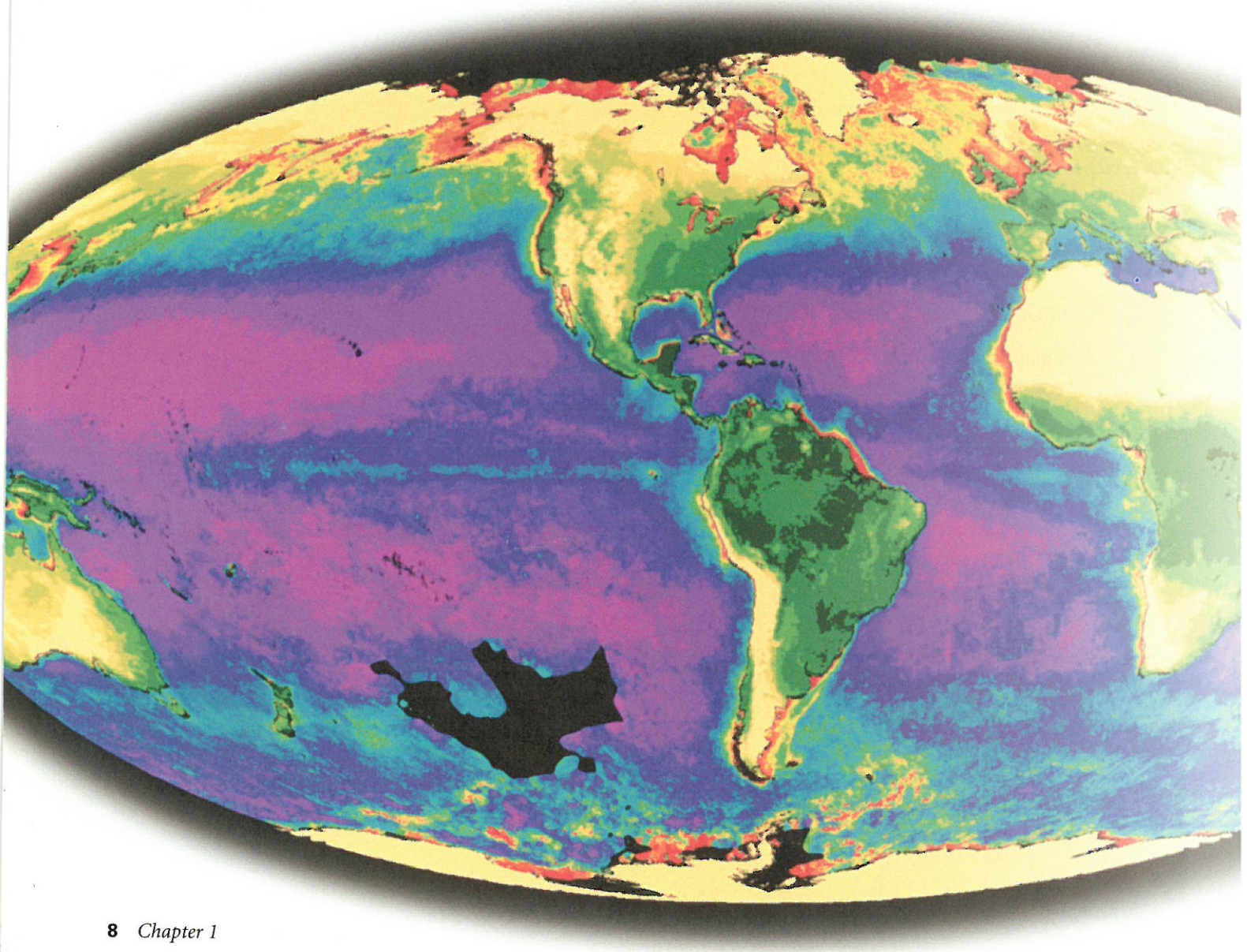
Chapter 1.1-1.5

CHAPTER

1 Diversity in Ecosystems

Getting Started

HAVE YOU EVER THOUGHT OF OUR PLANET AS A SPACESHIP? Travelling around the Sun in a slightly elliptical orbit, the Earth carries with it the only known forms of life in the universe. It is a closed system. There is no outside source for life-sustaining raw materials, nor any interplanetary garbage dump to store wastes. Life is totally dependent on solar energy and the matter available aboard the spaceship Earth.

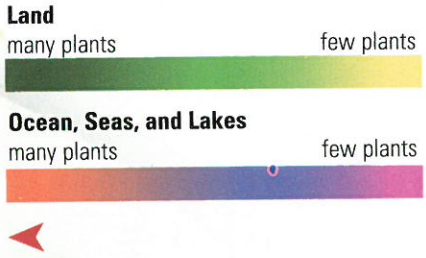


There is, however, one big difference between a spaceship and the Earth. On a spaceship, the temperature and other conditions are much the same throughout, and all of the astronauts have equal access to the ship's resources. On Earth, it is hot in some places, and cold in others. At the equator Earth's inhabitants receive sunlight for about half of each day, but those who live in the far north go months without ever seeing the Sun. The wind blows dry in some areas, and wet in others. For living things, there is no equal access to resources, and there may be wildly different conditions, all depending on where they live.

These differences affect the diversity of living things across our planet. **Figure 1** shows how the amount of plant life varies on Earth. Since animals depend on plants to survive, the number and variety of plants in any area also affect the number and variety (the diversity) of animals.

Figure 1

This satellite image was produced by combining three years of data obtained from a satellite orbiting Earth. It shows the number of plants that are found in each area of our planet.



Reflect on your Learning

1. As you study **Figure 1**, you can see that plant life seems dense in some areas, but much thinner in others.
   - **(a)** Explain the distribution of plant life.
   - **(b)** Based on the plant life, where in this photo would you expect to find many animals, and where would you expect only a few? How does this match what you know about these regions?
2. We cannot really "throw things away," because everything we discard stays on Earth. On spaceship Earth we cannot go to a "refuelling station" to take on supplies. In that way, Earth is more closed than even a spaceship. And of course on Earth, most of the inhabitants are not human. Spaceships have rules for behaviour that help astronauts to avoid fouling the air and overusing vital water and food supplies and that help them get along with each other.
   - **(a)** Suggest a set of rules for human passengers on spaceship Earth.
   - **(b)** How closely do we follow those rules now? Suggest some behaviours that we should consider changing.
   - **(c)** How might these human practices and behaviours affect the diversity of living things?

Throughout this chapter, note any changes in your ideas as you learn new concepts and develop your skills.

Try This Activity Earth Under a Microscope

You can investigate how living things interact in a closed system, on a small and simple scale, by observing microscopic organisms.

Materials: gloves, apron, tap water, medicine dropper, microscope slides, microscope, cultures of yeast, *paramecium*, and *didinium*

Use gloves while making and observing your slides. Dispose of slides and gloves as directed by your teacher. Wash your hands before leaving the lab.

- Using a medicine dropper, prepare separate wet mounts from each of the three cultures. Examine each slide under a light microscope.

(a) How many different kinds of living things do you see for each slide?

(b) Sketch and describe the organism.

(c) Describe the behaviour of the organism.

- Combine the living things to study how they interact. Prepare the following wet mounts:
  1 drop *paramecium* culture + 1 drop yeast culture
  1 drop *paramecium* culture + 1 drop *didinium* culture

(d) Describe the interactions between the organisms.

(e) How would an ecosystem that contained all three organisms be different from one that contained only *paramecium*?

