What type of soil will you choose? Potting soil? Soil from your area? How much should you use?
   - What containers will you use to grow your plants in? How many will you need?
   - How long will your experiment run?
3. Decide what variables you will control and what variables you will measure. For example, will you control the amount of water the plants get?
4. Decide what the control should be for the investigation. For example, will you grow two identical kinds of plants and treat each differently?
5. Decide what variables you will measure in the experiment, and decide how you will measure these variables. Design a data table in which you can record your measurements.
6. Write out your procedure. Have your teacher check it before you carry out your investigation.
7. When you have finished your investigation, dispose of your materials as instructed by your teacher. Clean your work area, and wash your hands.
8. Analyze your data. Did your results support your hypothesis? Explain why or why not.
9. ***ScienceSource*** Use the Internet and other sources to find out about fertilizer use in agriculture (Figure 2.37). In what ways can fertilizer use affect the soil?
10. Extrapolating from your data and from your research, what conclusions can you draw about fertilizer use and soil fertility?

Figure 2.37 Fertilizer being applied to a field

Part B — Fertilizers and Aquatic Ecosystems

Question

How does fertilizer use affect aquatic ecosystems?

Design and Conduct Your Investigation

1. Create a hypothesis to explain the effects fertilizer might have on aquatic ecosystems.
2. Once you have developed your hypothesis, consider the following questions.
   - How will you create an aquatic ecosystem?
   - What plants will you use? How many different types will you use?
   - Will you use animals as well as plants?
   - What type of fertilizer will you use and how much?
   - What will you measure in the aquatic ecosystem?
   - How long should the investigation run?
3. Decide what variables you will control and what variables you will measure. For example, will you control the amount of sunlight the ecosystems get?
4. Decide what the control should be for the investigation. For example, will you construct two identical aquatic ecosystems and treat each differently?
5. Decide what variables you will measure in the experiment, and decide how you will measure these variables. Design a data table in which you can record your measurements or observations.
6. Write out your procedure. Have your teacher check it before you carry out your investigation.
7. When you have finished your investigation, dispose of your materials as instructed by your teacher. Clean your work area, and wash your hands.
8. Analyze your data. Did your results support your hypothesis? Explain why or why not.
9. ***ScienceSource*** Use the Internet and other sources to find out about the effects of fertilizer use on the sustainability of aquatic ecosystems (Figure 2.38).
10. Extrapolating from your data and from your research, what conclusions can you draw about the effects of fertilizer use on the sustainability of aquatic ecosystems?

Figure 2.38 Aquatic ecosystems can be very near fields.

A18 Quick Lab

Deforestation and Watersheds

At the Hubbard Brook Experimental Forest, ecologists carry out large-scale long-term ecological experiments. Because forests take up a great deal of water and return water vapour back to the atmosphere through transpiration, ecologists believed that deforestation may affect the water cycle. You will be provided with actual data from a 30-year experiment, which continues to this day.

One set of data is from a forested watershed in which all the trees were clear-cut in 1965 (Figure 2.39). In 1966, 1967, and 1968, two herbicides were applied to the entire watershed to prevent any vegetation from growing again. The other set of data is from a neighbouring watershed where the trees were left untouched. In both watersheds, a weir was built to measure the amount of water in the stream flowing out of the watershed (Figure 2.40).

Purpose

To analyze data to determine the short-term and long-term effects deforestation has on the amount of water flowing out of a watershed

Figure 2.39 The deforested watershed

Figure 2.40 A weir

Materials & Equipment

- data sets
- graph paper
- coloured pencils

Procedure

1. Plot the data for both watersheds from 1958 to 1970 only. Use different colours to represent the two different watersheds.
2. Study the graphs for both watersheds. What trends do the data show?
3. Does cutting all the trees in a watershed increase water flow over the short term? Is there a significant difference? Explain your reasoning.
4. On the same graph, plot the remaining data for both forests from 1970 to 1988.

Questions

5. Does cutting all the trees in a watershed increase water flow over the long term? Is there a significant difference? Explain your reasoning.
6. Data were collected for seven years before the trees were cut down.
   (a) Why is this information important?
   (b) What misinterpretations could have been made without the first seven years of data?
7. (a) What was the control in this experiment?
   (b) Why is it necessary to have a control?
8. If the experiment had been stopped five years after the forest was cut, would the conclusions have been different? What is the importance of long-term research?
9. If a community wishes to increase the water in its reservoirs, would cutting down trees be a good solution? Explain.
10. Extrapolate data points for an additional five years, and infer any future trends.

