3.1 Investigating the Distribution of Living Things in an Environment

Think about your schoolyard or a local park for a moment. Changes continue to happen in both these areas. They may not be as dramatic as the extinction of the dinosaurs or dealing with the after-effects of a flood or drought, but they are still changes. Have you noticed any changes in your schoolyard or local park? How do you know that changes have occurred?

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Help with Counting

One way that scientists estimate the distribution of living things in an area is by a technique called sampling. Sampling is used when it is too difficult to count each living thing.

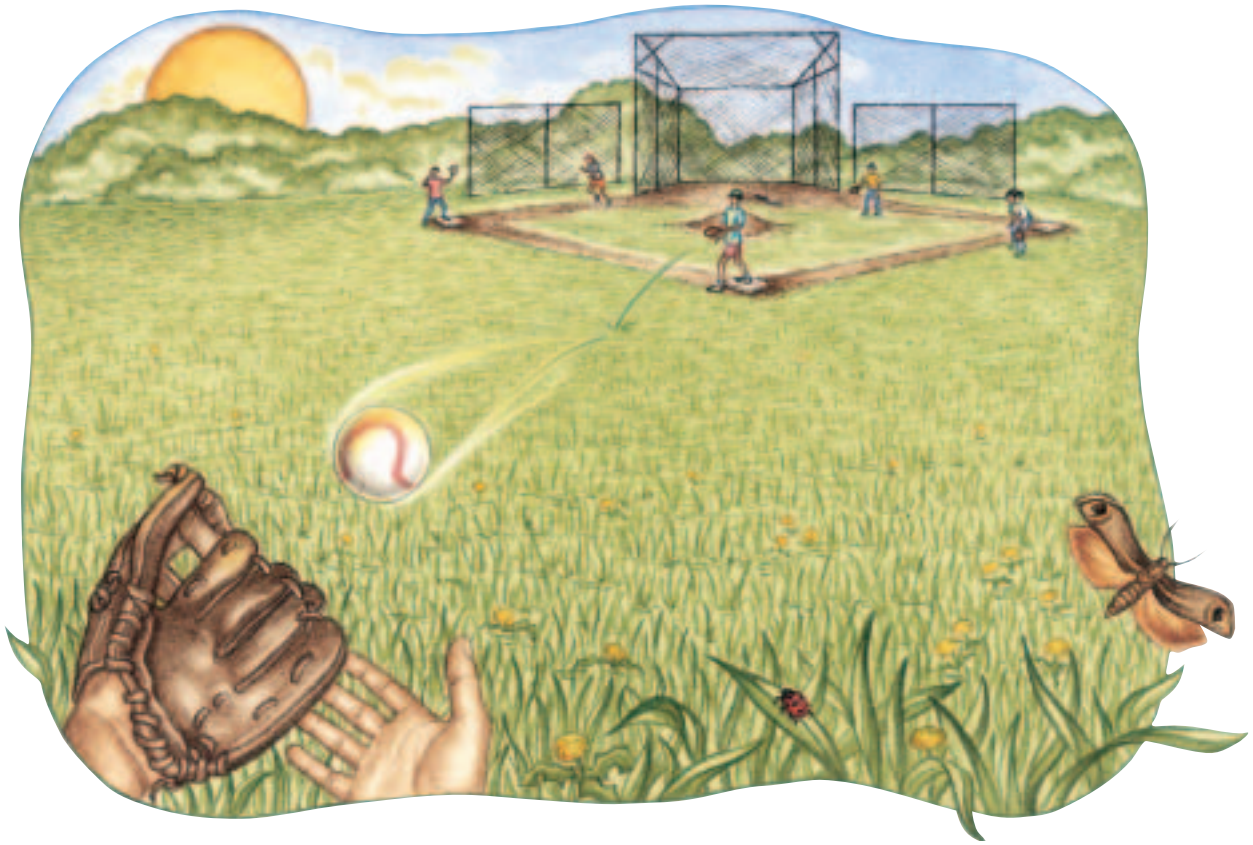

Figure 3.1 The distribution of living things in a park

Distribution of Living Things

If you look closely at your schoolyard or a local park, you are likely to see differences even within this small area. Perhaps there are more dandelions, grass, or daisies in one section, or perhaps there are more ants in another section. The distribution of living things may be different from one area to another. Think about why this is true.

Inquiry Activity

Human Impact in the Schoolyard

The Question

Has human impact affected the distribution of living things in the schoolyard ecosystem?

Materials & Equipment

- 8 metal or plastic tent pegs
- 2 pieces of string, each about 4 m long
- tape measure or metre-stick
- thermometer
- anemometer
- classification key for local plants and animals

Caution!
Do not remove the organisms or disturb the environment. Leave it as you found it.

The Hypothesis

Restate the above question in the form of a hypothesis. (See Toolbox 2 if you need help with this.)