1.1

The Silence of the Frogs

Imagine a silent pond. No croaks, no peeps, no "ribbits," no noisy frogs. If the number of amphibians like frogs continues to decline, you will not need to use your imagination. All ponds will be silent. Biologists have recently become aware of the gradual disappearance of frogs, toads, and salamanders, which seem to be dying at unprecedented rates. About 30% of North America's frogs and toads are in trouble.

Amphibians have been around for more than 400 million years. When most animals and plants died out about 250 million years ago, amphibians survived. Frogs skipped right by the catastrophe that killed all the dinosaurs 65 million years ago. Frogs and their relatives have adapted to ice ages and extended periods of global warming without missing a beat. These timid amphibians can withstand drought, flood, and winter ice. They can be found in most ecosystems that include water. (**Ecosystem** is a term used to describe the relationships among the many species living in an environment and the relationships among those organisms and the non-living components of the environment.) Amphibians live on the peaks of the Canadian Rockies, in the city parks of Toronto, and in the swamps of Newfoundland. They have even done well dealing with the growth of the human population — at least until recently.

Why Are Scientists Concerned?

Other than those who enjoy eating frogs' legs, why would scientists care about amphibians? Many believe that the health of amphibians indicates the health of the ecosystems they live in.

The word amphibian is a clue as to why frogs and toads can be used to diagnose the health of ecosystems. The word comes from two Greek words, *amphi* ("on both sides") and *bios* ("life"). Amphibians literally have two lives (**Figure 1**). Frogs begin as eggs and grow to tadpoles in ponds, and then enter their second life as adults in forest and grassland areas. This means they are exposed to hazards in both ecosystems, instead of only one. Any decline in the health of either of the two ecosystems in which they live will have an impact on frogs.

Not only do frogs occupy two different ecosystems, they are also parts of two very different food chains. A **food chain** is a step-by-step sequence linking organisms that feed on each other, starting with a food source such as plants (**producers**), and continuing with animals and other living things that feed on the plants and on each other (**consumers**).

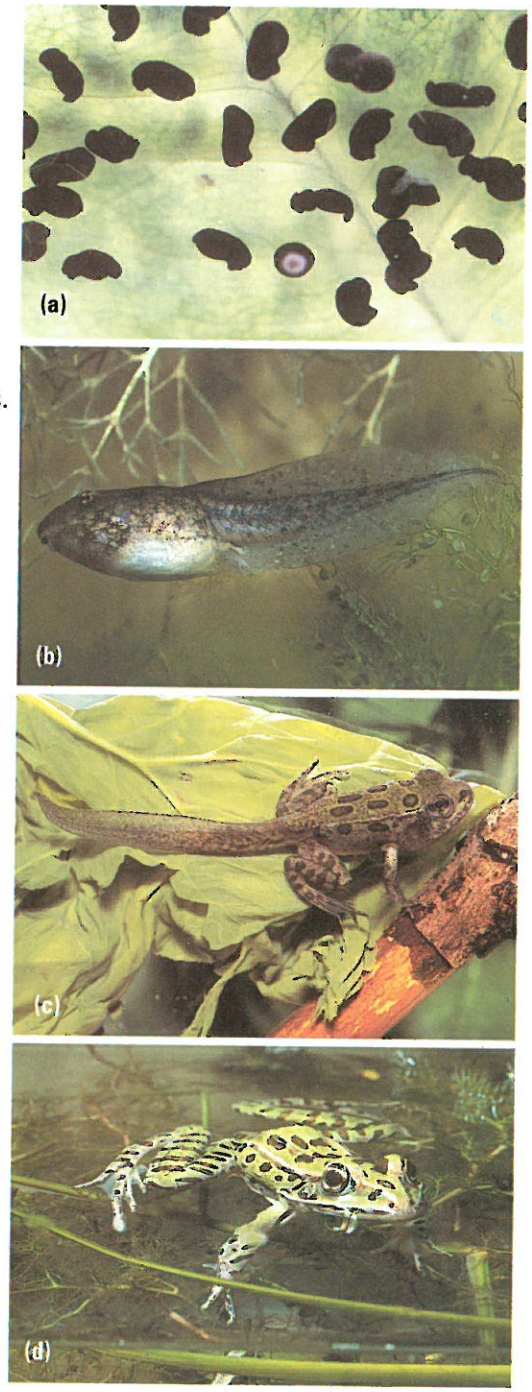


Figure 1
The northern leopard frog, native to Ontario, is one of the threatened amphibian species. **(a)** Leopard frogs lay their eggs in ponds. **(b)** Tadpoles develop. **(c)** Tadpoles grow into immature frogs. **(d)** Adult leopard frogs live in fields and around ponds.

Frogs in Their Ecosystems

Adult frogs eat mostly insects, although they may also eat some small fish. In turn, large fish, predatory birds, reptiles, and small mammals eat frogs. This makes the adult frog a member of a food chain (**Figure 2**) that includes producers (plants), **herbivores** (animals that eat plants) and **carnivores** (animals, like the frog, that feed on other animals). Animals that eat both plants and animals, such as humans, raccoons, and bears, are called **omnivores**.

If frogs were completely wiped out, insect populations would most certainly soar. This has already happened in Bangladesh, where frog populations have been decimated to supply restaurants with delicacies. The result is a rise in the number of mosquitoes, and a dramatic rise in cases of malaria among humans. Malaria is a disease that is transmitted by mosquitoes, which are eaten by frogs. The increase in malaria can be traced back to the disappearance of frogs from the local ecosystems.

Tadpoles eat large amounts of algae (small plant-like organisms), both living and dead. The tadpole is a herbivore, not a carnivore, and is part of a much different food chain (**Figure 3**). In this food chain there are two food sources — producers (the algae) and **detritus** (waste from plants and animals, including their dead remains). Detritus food chains are critical in the recycling of matter in ecosystems. They include **decomposers**, organisms that break down detritus to get nutrients for their own use, but in the process also release nutrients to the soil and water. Plants and algae use those nutrients to grow.

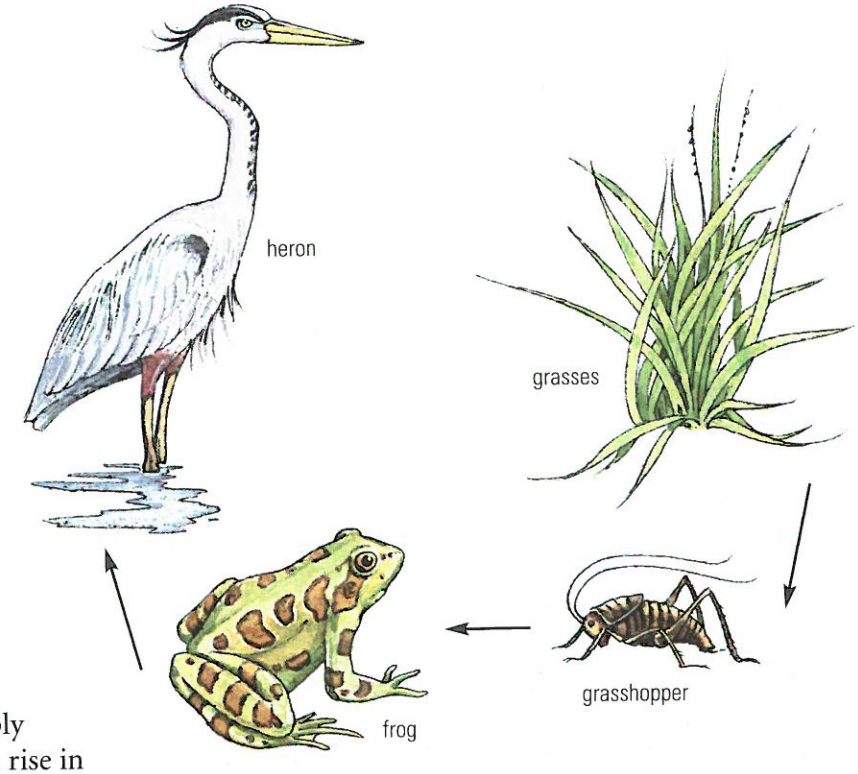


Figure 2
The adult frog is part of a food chain that includes producers (plants) that make the food and consumers (animals and fungi) that feed either directly or indirectly on the plants.