2.2 CHECK and REFLECT

Key Concept Review

1. Which has bigger rock particles, clay soil or sandy soil?
2. Describe the three layers of soil.
3. Why is humus important for healthy soil?
4. Why is it important to test for bacteria in water reserved for human use?
5. What indicators can be used to test water quality?
6. How is the water table connected to the soil?
7. Define a heavy metal, and give three examples.

Connect Your Understanding

8. Explain why topsoil is a vitally important layer of soil.
9. At which level of the food chain does biomagnification have the most impact? Explain.
10. What properties of plastic make it a dangerous pollutant in aquatic ecosystems?
11. Explain how the presence of coal-fired electricity plants can affect the ability of lakes to support life.
12. Suppose that there has been a sudden growth of algae in a lake in cottage country.
    (a) Suggest three possible causes for this situation.
    (b) Explain what could happen in the lake.
13. Manure is often used by gardeners to fertilize soil. How might this be effective in replenishing soil nutrients?
14. (a) What is the ecological problem illustrated in the photo below?
    (b) Name the human activity that may have caused the situation.

Question 14

15. Acid rain is not just a Canadian problem. It is an international problem. Justify this statement.
16. In the 1980s, lakes and forests in eastern Ontario were affected by acid rain. Describe the effects the acid rain might have had on the terrestrial and aquatic ecosystems.

Reflection

17. You can be a part of solution to the various problems you learned about in this section. Does your lifestyle affect neighbouring bodies of water? Identify any habits that you or your family have that may have an impact. How can you change your habits so that you do not negatively affect the water cycle?

For more questions, go to *ScienceSource*.

Great CANADIANS in Science David Suzuki

Figure 2.41 Dr. Suzuki visits students at William Lyon Mackenzie Collegiate to congratulate them on creating a renewable energy project.

Figure 2.42 Dr. Suzuki answers questions at a press conference about Canada's environmental priorities.

Dr. David Suzuki is an environmentalist, broadcaster, and scientist. As the cofounder of the David Suzuki Foundation, he has devoted an enormous amount of his time to saving the ecosystems of the world. The foundation focusses on four main areas: oceans and sustainable fishing; climate change and clean energy; sustainability; and the Nature Challenge. Through science and education, the foundation encourages solutions that will conserve nature while achieving sustainability within a single generation. The use of science and education are key to how Suzuki increases environmental awareness.

The Nature of Things is a television science magazine show, which is hosted by Suzuki. Suzuki uses the show to engage viewers in the natural world, point out threats to human well-being and the environment, and offer ideas for how to achieve a more sustainable future. With 6.6 billion human inhabitants, the biosphere is under tremendous pressure to support everyone's needs.

Suzuki is inspired by the energy of today's youth. He is encouraged to see students using tools such as blogs, email, podcasts, and social networking sites to spread the message about protecting the biosphere. The future depends on it!

Questions

1. What has David Suzuki done to increase awareness of sustainable ecosystems?
2. Go to ***ScienceSource*** to research David Suzuki's Nature Challenge. List three things you can do right now to live a greener life. Try them out for a week. How easy or hard were they to do?

Science in My FUTURE Ecological Consultant

Figure 2.43 An overpass being built for the Red Hill Valley Expressway in 2003. The expressway opened in 2007.

Figure 2.44 Ecological consultants spend time in the field collecting data.

As people and businesses become more aware of the stresses on ecosystems, they are starting to think more critically about their actions. An ecological consultant helps people make those decisions by doing many of the following things:

- providing data and recommendations on lessening impacts on the environment
- doing landscape assessment and planning
- ecological monitoring and research
- creating materials for educational workshops and public consultations
- providing logistical support for municipal environmental strategies
- providing expert testimony in environmental trials

The construction of a new highway through the environmentally sensitive Red Hill Valley in Hamilton is a typical project that requires the services of an ecological consultant (Figure 2.43). On this project, ecological consultants ensured that environmental concerns were being addressed before any construction began.

A consultant's job varies greatly depending on the client, the season, and the type of environment. However, it includes writing proposals and reports, working with clients, making presentations, and managing support staff. Field work is mostly done during the summer (Figure 2.44), and research, designs, and reports are mostly done during the winter.

Most ecological consultants are passionate about their work. They help to find a balance between ecosystem health and human needs.