Procedure

1. Go into the schoolyard. Look for two places: one that appears to be affected by human impact, and one that appears not to have been affected by human impact. Areas that appear to be affected by human impact might include an area on the soccer or baseball field, or in the playground. Make sure the places you choose are the same size and have similar abiotic conditions of light intensity and soil type.
2. Use the metre-stick to measure an area of 1 m by 1 m in a place of little or no human impact. Tie a length of string around the pegs to outline the square.
3. Draw a sketch of all the living (biotic) and non-living (abiotic) things inside the square. Count all of the individual plants that are growing inside the square. Count the animals that you see as well. Plants that are right under the string only count if more than half of the plant is inside the square. Do any of the abiotic or biotic factors cover a large area of your square? Estimate and record the percentage of your square covered by the factor(s).
4. Use your classification key to identify anything you do not recognize.
5. Repeat the procedure in another place with similar abiotic factors, but one where it appears that there has been human impact.

math Link

This staked-out area is known as a **quadrat**. Quadrats can be square, rectangular, or circular in shape. Studying the area in a quadrat is called quadrat analysis.

Collecting Data

6 Use the following table to record the data that you have gathered during your investigation.

Schoolyard Observations		
	Place with Little or No Human Impact	**Place with Human Impact**
date and time		
temperature		
wind speed		
light intensity (bright, shady)		
soil condition (dry, wet)		
number and type of plants observed		
number and type of animals observed		

Analyzing and Interpreting

7 Why did you try to choose two places that had the same abiotic factors, except human impact?

8 What type of graph would best display the biotic factors found in each place? Use it to graph each place.

9 What differences did you see in the biotic factors present in each place that you identified?

10 Did human use impact the biotic factors in this investigation? Why or why not?

Forming Conclusions

11 Think about the places that are most frequently used in the schoolyard. Does your data prove that human use has affected the number and distribution of living things in your schoolyard? Why or why not? What information would you gather to determine how much each place is impacted by humans?

Applying and Connecting

Ecologists use quadrat analysis to gather data about the location of plants and animals and their living conditions. Quadrat analysis can also be used to advise how a given area can be maintained or improved.

Extending

The ideal size of a quadrat is the smallest size that contains the same number of species as would be contained in a larger one. Determine the area of your schoolyard. Estimate the percentage of dandelions in your schoolyard by using quadrat analysis. How accurate do you think this number is? Explain your answer.

Check and Reflect

1. Describe two different things humans could do to have an impact on living things in your schoolyard.
2. Why is it important to investigate the distribution of living things in your schoolyard?
3. In many national and provincial parks, there are both wetland and dry-land areas for living things. Why do you think it is important to have both areas?
4. Figure 3.2 shows wetland and dry-land areas in a park. Create a chart with the headings "wetland" and "dry land" to list all the living things you see in each place. Why do you think park naturalists might want to know the distribution of each of these living things in the park?

*re*SEARCH

One, Two, Three ...
Research how scientists determine the populations of migrating birds.

Figure 3.2 Question 4

3.2 Interactions and Changes Occur in Ecosystems

In any ecosystem, living things need to interact with non-living things. As you have learned in previous sections, if there is an imbalance within an ecosystem, problems may occur. In some ecosystems, human activity has caused an imbalance.

An example of this is wetland ecosystems. At one time, wetlands were not considered to be important. In many countries, wetlands were drained to be replaced by farmland and housing. Others were destroyed by pollution. By destroying the wetlands, humans destroyed many plants and animals that lived in that ecosystem. Now, wetland ecosystems are recognized for their importance. Many steps have been taken to protect and preserve wetlands.

Give it a **TRY** ACTIVITY

To Change or Not to Change

Forest ecosystems have also undergone changes. Look at Figure 3.3. A forest once stood here. That was before the thunderstorm. Lightning pierced the sky, striking and igniting one of the taller trees. The fire jumped from treetop to treetop until the entire forest was burning. The photo shows all that's left.

Figure 3.3 A forest after a fire caused by lightning

Imagine what the forest scene in the photo looked like before the fire. Make a sketch to show what you're imagining. What kinds of living things populated this scene? What abiotic and biotic factors of the forest ecosystem supported them? Where are the living things now? Don't forget about human involvement in the area.

How do you think this scene will look a few years from now? Will it be any different? What could make it different? Use a sketch to record your impressions. Add labels to clarify your ideas. How will this scene look 20 years from now? 50 years from now? 100 years or more from now?

Do you think it ever burned before? Does the fire do any good?

Share your ideas with a group. Do they have the same ideas as you? Add one new idea to your sketch.

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Disappearing Dragonflies

Dragonflies, which live in wetlands, are an early warning sign for pollution. If the dragonflies at a pond disappear, then other pond plants and animals will soon follow if the pond isn't cleaned up.

All Things Change

Everything changes. You may not notice it, but you are not exactly the same as you were one day ago. Tomorrow, you will be different again. Change is always happening, everywhere inside you and around you. All things change, including ecosystems. Some of the ways that changes can occur are through **bioinvasion**, **competition**, **predation**, and weather.

Bioinvasion

Many of the plants and animals that you may think are common to Canada actually have come from somewhere else. European settlers introduced plants and animals from their home countries. Some well-meaning naturalists introduced other species, while still others were accidentally introduced.

Scientists call this species introduction bioinvasion. Because many of these new species were stronger than the native species or had no natural enemies, they quickly multiplied. Their effects on ecosystems and on other living things have been dramatic.