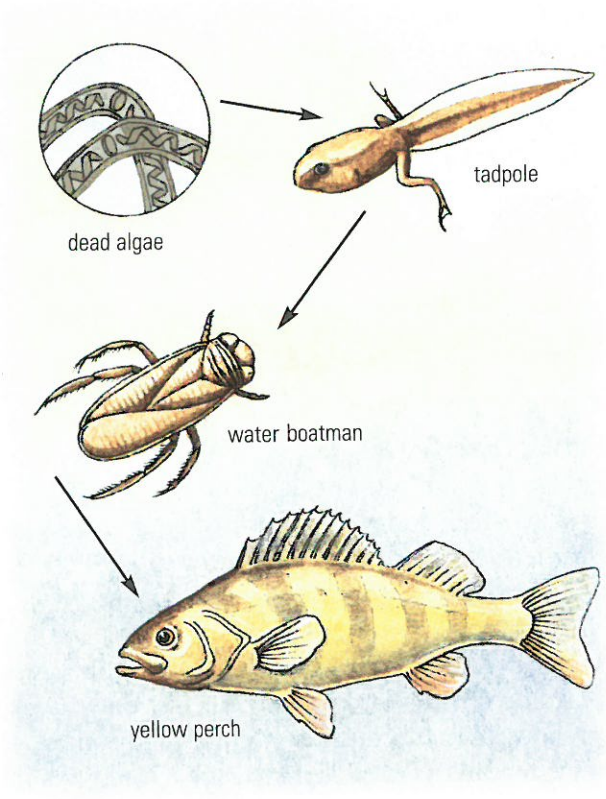


Figure 3
Waste is recycled within a detritus food chain. Organisms in the chain include fungi, bacteria, insects and other invertebrates, and, in ponds, tadpoles.

Why Are Frogs Disappearing?

The worldwide disappearance of frogs is a bit of a puzzle. In some areas, scientists don't really know what is causing the problem. In other areas, they have identified some probable causes.

Loss of Habitat

In Canada, frogs in more heavily populated areas, such as southern Ontario, seem to be in great danger. The loss of **habitat**, places where a species can live, is most often mentioned as the main cause. Frogs need wetlands, ponds, or lakes with clean water so they can breed and lay their eggs. As adults they need a place such as a forest or a field, where they can catch insects. They also need a safe path between the two. The growth of cities and other human activities, such as farming and industry, takes away all of these things. Humans drain wetlands, cut down trees, build on fields, and build roads between ponds and woods.

A highway separating a woodlot from a pond or lake can claim the lives of many frogs as they move between their feeding and breeding areas. Cutting down some of the trees that surround a lake creates problems for amphibians by exposing them to predators as they make their way between the water and the denser trees farther from the lake.

From 1984 to 1986 scientists studied an area where a swamp and a forest were separated by a road (**Figure 4**). When trees bordering the road were cut in 1986, researchers noticed a huge decline in the number of frogs and other amphibians.

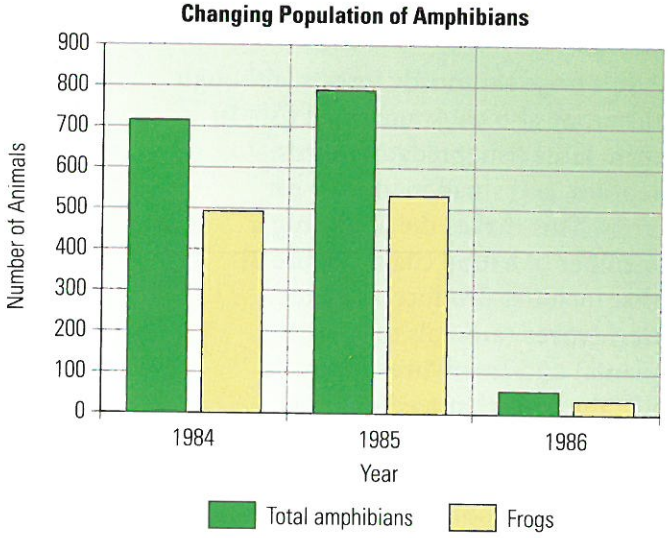


Figure 4

In the first year of the study, researchers counted 716 amphibians, of which 493 were frogs. After the trees were cut in 1986, they found very few.

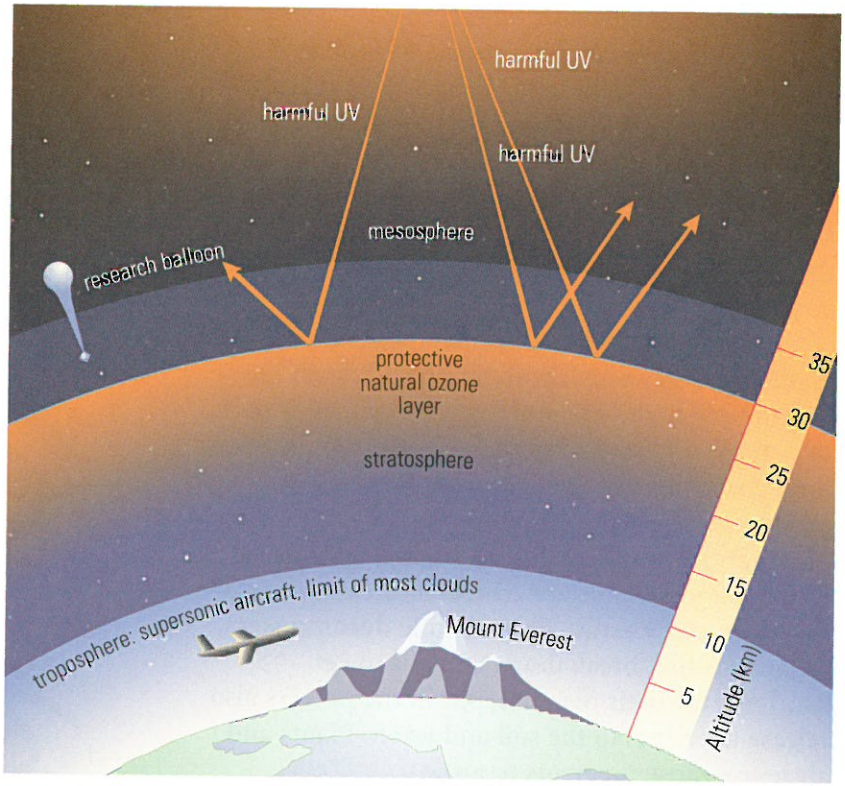


Figure 5

A thin layer of ozone (O_3) blocks harmful solar radiation. The layer is getting thinner. Atmospheric scientists believe that chlorofluorocarbons (CFCs), which were widely used in spray cans and refrigerators, are at least partly responsible for the thinning.

Air and Water Quality

A second cause for the decline in frog numbers is pollution. This is because frog skin is thin and it is not protected by feathers, fur, or scales. Frogs have lungs, but they also breathe through their skin, which must be thin to allow oxygen through. Pollutants can also pass through their thin, moist skin. Acid rain, caused mostly by pollutants released by vehicles and industry, is just one example.