Questions

1. Write a short paragraph explaining what the typical day or week in the life of an ecological consultant would look like.
2. Go to ***ScienceSource*** to research what education or training is needed to become an ecological consultant.

2 CHAPTER REVIEW

ACHIEVEMENT CHART CATEGORIES

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

Key Concept Review

1. What negative effect can habitat change have on native species? (k)

2. (a) What is causing climate change? (k)
   (b) Describe the impact climate change is having on an Arctic species. (k)

3. What is the relationship between dissolved oxygen and biological oxygen demand? (k)

4. Classify the following pollutants as either point source or non-point source. (k)
   (a) excess fertilizer from fields
   (b) pesticide residue from local gardens
   (c) discharge of waste water from a cruise ship
   (d) leaking storage tanks
   (e) a leaking landfill
   (f) animal waste treatment facility
   (g) sediment from a clear-cut forest
   (h) stormwater from an urban parking lot
   (i) bacteria from pet wastes

5. Give an example of overexploitation in a marine environment. (k)

6. List some chemical indicators that can be used to test water quality. (k)

7. (a) What is acid rain? (k)
   (b) What are the causes of acid rain? (k)
   (c) List ways that acid rain affects a terrestrial ecosystem. (k)

8. If too much sewage is added to water, the aquatic organisms may die due to lack of oxygen. Explain how this might occur. (k)

9. Explain habitat fragmentation, and suggest ways in which it could degrade the quality of an ecosystem. (k)

10. What advantages might an introduced species have when competing with native species? (k)

Connect Your Understanding

11. Explain how irrigation systems might actually cause a decrease in water quality. (a)

12. Many potential home buyers want lots of trees around their homes. A housing developer builds a residential community in a forested area. To show his ecological responsibility, he leaves patches of the forest untouched and builds roads to connect the various parts of the development. Critique how ecologically responsible the developer's actions are. (a)

13. The human activity pictured below may affect biodiversity. Create a concept map that shows how the activity may affect biodiversity. (c)

Question 13

14. Suppose that a homeowner wishes to start a small garden in her backyard. Why is it important that she determine the type of soil she has before planting any vegetables? (a)

15. How might biodegradable plastics help reduce pollution? (a)

16. Consider the following hypothetical situation. Suppose that a factory emits a number of pollutants that cause health problems in young children and the elderly. This factory also employs 50 percent of the town's residents directly and indirectly, and closing the factory would cause severe financial hardship in the town. Forcing the factory to clean up its emissions would also cause the company to lose money and make it difficult for it to compete with similar companies. You are the mayor. Suggest an action plan for your town that will help to deal with this crisis. (a)

17. The data in the table gives the average dissolved oxygen values in the Gulf of Mexico. Normal seawater has at least 6.9 mg/L.

Dissolved Oxygen Values

Month	Dissolved Oxygen (mg/L)	Month	Dissolved Oxygen (mg/L)
Jan 1	8.5	Jan 15	9.0
Feb 1	8.5	Feb 15	9.0
Mar 1	8.0	Mar 15	7.5
Apr 1	5.0	Apr 15	3.5
May 1	2.0	May 15	3.0
June 1	0.0	June 15	1.0
July 1	1.0	July 15	0.0
Aug 1	0.0	Aug 15	0.0
Sept 1	0.0	Sep 15	0.0
Oct 1	3.0	Oct 15	4.5
Nov 1	6.5	Nov 15	7.5
Dec 1	8.0	Dec 15	7.5

(a) Graph the data. (c)

(b) Which months have dissolved oxygen levels that are too low to support aquatic life? (t)

(c) The name "dead zone" is given to the zones in aquatic ecosystems that do not have enough oxygen to support life. Why is this name appropriate? (t)

(d) Create a hypothesis that might explain the trends in the data. (t)

(e) What changes could be made to correct this situation? (t)

Reflection

18. The World Water Council ranked Canada second out of 147 countries in terms of water sustainability. However, Canada ranked 129th in terms of responsible water use. How could you change your actions to improve this placement? (c)

After Reading

Thinking Literacy

Reflect and Evaluate

With a partner, share and summarize some of the questions you posed during this chapter. Compare any conclusions you drew. Write a three-sentence resolution about ways that you will both be more responsible in how you deal with ecosystems in the environment. Share your resolutions with another pair of students.

Unit Task Link

In this chapter, you have learned about the negative effects human activities can have on ecosystems. In the Unit Task, you will be designing a sustainable community. Think about ways you could lessen habitat loss/fragmentation, pollution, and overexploitation in your sustainable community.