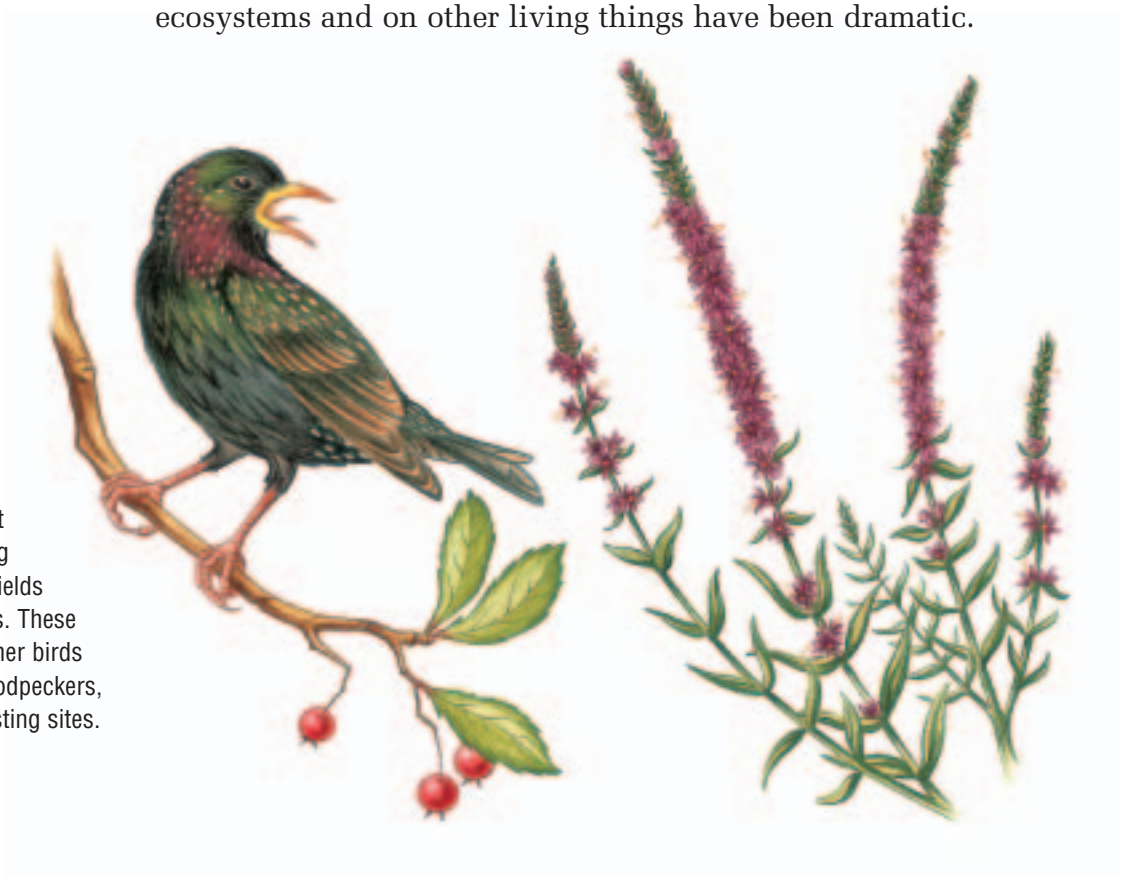

Figure 3.4a) In 1890, a hundred European starlings were released into New York's Central Park. Starlings have been very successful, and now number over 200 million throughout North America, causing problems in farmers' fields and hazards at airports. These birds compete with other birds such as bluebirds, woodpeckers, and flycatchers for nesting sites.

Figure 3.4b) The first wild plants of purple loosestrife in North America probably escaped from people's gardens. They originally came from Europe. The plant has spread so fast that it has pushed native species out of the way. This is especially true in wetland and marshy areas. Birds have a harder time making nests among purple loosestrife than among native species.

Figure 3.4c) Zebra mussels were first noticed in the Great Lakes in 1988. They probably travelled over here on a ship from Europe. By 1994, there were as many as 50 000 mussels/m^2 in some rivers near the Great Lakes.

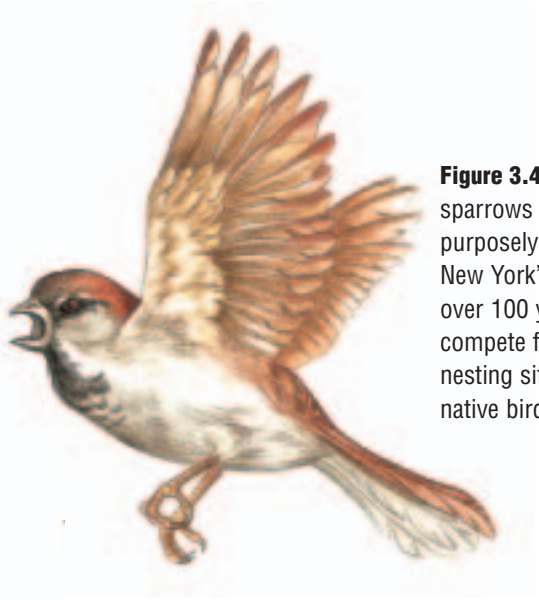

Figure 3.4d) House sparrows were also purposely released in New York's Central Park over 100 years ago. They compete for food and nesting sites with many native birds.

Figure 3.4e) More than one-quarter of Canada's plant species are not native.

Competition

Changes also occur in the population of species in ecosystems due to their interaction with other biotic and abiotic factors. One of these interactions is competition.

You probably have been involved in some type of competition. Whether it is running a race or designing a school logo, for humans, a competition involves more than one person trying to reach the same goal. All living things compete with all other living things in their community, but they compete for resources like food, water, and space to live. Because there is only so much of each resource, all living things are always trying to get enough of these resources to meet their needs.