Acidity also affects frogs' ability to reproduce. Researchers have noted that if the water is even slightly acidic, it reduces the mobility of frog sperm cells. This makes it less likely that eggs will be fertilized. Even if

mating is successful, acid affects the frog's development. Embryos, if they develop at all, grow slowly in acidic water. In some locations, this means that the pond they are in will dry up before tadpoles can become adult frogs, and the tadpoles die. Acidic water can cause other problems. For example, embryos may develop deformed limbs. Tadpoles with such limbs do not survive for very long.

Ultraviolet Radiation

The thin skin of the frog is also susceptible to ultraviolet (UV) radiation. This invisible radiation from the Sun causes sunburns, but it has also been linked with more serious cell damage. The amount of UV radiation reaching Earth's surface is increasing because of damage to the protective ozone layer surrounding our planet (**Figure 5**).

Frogs at higher altitudes, where the problem of UV is greater, seem to be the ones that are most endangered. Many highland species are used to dealing with UV radiation (they lay black eggs and have developed a black covering that lines their internal organs for protection), but biologists speculate that these adaptations cannot keep pace with changes in the ozone layer.

The frog is not the only animal whose skin is exposed to UV radiation. Humans also have a delicate skin and are affected by the increase in UV rays. The fact that the rate of human skin cancer is rising all over the world underscores the importance of studying the frog as a "bioindicator" of the health of the planet.

Climate Change

Human activities that are causing a change in climate have also been linked to the disappearance of frogs. There is evidence of a global warming trend. One hypothesis links increasing global temperatures with the increased use of fossil fuels such as coal, oil, and gasoline. Climate changes can cause important changes in local ecosystems. For example, if the climate becomes drier, frogs will suffer. No frog can stay in the sun too long or completely separate itself from fresh water.

Challenge

1,2 Frogs can be used as indicator species for the health of ecosystems. What other plants and animals could be used as indicators in your Challenge? Record your thoughts as you progress through this unit.

Understanding Concepts

1. A decline in the number of frogs would affect other species. Using the term food chain, explain how the decline would affect
   (a) insects
   (b) algae
2. Classify each of the organisms in **Figures 2** and **3** as herbivore, carnivore, or omnivore. Explain your classifications.
3. In a paragraph, explain the difference between the two food chains to which the frog belongs. Explain the role of the frog in each chain.
4. **(a)** Explain why the life cycle and skin of the frog make it a good indicator animal if you want to determine the health of local ecosystems.
   (b) (Y) Construct a concept map that links the decline in the number of frogs to factors that may cause the decline.
   (c) Choose one of the possible causes and, using your own words, explain how it affects frogs.

Making Connections

5. Make a list of things that you could do, or avoid doing, that might help frogs to survive.

Exploring

6. **(a)** Design a scientific experiment that would assess the impact of acid rain on one species of frog.
   (b) (K) If you actually carried out such an experiment, what would happen to the animals you experimented on? From an ethical perspective, discuss your experimental design.

Reflecting

7. In question 5 you made a list of things you could do or avoid doing to help frogs. Identify the things that would be easy for you, and those that would demand sacrifices. Would you be willing to do the hard things to save frogs? Explain your answer.

Work the Web

Research the disappearance of the northern cricket frog (*Acris crepitani*) from southwestern Ontario and produce a report. Visit www.science.nelson.com and follow the links from Science 10, 1.1 to help in your research.

1.2

Canada's Endangered Species

The first bald eagle born and raised on the shores of Lake Erie in nearly 30 years took flight in 1983. Wildlife officers had moved the parent birds to Long Point peninsula in an attempt to re-introduce the birds to the natural ecosystem in the lower Great Lakes.

During the 1700s and 1800s the bald eagle was common along the northern shores of Lake Erie. By the early 1900s, biologists had started to note a decline in their numbers. Early settlers and farmers regarded the bird as a threat to livestock and were only too ready to kill them. (Bald eagles eat mostly fish, but they will take chickens and other small animals.) A second, and even more deadly threat, followed. Toxic chemical waste, produced by the many industrial plants that lined the Great Lakes, entered the eagles' food chain. The high levels of toxins caused eggshells of the bald eagle and some other birds, such as the double-crested cormorant and the herring gull, to become unusually thin. Eggs broke more easily, and many eagles were born with abnormalities.

The health of top-level carnivores like eagles indicates whether toxins are entering an ecosystem. Eagles depend directly or indirectly on all of the other members of their food chain (**Figure 1**).

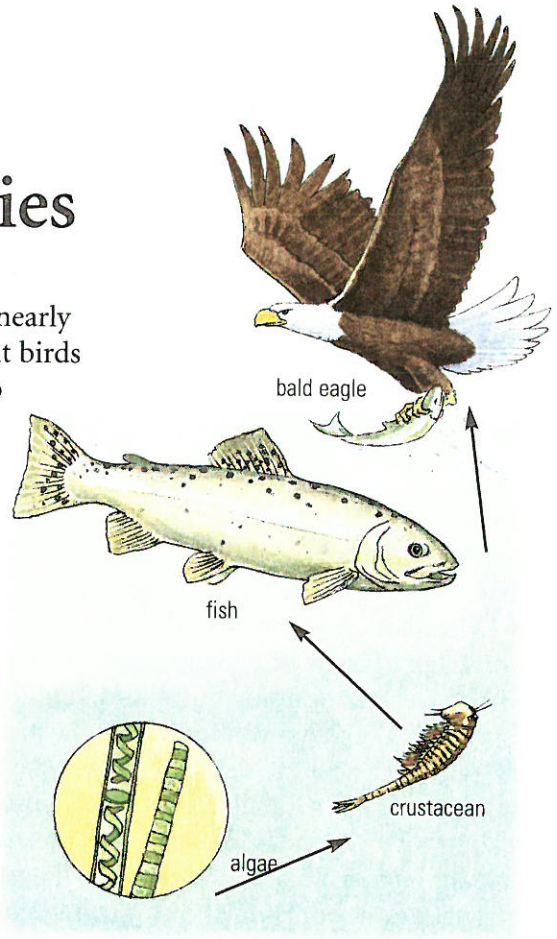


Figure 1
The bald eagle has been re-introduced to the shores of Lake Erie, in an attempt to re-establish a natural ecosystem.

Classifying Species at Risk

Amphibians are not the only wildlife that is disappearing. In Canada there are more than 250 species of plants and animals at various degrees of risk (**Table 1**).

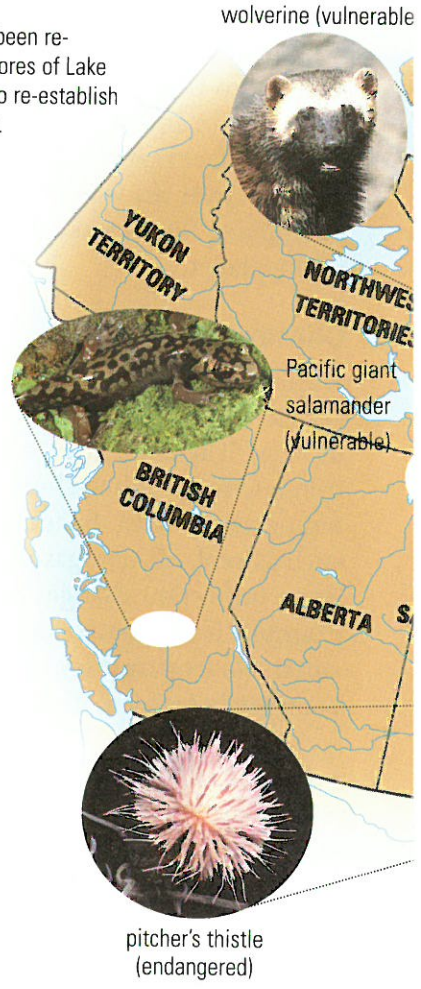


Table 1 **Classification System for At-Risk Species**

Classification	Description	Example
extinct	a species that is no longer found anywhere	blue walleye (the last fish of this species was taken from Lake Erie in 1965)
endangered	a species that is close to extinction in all parts of Canada or in a significantly large location	eastern cougar (sightings of this large cat are very rare)
extirpated	any species that no longer exists in one part of Canada, but can be found in others	grizzly bear (no longer found in Manitoba and Saskatchewan, but still found in the mountains of Alberta and British Columbia)
threatened	any species that is likely to become endangered if factors that make it vulnerable are not reversed	wood bison (their number is small, and recently tuberculosis has become a problem)
vulnerable	any species that is at risk because of low or declining numbers at the fringe of its range or in some restricted area	grey fox (is beginning to return to southern Ontario, but needs woodlands)

Understanding Concepts

1. **(a)** In your own words, describe the classification system for at-risk species.

