Section 2.2 Summary

Carbon cycles through the biotic and abiotic parts of an ecosystem. Carbon is found in carbon dioxide in the abiotic part of an ecosystem. In the biotic part of an ecosystem, carbon is in high-energy materials, such as sugar and starch.

Water cycles between the liquid, solid, and gaseous states. The water cycle has four main processes:

- Evaporation is the process in which liquid water changes into a gas.
- Transpiration is the process in which water evaporates from the leaves, stems, and flowers of plants.
- Condensation is the process in which water vapour changes into a liquid.
- Precipitation is the process in which tiny droplets of water inside clouds combine to form large drops that fall to Earth.

Pollution can also cycle through ecosystems. Pollutants are substances that cannot be broken down, stored, or recycled in the environment in a way that is not damaging. Bioaccumulation is the accumulation of pollutants in an organism after eating several polluted small organisms. The top consumers in food chains are affected most by bioaccumulation.

Key Terms

carbon cycle
water cycle
evaporation
transpiration
condensation
precipitation
ground water
run-off
pollution
pollutants
bioaccumulation

Check Your Understanding

1. In what forms do you find carbon in the carbon cycle?
2. Draw a diagram of the water cycle, showing the four main processes. Label and describe each process.
3. What are the similarities and differences between pollution and bioaccumulation?
4. **Apply** Pesticides are chemicals that are commonly used to control agricultural pests, such as insects. How might pesticides affect carnivores, which are higher up in food chains? Explain.
5. **Thinking Critically** What are the advantages of a human, or another omnivore, eating organisms that are lower rather than higher in the food chain?
6. **Thinking Critically** How do pollutants accumulate in food chains? Design a game that shows the process of bioaccumulation.

Section 2.3 Factors in Ecosystems that Limit Populations

Many species, such as rabbits, have an amazing capability to reproduce quickly. In any ecosystem, however, there are limits to the amount of food, water, living space, mates, nesting sites, and other resources that are available. Populations cannot continue growing larger forever. A population eventually reaches the largest number of individuals that an environment can support over a long period of time. This maximum number of individuals is called the **carrying capacity** of the ecosystem. Some common limiting factors are discussed on the following pages.

READING Check

How are limiting factors related to carrying capacity?

Limiting Factors

A **limiting factor** is any abiotic or biotic factor that controls the number of individuals in a population. In Figure 2.17, for example, you can see a distinct line across the mountainside. Trees do not grow above this line. The temperature is too cold for the trees to survive above this elevation, called the *tree line*. Temperature is one limiting factor for this population of trees. The strength of the winds and the thin soil may also limit the growth of these trees.

Figure 2.17 The growth of trees can be limited by temperature. The trees in this ecosystem will not grow above a certain elevation.

Figure 2.18 Predation is one type of limiting factor in a population.

Predator-Prey Cycles

In Chapter 1, you studied the populations of hare and lynx. You learned that predator-prey populations often increase and decrease in cycles. Predation is one way in which one population can limit another. The wolf in Figure 2.18 may catch one of the elk in the herd it is chasing. If so, predation by the wolf has limited the population of elk. Predator–prey cycles limit other things in ecosystems. When populations of deer, elk, and caribou are large, they eat more grasses and limit the population of the grasses.

Diseases and Parasites

Diseases and parasites can limit populations. In most of North America, a disease called canine distemper can infect and kill animals such as wolves, coyotes, foxes, raccoons, and weasels. Diseases and parasites limit populations of plants, as well. For example, a fungus called spruce broom rust has infected the spruce tree shown in Figure 2.19.

Figure 2.19 White spruce can be found throughout most of the interior of British Columbia. Trees that are infected with spruce broom rust have strange yellow growths, which are sometimes called "witches' brooms."

Figure 2.20 Grizzly bears need a large amount of space for their habitat.