Inquiry Activity

Survival in the Field

The Question

How does competition between two species affect their numbers and health?

Materials & Equipment

(for a group of 10 students)

- 4 plastic spoons
- 4 forks with centre tines removed
- 100 g sesame seeds
- 10 small Styrofoam balls
- 10 10-cm pieces of string
- 10 toothpicks
- a timing device

Figure 3.5 Lions chasing vultures off the lions' kill

The Hypothesis

Restate the above question in the form of a hypothesis. (See Toolbox 2 if you need help with this.)

Procedure

1. You are about to be part of a simulation of species competing for the same resource: food. There are two species, the forks and the spoons. In your group, assign four people to be spoons, four to be forks, and one person to be the recorder for each species.
2. The recorders randomly spread out the materials in an area 10 m by 10 m. This is the community.
3. The task for the members of the two species is to collect one food item from the community within 20 s. Members who cannot collect a food item and return to the recorder in this time period are considered to have died from starvation. Only members who collect one food item can go on to the next round. A food item is one pile of sesame seeds, one ball, one string, or one toothpick.
4. Begin Round 1 by having all the forks and spoons line up on one edge of the community. When your teacher tells you to start, go into the community and collect one food item. When you get your food item, come back to your recorder to have your item recorded. Any fork or spoon who is unable to collect food or who has collected too much cannot continue into the next round.
5. Repeat step 4 until no forks or spoons are left. Make sure each food item you collected is recorded at the end of each round.

Collecting Data

6 To record what each fork and spoon collected in each round, draw the following table on a clean sheet of paper.

Species	Round 1	Round 2	Round 3	Round 4	Round 5
Fork 1					
Fork 2					
Fork 3					
Fork 4					
Spoon 1					
Spoon 2					
Spoon 3					
Spoon 4					

Analyzing and Interpreting

7 Create a line graph that shows how many spoons and how many forks competed against each other in each round.

8 Using the graph, can you describe a trend that shows which species was more successful in the competition for food? What information can you use to support your conclusion?

9 Create a bar graph for forks and spoons that shows what type and how much food each species collected in each round.

10 Was there a preferred food at any time for each of the species?

11 Was there a food that you thought limited the survival of a species? Was there a food that only one species could use to survive?

Forming Conclusions

12 Use the data you collected from this activity. Describe how you think competition for food might affect the number and health of the forks and spoons in this activity.

Applying and Connecting

Look at the photo on the previous page of lions and vultures competing for resources. Work with a partner. Find examples of species in your community that compete for resources.

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Non-native Species

Research three common plants and animals that are not native to Canada. Choose ones not mentioned in this subsection.

Why are some of these alien species so successful in North America? Why are some a threat to our ecosystems?

Predation

Competition for resources is not the only factor that can affect a species' survival. Predation occurs when an animal hunts other animals for food. Organisms that are being hunted are the **prey**. An example of this is the lynx hunting snowshoe hares. The interactions of predators and their prey can affect an ecosystem. If there are too many predators, the prey population will decrease. This may increase competition for food among predator populations, so that one or more will either die out or move to a new location. If there are too few predators, then the prey population may increase. This would increase the competition for food among prey species, so that one or more will either die out or move to a new location.

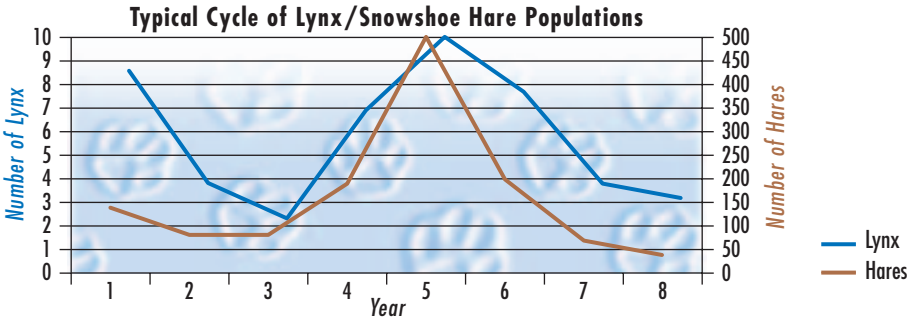

Figure 3.6 Typical cycle of Lynx/snowshoe hare populations over an eight-year period

Weather

Weather can also affect ecosystems. Many days of the right temperature and amount of rain can help plants grow. If the weather conditions are poor, the growth of plant populations may slow or stop. Natural disasters can also change ecosystems. Bad storms can damage plants. Floods can kill some plants and animals. Lightning can cause fires that destroy plants and kill animals.

Check and Reflect

1. How may the introduction of a non-native plant or animal species affect an ecosystem?
2. How do you think the following factors can affect populations and communities in ecosystems?
   a) the introduction of a new species
   b) the availability of food
3. Why do the populations shown in Figure 3.6 peak and crash at different times?

Experiment ON YOUR OWN

Competition between Three or More Species

Before You Start ...

There may be hundreds or even thousands of populations in an ecosystem. In the experiment below, you will work with just a few populations to observe what happens when several species compete in an ecosystem.

The Question

How does competition affect the number of plant populations in an ecosystem?

Design and Conduct Your Experiment

TOOLBOX

You may wish to use Toolbox 2: The Inquiry Process of Science to help you plan your experiment.