   (b) Why is a classification system like this useful?

2. Using the criteria in **Table 1**, classify each of the following species as extinct, endangered, extirpated, threatened, or vulnerable. Explain your classification.

   (a) The wood turtle is found in pockets throughout southern Ontario, southern Quebec, New Brunswick, and Nova Scotia. The number of wood turtles in Canada seems to be stable, but in the United States their numbers are decreasing as many are being taken from the wild into homes as pets.

   (b) Furbish's lousewort is a tall herb that grows on riverbanks. In Canada, it grows only on a 200-km stretch of the Saint John River in New Brunswick. Forestry, farming, and flooding caused by hydroelectric dams all affect the area in which it lives.

   (c) The greater prairie chicken has not been seen in Ontario, Manitoba, or Alberta for many years. It was last seen in Saskatchewan in 1977. It can still be found in the prairie states of the U.S.

3. Choose one of the species listed in **Table 1** or **Figure 2** for further research. Why is the species at risk? Are there any initiatives underway to improve the status of the species? (I) What could you do to help? Report on the results of your (R) research.

Making Connections

4. **(a)** Predict which area of Canada has the greatest number of organisms at risk. Provide a hypothesis that explains why wildlife in this area would have more problems.

   (b) Do national and provincial parks help alleviate this problem? Explain.

Reflecting

5. The bald eagle is not listed as at risk in Canada. Should resources be used to help restore this bird around Lake Erie?

Work the Web

The peregrine falcon was once considered endangered. Research Canadian efforts to restore this predator and report on their success. To do your research, visit www.science.nelson.com and follow the links from Science 10, 1.2.

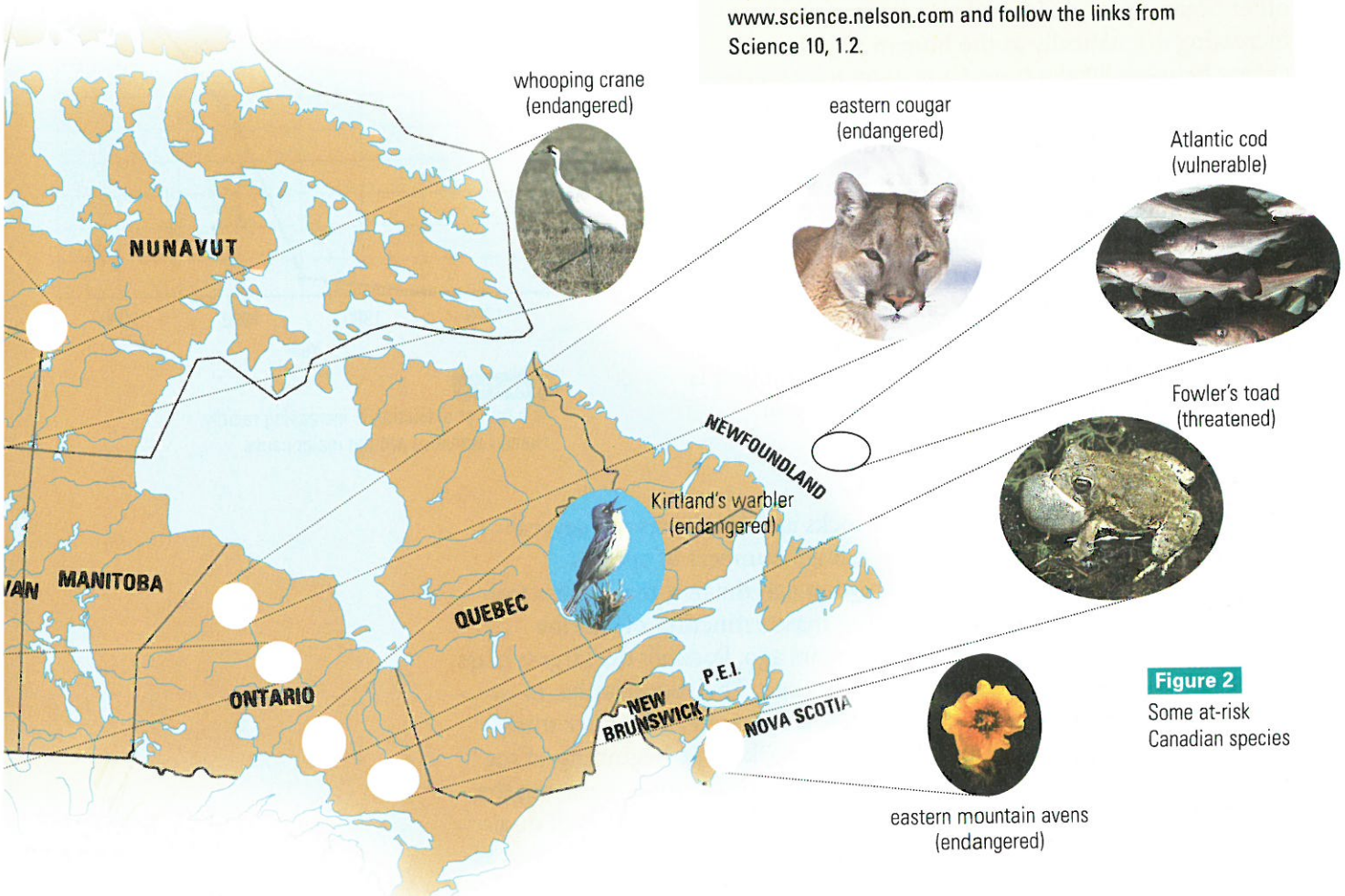


Figure 2
Some at-risk Canadian species

1.3

Extinction in the Modern World

In the 1850s, flocks of passenger pigeons (**Figure 1**) would darken the sky as they migrated south for the winter. Alexander Wilson, a scientist who studied birds, once saw a flock that he estimated contained nearly 2 billion birds. By 1914, there wasn't a single passenger pigeon anywhere on Earth. The species was extinct.

How could such a successful species suddenly become extinct? Massive commercial hunting and the clearing of forests, which destroyed habitat and food for the pigeons, were both part of the reason. Passenger pigeons were curious animals, and easy to kill. A common practice was to tie a captured bird to a perch. As other pigeons flew by during their migration, they would stop to see what was going on. When a flock landed, they were slaughtered. The perch was known as a "stool," and the practice has given us the name "stool pigeon."

Figure 1
The extinction of the passenger pigeon is just one example of the growing influence of humans.