Competition for Resources

Only limited amounts of food and living space are available in any ecosystem. The amount of food and the type of den site that a grizzly bear (see Figure 2.20) needs requires a lot of space. In an ecosystem, grizzly bears must compete for food and den sites. Loss of habitat is one of the main reasons that wildlife populations become threatened. Cities, highways, campgrounds, and orchards reduce the available habitat for many animals. For example, bighorn sheep live high in the mountains in the summer. In the winter, however, the sheep must go down into the valleys. Development in the valley bottoms has limited the sheep's winter range in some places.

CONDUCT AN

INVESTIGATION 2-E

SKILLCHECK

- Controlling Variables
- Predicting
- Observing
- Interpreting Data

What's the Limit?

Organisms depend on many biotic and abiotic factors in their environment. When these factors are limited or not available, their survival can be threatened. In this investigation, you will experiment with some limiting factors to see how they affect the growth of plants.

Question

How do abiotic factors, such as light, water, and temperature, affect the germination of seeds?

Safety Precautions

- Wash your hands when you have completed each part of this investigation.

Apparatus	Materials
waterproof marker	masking tape
6 small plastic plant pots	potting soil
refrigerator	18 bean seeds
small watering can	cardboard box
ruler	

Procedure

1. Make "DO NOT WATER" labels for three of the pots, using the marker and masking tape. Put the labels on the three pots.
2. Fill all six pots with potting soil. Plant three bean seeds in each pot.
3. Place one labelled pot and one unlabelled pot in:
   - the sunshine near a window.
   - a dark closet or under the cardboard box.
   - a refrigerator.
4. **Predict** what will happen to the growth of the seeds in each pot. Why do you think this will happen? Write down your predictions.
5. Leave the plants for several days. Add water to the three unlabelled pots every other day or as needed. Do not overwater.
6. After the seeds have sprouted, **measure** your plants every day. **Record** your measurements in a data table. Continue to **observe** your plants until some of the plants have two fully formed leaves.

Skill POWER

For tips on graphing, turn to SkillPower 5.

Analyze

1. Create a bar graph to show your results.
2. (a) What independent variables did you test in this investigation?
   (b) What was the dependent variable in this investigation?
   (c) What variables did you control in this investigation?
3. Were there variables that you were unable to control? If so, what were they? What effects do you think they had on your results?
4. Compare your results with the results of other groups in your class.

Conclude and Apply

5. What abiotic factors did you test in this investigation?
6. How did the abiotic factors you tested affect the growth of the bean seeds? (Hint: When you make comparisons, be sure that only one variable was different for the plants you are comparing. For example, do not compare a cold, unwatered plant with a warm, watered plant.)
7. Why did you use more than one seed in each pot?

Natural Disturbances

Avalanches, landslides, forest fires, floods, and extreme weather such as tornadoes, are all examples of natural disturbances that can cause changes in ecosystems. The avalanche, for example, can destroy all the plants in its path. As well, it might have carried sheep and mountain goats down the mountain. In Figure 2.21 you can see where an avalanche killed trees and carried debris down the mountain.

Figure 2.21 Each spring, grizzly bears and wolverine travel to places where avalanches have occurred. There they feed on the carcasses of animals that were caught in the avalanches. It will take many years for the trees to grow large again.

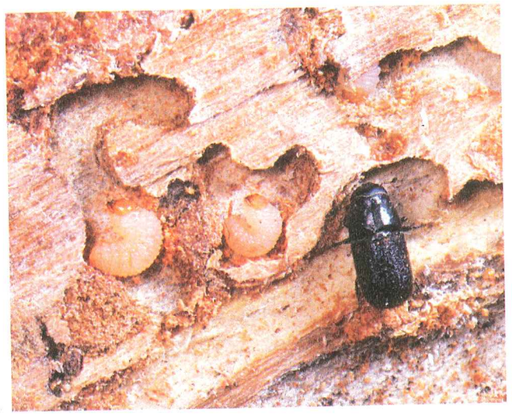


Figure 2.22 With the bark removed, you can see how the beetles dug tunnels in the wood and laid eggs.