1. Make a hypothesis to test how the populations of three or more species of plants will be affected when they compete with each other in a small area. (A hypothesis is a possible answer to a question or a possible explanation of a situation.)
2. Decide what materials you'll need to test your hypothesis. For example, you might consider the following questions:
   a) How many populations will you experiment with?
   b) Will you grow the plants from seeds or work with seedlings?
   c) How many containers will you need?
   d) How much soil will you need?
3. Plan your procedure. Ask yourself questions such as
   a) What evidence am I looking for to support my hypothesis?
   b) What steps will I follow to collect the data I need?
   c) Is the test I'm designing fair? How do I know?
   d) How will I record my results? For example, will I need a data chart? a graph? both? neither?
   e) How long will I run my experiment?
   f) How long do I have to complete my experiment?
4. Write up your procedure. Be sure to show it to your teacher before going any further.
5. Carry out your experiment.
6. Compare your results with your hypothesis. Did your results support it? If not, what possible reasons might there be?
7. Share and compare your experimental plan and findings with your classmates. Did anyone plan an experiment exactly like yours? similar to yours? completely different from yours? How do your results compare with theirs?

Figure 3.7

3.3 Succession: How Ecosystems Change over Time

*info*BIT

Taking Over

The pioneers of succession on bare rock are lichen. Lichen are actually two organisms (an alga and a fungus) living together in mutualism.

Have you ever noticed how bare patches on the ground don't often stay that way? Sooner or later, you will see new plants growing where there used to be just soil. Scientists call the first species that arrive **pioneer species**. Even though the abiotic conditions may be harsh, these pioneers find a way to live there. They also "pave the way" for populations of other species to enter the community and establish themselves. As time goes on, many of the pioneer species may get replaced by the new arrivals. These, in turn, may be replaced by other, newer arrivals.

This process of change can take a long time. It may take decades, centuries, even thousands of years. Scientists have been observing enough of these changes to notice a pattern. They can usually tell which species came first and which came later just by looking at an ecosystem.

This predictable pattern of change in ecosystems is called **succession**.

Give it a **TRY** ACTIVITY

Can You Identify the Pioneer Species?

Pioneer species are the first to arrive in an area. Look at Figures 3.8a)–c). Try to decide which one(s) are pioneer species. Explain your reasoning.

Figure 3.8a)

Figure 3.8b)

Figure 3.8c)

What Is Succession?

There are two types of succession to consider when observing communities.

Primary succession occurs in areas where no life exists due to an absence of soil. Common areas of primary succession include volcanic islands, lava flows, and rock left behind by retreating glaciers. In succession on rock or lava, usually one of the pioneer species to arrive is lichen. Each change that occurs helps prepare the way for another set of changes. Lichens are suited to grow in barren, rocky areas. Over time, they help to break down the rocks into soil. As the soil becomes more fertile, mosses, fungi, grasses, and herbs begin to appear. Grassy areas are replaced by trees with shallow roots. As more soil builds up, larger trees become established. Succession on sand dunes usually begins with grasses, followed by shrubs, and then trees.

In the process of succession, communities will grow and replace one another until a **climax community** forms. A climax community is a stable community of a diverse number of species that is not easily replaced by other communities. Unless disturbed by natural or human forces, a climax community can exist for many years. Even though a climax community may be fairly stable for a long time, change is a continuous process, and very little will stay exactly the same.

Secondary succession occurs when a community has been destroyed or disturbed by natural occurrences or human activities. Secondary succession is different from primary succession, because in secondary succession, these habitats previously supported life. A farmer's field, a vacant lot in the city, a newly forested area, even a strip mine, are examples of where this type of succession occurs. When a corn field is left alone, weeds are the first to grow.

Work with a group. Think about areas in your local community that have any of these stages of succession. Create a poster of the area. Make sure your poster includes pictures as well as a written description of the area.

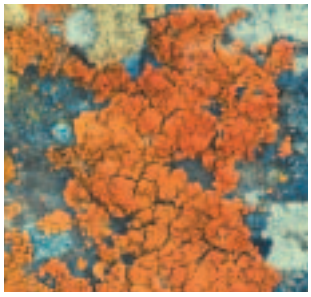

Figure 3.9a) Lichen

Figure 3.9b) Growing grass

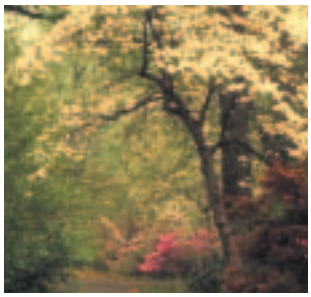

Figure 3.9c) Young forest

Figure 3.9d) Climax forest

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Surtsey

Surtsey, one of Earth's newest islands, is situated off the coast of Iceland. Research what pioneer species first inhabited Surtsey. What type of succession is present on Surtsey?

Check and Reflect

1. Which living things seem to be the pioneer species in all ecosystems? Suggest a reason to explain this.
2. Describe the key stages to the development of a climax community.
3. What is the difference between primary and secondary succession?
4. Give an example each of a pioneer species and a species of a climax community.
5. Over many years, the following plants and animals appeared in an area where a forest fire occurred. In what order do you think they appeared?
   - fireweed
   - birch tree
   - mouse
   - bear
   - grass
6. What examples of succession can you find in this scene of farmland that is no longer used for farming? Can you find a similar example in your community?