Humans and the Rate of Extinction

The extinction of the passenger pigeon was sudden, but it is not an isolated event. Humans, a recent addition to the planet, have had a profound effect on other organisms. Species extinction rates are increasing dramatically as the human population grows. Between 8000 B.C. and A.D. 1600 the species extinction rate is estimated at one species every 1000 years. Between 1600 and 1900 the estimate is that one species went extinct every four years. In modern times, the rate is soaring (**Figure 2**). In the early years of the 21st century, the projection is that one species will become extinct every 30 minutes. Although the majority of threatened species can be found in tropical rainforests, the problem also exists in Canada. The number of species at risk of extinction is growing, at the rate of about 80 species per year.

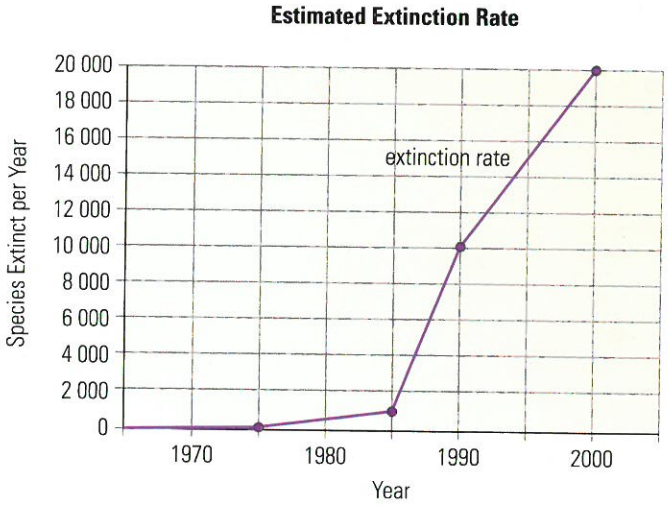


Figure 2
The rate of extinction is increasing rapidly. Human activities are the major cause.

A Brief History of Extinction

The history of our planet, recorded in rocks and fossils, reveals several large-scale disasters that have destroyed huge numbers of species (**Figure 3**). Approximately 438 million years ago the first mass extinction of marine organisms took place. Another mass extinction of marine organisms happened nearly 360 million years ago. Possibly the largest mass extinction occurred about 245 million years ago. That catastrophe, in which about 80% of all species perished, was followed by another mass extinction 208 million years ago. This event marked the beginning of the age of dinosaurs. It may well have removed the competition, ensuring the success of the early reptiles, which were then no larger than a small dog. The most famous mass extinction, even though it was not as disastrous as

some of the earlier ones, happened about 65 million years ago, and it marked the end of the age of dinosaurs.

Mass extinctions occurred before humans existed, but scientists believe the causes were much different from those of the modern era. The most promising theories involve asteroids crashing into Earth (**Figure 4**). A collision would raise tremendous amounts of dust, blocking light from the Sun, and set off many volcanoes, quickly altering environmental conditions. There is evidence that an asteroid hit Earth about 65 million years ago. The crater, just off the Yucatan Peninsula of Mexico, is 9.6 km deep and 300 km wide.

Other Causes of Extinction

It is estimated that nearly 500 million different species have inhabited the planet. Of these, more than 90% have either become extinct or have evolved into new species. The mass extinctions, probably caused by single catastrophes, are not the only reasons for these losses.

Climate changes and the pressure of competition from other species force organisms to adapt or die. If a new species enters an area, species that eat the same food must compete with it. A species that is better at finding food, reproducing, or defending its territory could force competing species into extinction. If one species disappears, even if only from part of its range, it can affect other species that rely on it for food.

Over the long term, hundreds of millions of years, all species eventually encounter conditions to which they cannot adapt, and they become extinct.

In modern times, however, human activities are the major causes of extinction.

The Banff longnose dace (**Figure 5**), a small minnow, was recently declared extinct. It was unable to compete with the guppies, swordtails, and other tropical fish released accidentally into warm marsh waters below the hot springs in Banff National Park.

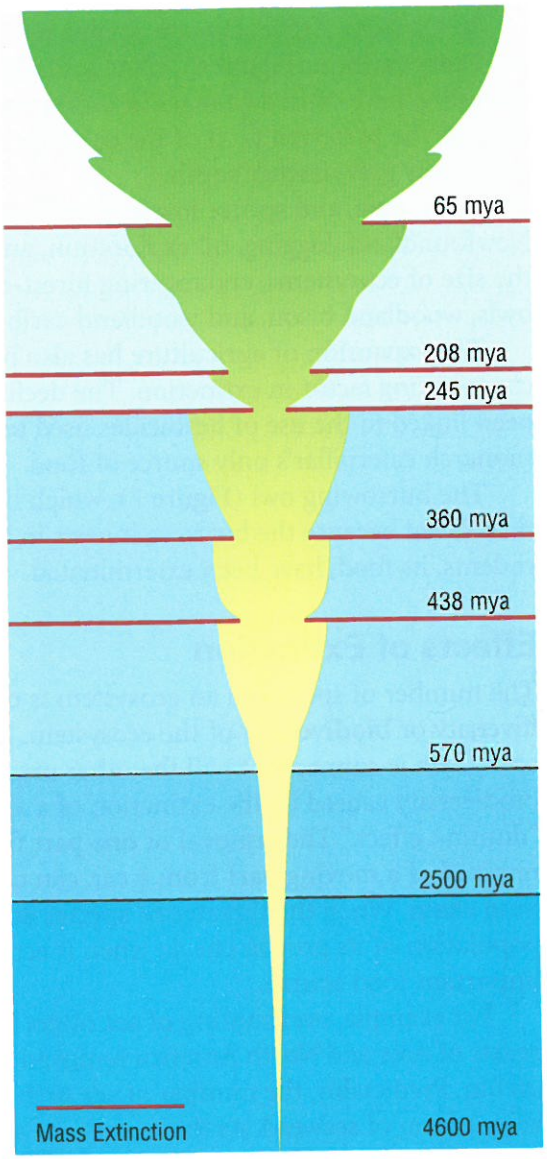


Figure 3
Fossil evidence shows that many species suddenly disappeared in several episodes over the last 500 million years.

Figure 4
This large circular lake in Manicouagan, Quebec, is actually a crater formed when an object from space collided with Earth.

Figure 5
The Banff longnose dace lost a competition with exotic fish.

In Canada's Arctic, climate change has been blamed for the demise of the Peary caribou (**Figure 6**). Changes in snow cover, caused by global warming, have caused changes in local plant communities. Lichens and mosses, the preferred food of the caribou, are being replaced by plants that previously grew farther south.

In fir, pine, and spruce forests from British Columbia to Newfoundland, logging, oil exploration, and expanding cities have reduced the size of ecosystems, endangering forest-dwelling species such as spotted owls, woodland bison, and woodland caribou.

The expansion of agriculture has also been identified as a major contributing factor in extinction. The decline of the monarch butterfly has been linked to the use of herbicides used to control milkweed, the monarch caterpillar's only source of food.

The burrowing owl (**Figure 7**), which lives on the prairies, is threatened because the burrows it nests in have been plowed under and rodents, its food, have been exterminated.

Figure 6
The Peary caribou was a victim of climate change.

Figure 7
The burrowing owl is at risk of extinction due to pressures created by agricultural practices.

Effects of Extinction

The number of species in an ecosystem is described as the biological diversity or **biodiversity** of the ecosystem. Because every organism in an ecosystem is connected to all the other organisms, the reduction in biodiversity caused by the extinction of a single species can cause a "domino effect." The removal of one part from an ecosystem, like the removal of a moving part from a car, can cause the collapse of an entire food chain. When the threatened species acts as a predator, it keeps the population of its prey in check; when it acts as prey, it provides an important food source.