Year 1

Figure 3.10a)

Year 2

Figure 3.10b)

Year 10

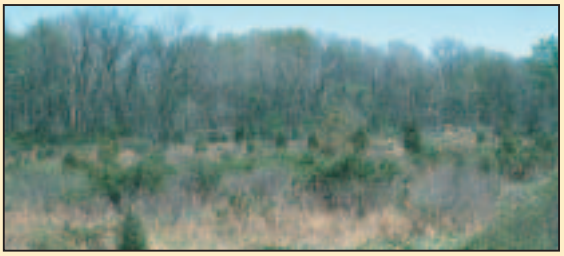
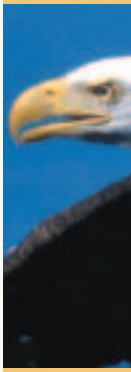


Figure 3.10c)

Year 20

Figure 3.10d)



Assess Your Learning

1. a) Whether they're started naturally or by people, forest fires change the ecosystem of a forest. Name at least three other natural changes that can affect ecosystems.
   b) Choose one of the above natural changes. Describe how it might affect an ecosystem.
2. Use words, pictures, or both to describe how primary succession takes place.
3. Describe how population fluctuations can change an ecosystem.
4. What interactions between living things can cause change in an ecosystem?
5. Give an example of an ecosystem where secondary succession can occur.
6. Imagine if all the bears (both grizzly and black) in Jasper National Park were removed from the park. Make a plan to investigate the changes that would take place in the ecosystem.

Focus On — Social and Environmental Context

In this section, you looked at changes that occur in ecosystems and the way that they can be assessed and monitored. Changes and interactions can have both intended and unintended consequences for humans and the environment. As you continue to gather information and ideas that will help you to design and develop your project, consider:

1. What types of changes and interactions need to be monitored?
2. What technology will need to be used to assist with the monitoring?
3. When should the monitoring be done?
4. How much importance should be given to impacts on the ecosystem compared with the needs of humans?

4.0

Maintaining sustainable environments requires knowledge, decisions, and actions.

Key Concepts

In this section, you will learn about the following key concepts:

- endangered species
- environmental monitoring
- environmental impacts
- extinction
- environmental management

Learning Outcomes

When you have completed this section, you will be able to:

- identify how some pollutants become concentrated in organisms
- identify intended and unintended consequences of human activities within ecosystems
- describe how information from scientific investigations can assist environmental decision-making
- describe examples of limitations of scientific and technological knowledge when making decisions about environments
- use evidence from many sources to help analyze a local environmental problem

Before a decision can be made, the situation must be studied, and the consequences of the actions must be analyzed. Some decisions may have the best intentions, as you saw in the case of Yoho National Park, with unfortunate results. In this section, you will look at the consequences of human activities within ecosystems, and how science investigations can help inform environmental decision-making. But science and technology are not always able to provide help with environmental issues, as you will learn. You will get the chance to analyze a local environmental problem and identify possible actions and consequences.

4.1 There Are Intended and Unintended Consequences of Human Activities within Ecosystems

The human population on Earth is very large, and continues to grow. This means we need more space to live, and more land to grow and raise living things for food. We need more energy sources such as coal and oil to fuel our technologies, and more raw materials such as wood, rocks, and minerals to build our homes, our industries, and our vehicles. Each human "need" has an impact on ecosystems and the living things that populate them—including ourselves.

*info*BIT

Rabbits Everywhere

In the summer of 1999, there was a population explosion of domestic rabbits living on the lawns of the Royal Victoria Hospital in Victoria, British Columbia. Hundreds of rabbits were seen every day feeding on the lawns. It is believed that these rabbits were released pets.

Figure 4.1 A human activity having a major impact on an ecosystem

Human Impact on Ecosystems: Chemical Use

Here's what can happen when humans interfere with an ecosystem they don't understand. In the early 1950s, malaria-carrying mosquitoes infected the Dyak people of Borneo. The World Health Organization was called to help. Their solution was to use a chemical pesticide called DDT to spray on the mosquitoes. As a result, the mosquitoes died off and the malaria diminished.

Unfortunately, there were problems. The DDT also killed a species of parasitic wasp. The wasps were helpful because they ate a species of caterpillar. This population of caterpillars ate the materials that the roofs of houses were made of. Now roofs were

falling on peoples' heads. The DDT also affected many species of small bugs that were eaten by geckos. The geckos began to suffer nerve damage and started moving more slowly. Cats, who normally ate rats, switched to the slow-moving geckos. The cats started dying from DDT poisoning. Not only had DDT worked its way up the food chain, but it had increased in concentration at each successive level of the food chain. When the cats died, the rats multiplied quickly. Fleas, piggybacking on the rats, carry a bacteria that causes typhus and sylvatic plague, which were much worse than the original malaria. The World Health Organization was called in again. This time their solution was to parachute live cats into Borneo. But this led to other problems. What do you think happened to the cats?

While DDT has now been banned in North America, there are other pesticides that threaten species. Migrating birds are very vulnerable because they visit so many localities. A recent example is the case of the Swainson's hawks. Many of these birds of prey summer in Saskatchewan and Alberta. They winter in Argentina and Brazil.

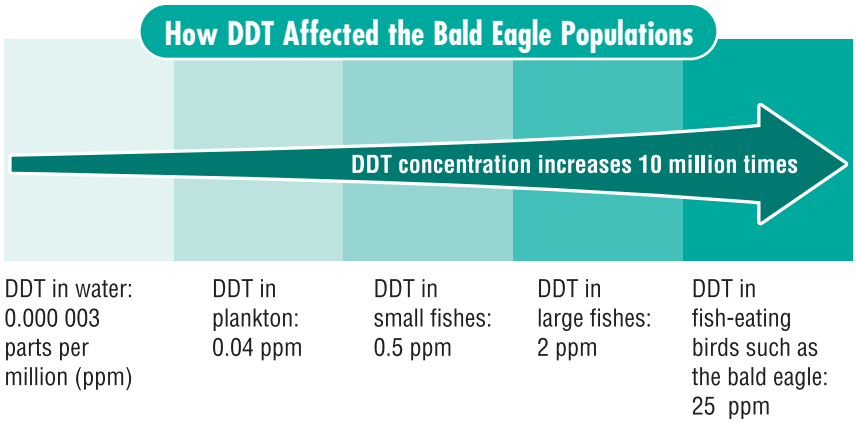


Figure 4.2 Look at how DDT became more concentrated as it moved up the food chain. By the time it reached the bald eagles, the DDT concentration was 10 million times the original concentration in water. DDT affected the eggshells of the bald eagles. Most eggs broke and therefore did not hatch. This resulted in a decline of the bald eagle populations.

Mysteriously, in just a few short years, between five and ten percent of the world's population of Swainson's hawks died. That translated into thousands of deaths to the 100 000 birds that summer in Canada. The reason is that Argentinian farmers used a pesticide to kill grasshoppers. What farmers didn't realize was that the hawks eat grasshoppers.

Now, thanks to environmentalists in North America and Argentina, and other concerned people, alternatives to using pesticides are being explored.

Human Impact on Ecosystems: Too Little Too Late?

Many species of plants and animals are in danger of being eliminated from the planet completely. Many others are already **extinct**. Extinction occurs when a species no longer exists anywhere on Earth. Extinction is a natural part of the planet's history. But in the past three hundred years or so, human activities such as hunting, bioinvasion, farming, building cities, and cutting down forests have greatly increased the rate of extinction. Human activities increase the rate of extinction because the environment is changed too quickly for organisms to adapt.

When their environment changes too quickly for them to adapt, organisms become rarer and rarer. Organisms that are so rare that they are in serious danger of becoming extinct, are considered **endangered**. **Threatened** species are species whose numbers are declining.

The chart outlines some of the 85 plants and animals in Canada that are extinct, endangered, or threatened.

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Grizzly Bears

Right now, there are about 20 000 grizzly bears in North America. Before the 1800s, there were more than 100 000. Research to find out what, if anything, is being done to protect the grizzly. Do you think it will be extinct in Canada someday?

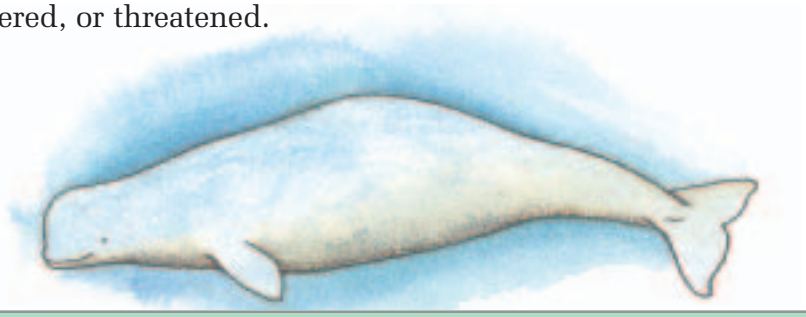

Figure 4.3a) Beluga whale

Extinct, Endangered, or Threatened Plants and Animals in Canada

Extinct	Endangered	Threatened
• Dawson's caribou • sea mink • great auk • Labrador duck • passenger pigeon	• eastern cougar • Oregon spotted frog • sea otter • beluga whale • whooping crane • eastern prickly pear cactus • Arcadian whitefish	• wood bison • pine martin • burrowing owl • eastern massasauga rattlesnake • ginseng