For example, overhunting of sea otters (**Figure 8**) along the Pacific coasts of Asia and North America removed the main predator of the sea urchin. Predictably, the number of sea urchins grew rapidly. Sea urchins eat kelp, a form of seaweed. As the number of sea urchins grew, the amount of kelp declined, and so did the fish that relied on the kelp bed ecosystem for habitat and food.

Sea otters very nearly became extinct due to hunting pressure. From the point of view of humans, killing sea otters for their fur resulted in the decline of a valuable fishery. Where the sea otter has been reintroduced, sea urchin populations have fallen, kelp beds are being re-established, and the number of fish is increasing.

Figure 8
A sea otter eats a sea urchin. The removal of the sea otter caused a major change in the ocean ecosystems of the Pacific coast.

Restoring the Balance

The reintroduction of the sea otter to the Pacific northwest is an example of an attempt to restore a natural balance. It is not always easy to do.

The whooping crane (**Figure 9**) may be a success story — or it may not. In spring, whooping cranes fly north to live in the marshes and swamps of the prairies and the Canadian north, where they eat crayfish, fish, small mammals, insects, roots, and berries. Efforts by Canadian and U.S. conservationists over the past three decades have helped increase the population from a low of 14 individuals in 1940 to 183 in 1999. Chemical pesticides were the original human threat to the crane, but it was already

Figure 9
The efforts of wildlife biologists are preventing the whooping crane from becoming extinct. Some young birds are being hand-raised but, to prevent the chicks from associating humans with safety, the caregivers disguise themselves as adult cranes!

struggling. Cranes must fly a long way between their summer homes in the north and their winter homes on the Gulf of Mexico. Along the way they are vulnerable to hunting and accidents. In addition, the whooping crane reproduces very slowly. Each year females produce two eggs; however, only one will mature. The first fledgling to emerge from its egg kills its brother or sister. This ensures there will be enough food for the survivor, but it also means that once the number of whooping cranes is small, it is very difficult for the species to increase its numbers.

We do not fully understand all the relationships between species in many ecosystems, so we cannot predict reliably what will happen to an ecosystem if its biodiversity is reduced, even by one species. Allowing or forcing just one species to become extinct could possibly be disastrous, and we would not know the extent of the disaster until later.

Challenge

1 Why would a golf course have less biodiversity than a natural ecosystem? How might the lower biodiversity affect surrounding ecosystems?

Understanding Concepts

1. **(a)** Explain why the passenger pigeon became extinct.
   (b) Speculate about which animals might benefit if the passenger pigeon had not become extinct.
   (c) Compare the extinction of the passenger pigeon to the near extinction of the sea otter.
2. Explain how each of the following factors could lead to the extinction of a species. With each explanation include an example of a threatened species.
   (a) Poor reproductive success
   (b) Competition from a species newly introduced into an ecosystem
   (c) Change in climate
   (d) Hunting by humans
3. **(a)** In your own words define the term "biodiversity."
   (b) Explain why diversity is important for ecosystems.
   (c) Give two examples of ecosystems that have high biodiversity, and two that have low biodiversity. Explain your classification.

Making Connections

4. The common cockroach is not at risk of extinction. In fact, it is one of the species that have benefited from human activities.
   (a) Hypothesize about which human activities benefit the cockroach.
   (b) If a chemical company invented a spray that could kill all cockroaches, would it be acceptable to use the spray to make the cockroach extinct? Explain your position in a letter to the chemical company.

Exploring

5. (I) The passenger pigeon is not the only bird that has become extinct due to human hunting. Research and prepare a report on the great auk or the dodo.

Work the Web

Canadian wildlife biologists have been attempting to preserve the whooping crane. Are they succeeding? In a short essay, evaluate the success of their program. To research the whooping crane program, visit www.science.nelson.com and follow the links from Science 10, 1.3.

1.4 Explore an Issue

DECISION-MAKING SKILLS

● Define the Issue	● Analyze the Issue
○ Identify Alternatives	○ Defend a Decision
● Research	○ Evaluate

What Is the Value of Wolves?

Once an ecosystem has been damaged by extirpation, should it be "fixed" by restoring the species that was removed? Do we "own" wildlife? The case of the wolves of Yellowstone National Park (**Figure 1**) can help us think about this issue.

Few animals stir as many emotions as the wolf. Some Native North American peoples saw the wolf as a traveller, a guide, and a teacher capable of appearing and disappearing at will. Admiration for the tireless predators, who work together to bring down much larger and more powerful prey, is easy to understand. People saw many similarities to humans in the way wolves cooperate.

The image of the wolf held by early settlers from Europe was also influenced by folklore. The wolf of European stories chased three little pigs, disguised itself in the fleece of a lamb, and ate the grandmother of Little Red Riding Hood. Unlike the Native Peoples of the Plains, Europeans held an image of the wolf as a sharp-toothed villain, that preyed on livestock and people.

Figure 1
In 1996 wolf packs were relocated from Alberta to Yellowstone National Park in an attempt to restore an ecological balance.

The Decline of the Wolf

When European settlers reached central North America, and found plains covered in bison, they were not willing to compete with the wolf for valuable hides. Thousands of wolves died after they ate poisoned bison carcasses that had been laid out as bait.

After the bison hunters left, having killed most of the bison, there was a break of a few years before the killing of wolves was revived again by ranchers in the 1880s and 1890s. Wolves killed cattle, and it was also widely believed that they killed people, despite the lack of evidence to support that belief. In both the United States and Canada, anyone bringing a wolf skin to a local government office would be paid. In 1910 the bounty for each adult wolf was $400 — a large amount at the time. In Montana alone, more than 80 000 wolves were destroyed between 1883 and 1918. The bounty is no longer in place in Midwestern states, and the wolf is considered an endangered animal, protected from hunting.

However, the effects of the removal of the wolves were dramatic. The disappearance of the wolf was followed by a dramatic increase in the population of the next dominant predator, the coyote. The coyote, a close relative of the wolf, is smaller and rarely forms packs. Bison and elk are much too large for single coyotes to hunt. The coyote eats mostly small mammals, such as mice, voles, and ground squirrels, and the eggs and fledglings of ground-nesting birds. It competes with foxes, badgers, and martens, who eat similar things. As the number of coyotes grew, the numbers of these smaller predators declined.

Wolves frequently left remains from their kills. These leftovers were taken by scavengers such as magpies, ravens, and vultures. Without the wolf, these species began to decline. Even grizzly bears, who frequently scavenge wolf kills, were deprived of an easy source of food.

Work the Web

Explore the controversy over wolves in Yellowstone National Park by visiting www.science.nelson.com and following the links from Science 10, 1.4.

Meanwhile, large herbivores such as the elk were safe. No predator, except for an occasional bear, could kill them, and they began to multiply. The population of elk in the highlands grew so large that they stripped the hills of plants. Diseases spread rapidly within their large herds.

The Return of the Wolf

The wildlife managers of Yellowstone saw all these signs and recognized that something was seriously wrong. In 1987 they put together a plan: they were going to import wolves from Canada.

Despite continuing resistance from local ranchers, who feared for their sheep and cattle, 35 wolves were transplanted from Alberta in 1996. More have since been added. Signs of change are already evident. Where wolves have been introduced, elk have moved from open fields (where they are more vulnerable), and now stick to tree-covered areas. Vegetation is recovering, and the number of small predators, such as the kit fox, is increasing. As ranchers feared, some of the new wolves have killed livestock. Five cows and 53 sheep were killed by wolves in Idaho in the spring of 1997. Ranchers are compensated for losses to wolves, but they are not happy about the reintroduction of wolves, which add to their problems.