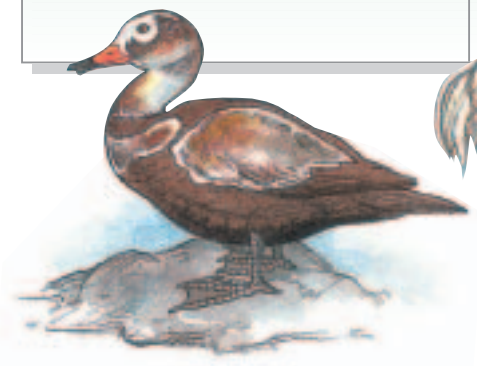

Figure 4.3b) Labrador duck

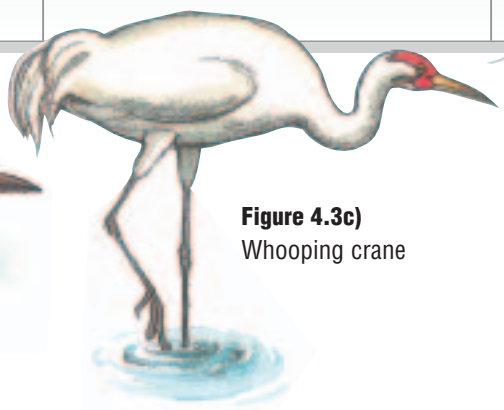

Figure 4.3c) Whooping crane

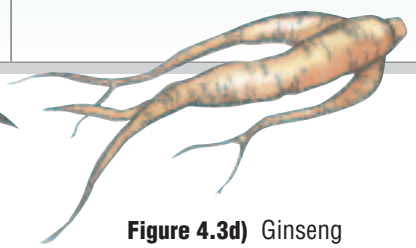

Figure 4.3d) Ginseng

Decision Making Activity

Crossing the Border

The Issue

If you take a trip outside Canada, when you return, you must fill out a Canadian customs form declaring what you are bringing back to Canada. There is a list of things that are not allowed to be brought into the country. Why do you think this is?

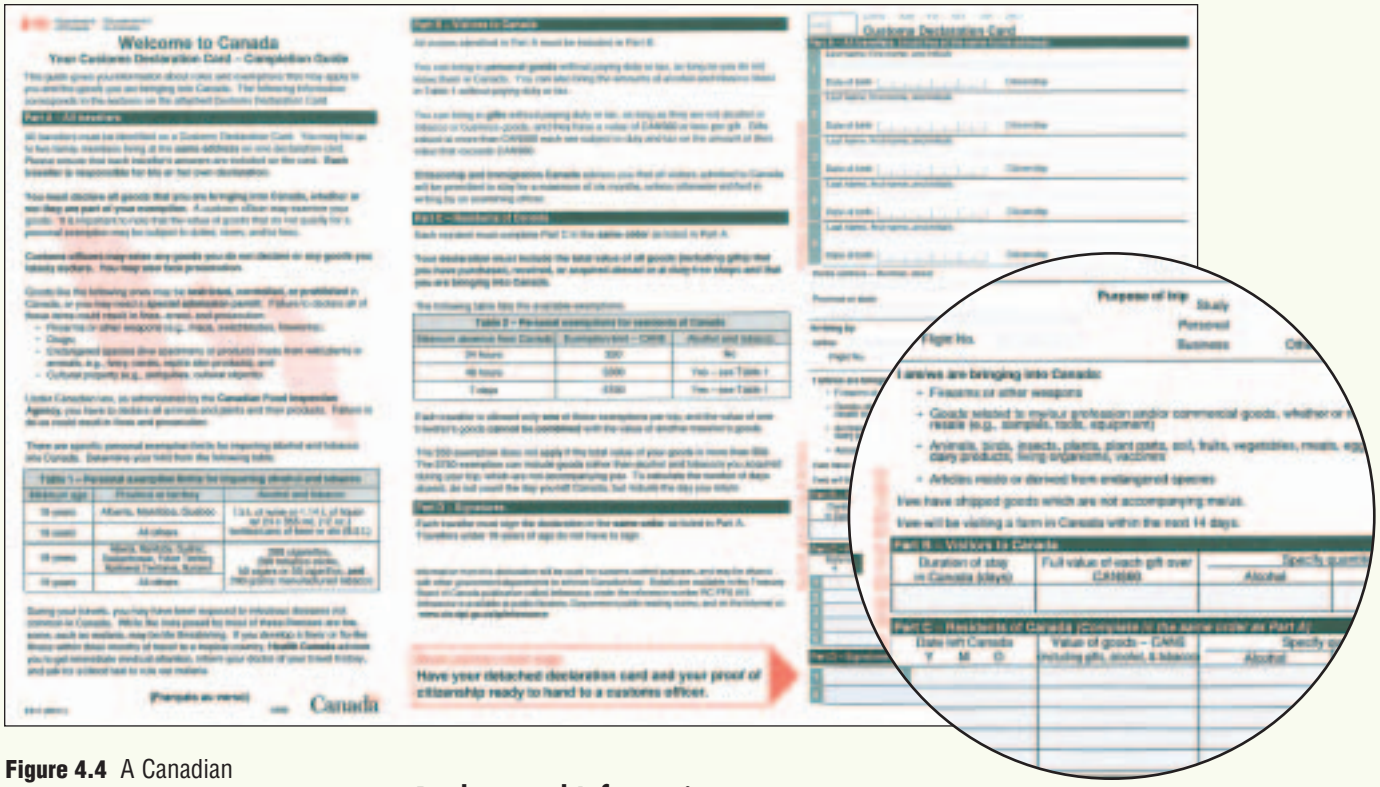

Figure 4.4 A Canadian customs form

Background Information

Look at the form shown here. Look at the list of things that must be declared. Often people try to sneak exotic animals into the country by hiding them on their person or in their luggage. According to Canada Customs, long trench coats lined with pockets are used to hide exotic birds such as parrots. In luggage, such things as poisonous snakes, baby alligators, and rare turtles have been found. One of the most dangerous animals found in luggage was the green Mambo snake from Guam. It is one of the most poisonous snakes in the world! Foods such as bacon and sausage, soft cheeses, flour, vegetables, and plants for the garden will be confiscated because they may carry disease. If these and other illegal items are brought into the country, how would they affect our ecosystems? Why do you think it matters if you are visiting a farm in Canada within 14 days of returning from your trip?

Support Your Opinion

Write a paragraph summarizing your viewpoint on this topic. Make sure you support your viewpoint with facts from the unit or other resources.