Understanding the Issue

1. Classify the at-risk status of the wolf in and around Yellowstone National Park
   - **(a)** before European settlers arrived.
   - **(b)** during the bison hunt.
   - **(c)** after ranchers arrived.
   - **(d)** in 1996.
2. First Nations hunters lived on bison long before European hunters arrived. When they killed a bison, they would use the entire animal for food, clothing, and medicines. Many European hunters killed only for the animal's skin. How might the views of First Nations people about hunting the wolf lead them to treat wolves differently than European settlers and hunters?
3. (Y) Make a concept map showing how the removal of the wolf caused problems in the local ecosystem.

Take a Stand — Perspectives on the Value of Wolves

Below are three views on what should have been done about wolves in Yellowstone Park.

The Frontier View: To feed ourselves and the hungry of the world, we must open up, clear, and claim wilderness areas for ranching and other forms of agriculture. Wolves endanger that effort. They kill cattle and sheep. They must be removed wherever they interfere with farming and ranching, and they should not be reintroduced once they have been extirpated.

The Stewardship View: Humans are the most intelligent animals on the planet. It is our duty to take care of other species and preserve our world. Once we recognize that we have damaged an ecosystem, we must try to repair the damage using whatever resources are available to us. Wolves must be preserved in all ecosystems where they are now found, and reintroduced to ecosystems where they once lived.

The Ownership View: Canadians do not own wild animals or plants just because they live in Canada. We have no right to move them around whenever we feel like it. It may have been a mistake to kill the wolves of Yellowstone, but we have no right to take Alberta wolves and move them to a place they've never been before. It is better to let the ecosystem in the park find a new balance. Perhaps one day wolves will find their own way to the park.

Taking a Position

1. (F) Should we have captured wolves in Alberta and shipped them to Yellowstone National Park? After a group discussion, decide which views you support, or develop an alternative view.
2. (J) Using libraries, the Web, and CD-ROMs, research to find information that will support your position and write a report on the results of your research.

1.5

Ecology

Have you ever been stung by a wasp? The unpleasant experience is not soon to be forgotten! Organisms that cause problems for humans, like wasps, are often categorized as **pests** (**Figure 1**). Why don't scientists work to eliminate pests rather than just control their numbers?

Imagine a world without biting flies, mosquitoes, termites, caterpillars, or weeds. At first thought that world might seem very appealing, but consider how other organisms might be affected. For example, some fish and amphibians rely on mosquito larvae for food. The elimination of mosquitoes would have a devastating effect on lakes. In addition, adult mosquitoes are an important food source for swallows, robins, and other small birds.

Some other insect "pests" are needed by plants. Most plants rely on insects for pollination. Plants also benefit from insects like the wasp that help decompose tissues of dead plants and animals, returning nutrients to the soil. Many of the insects we call pests also dig around plants, loosening the soil and allowing more oxygen to get to plant roots.

Even garden weeds like crab grass serve an important purpose. Outside the garden these rapidly growing plants are an important source of food for many animals. Eliminate wild grasses and cattle, sheep, and other grazing mammals would soon become extinct. The long and fibrous roots of these hardy, fast-growing plants also pump nutrients back to the soil's surface, where they can be used by more delicate domestic plants. The greatest benefit of these plants might be their ability to grow along cliffs and in other precarious locations. Here they anchor the soil, preventing erosion.

Figure 1
Humans categorize mosquitoes as pests, but some birds and other insects would categorize them as food.

Organisms Interact Within Ecosystems

To better understand living things, scientists must put aside the idea of the pest, and examine organisms within their natural setting. Ernst Haeckel, a German biologist, first coined the word **ecology** in 1866 to describe the study of how organisms interact with each other. Ecology combines the Greek words *oikos*, meaning "the place where one lives," with *logos*, meaning "study of."

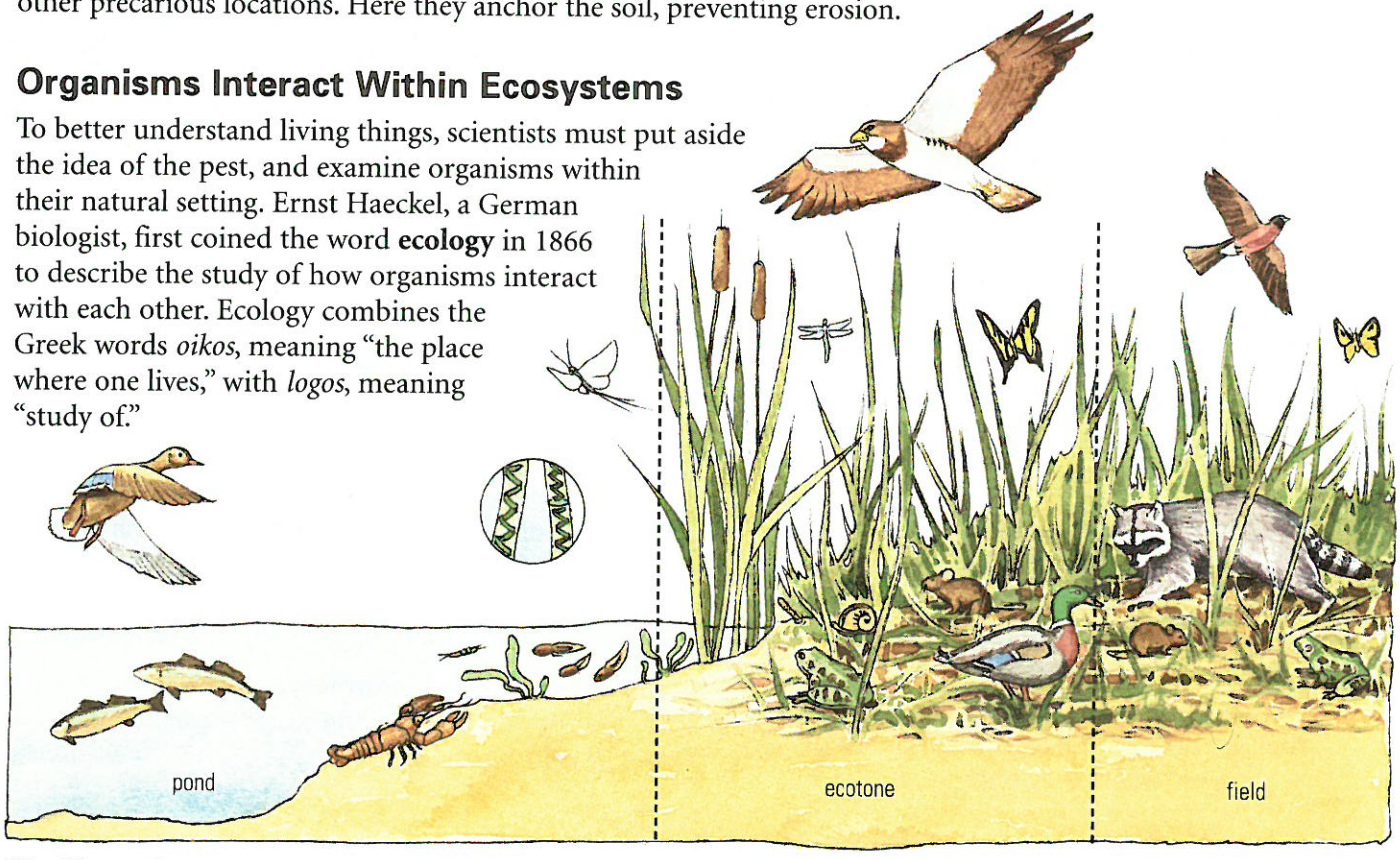


Figure 2
In the ecotone between the pond and the field, species from both ecosystems meet.