Figure 2.23 Large parts of British Columbia's lodgepole, limber, and ponderosa pine forests have been attacked by mountain pine beetles.

Several mild winters in a row have contributed to an outbreak of mountain pine beetles in pine forests throughout most of British Columbia. At least two weeks of very cold weather are needed in the winter to kill the beetles. Without this cold weather, these insects thrive. As shown in Figure 2.22, the beetles bore into the trees and carry with them a fungus. The effects of beetles and the fungus eventually kill the trees. The mild winters with no cold spells have allowed the pine beetles to infest large parts of British Columbia's pine forests. As you can see in Figure 2.23, many trees have turned brown and died.

Lightning strikes have always caused forest fires. Despite what you might expect, deer, bears, blue jays, and many other animals are quick enough to escape forest fires. Also, some species need occasional forest fires to keep their populations healthy. For example, lodgepole pines need fires occasionally, in order to reproduce. As you can see in Figure 2.24, the cones of lodgepole pines are tightly sealed. They remain sealed until they are opened by intense heat.

Figure 2.24 The cones of lodgepole pines need the intense heat of a forest fire to open and release the seeds.

Bushes, trees, and other plants are burned in naturally occurring forest fires in many ecosystems. Usually, burned forests quickly begin to grow again. Fires once occurred on a regular basis. However, in the past 100 years or so, people have put out forest fires as quickly as possible. Without these small fires, large amounts of live and dead vegetation have accumulated on forest floors. This vegetation provides excellent fuel for fires. As a result, uncontrollable forest fires have burned large areas in British Columbia and elsewhere in Canada. The fires that occurred in British Columbia in the summer of 2003 were especially destructive. These uncontrollable fires can be much more damaging to ecosystems than the smaller fires that once occurred on a regular basis.

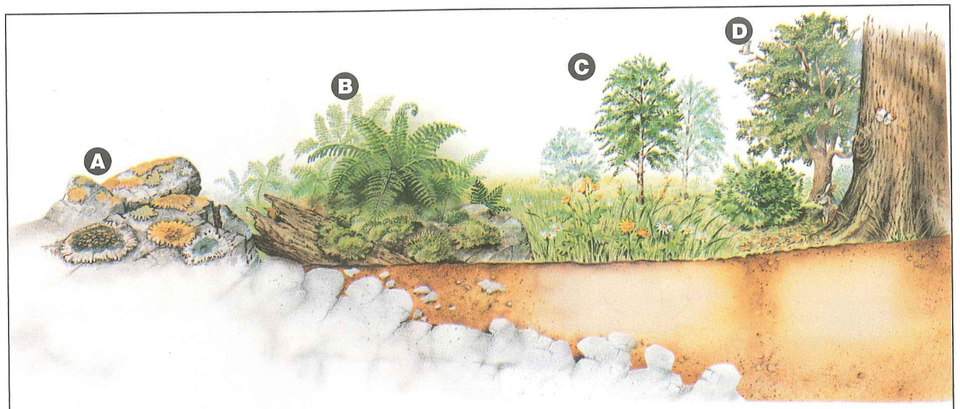
Many scientists feel that **global warming** (the steady increase in the temperature of Earth's atmosphere) has led to reduced moisture in the environment. Less snow in the winter and less rain in summer have caused the forests to be drier and more likely to catch fire.

READING Check

What are three natural disturbances that can be limiting factors for a population of organisms?

Ecological Succession: Changes Over Time

Ecological succession is the gradual change in the make-up of a biological community over time. In the process of ecological succession, organisms that are present at one stage change the environment in some way. This change makes it possible for other species to move in, because the new conditions are more suited to their needs. Figure 2.2 shows one example of succession.



A Lichens [LIH–kuhns] are plant–like organisms that can grow on rocks. They produce acids that help to break down the rock. The broken-down rock and the decomposing bodies of dead lichens contribute to soil formation.

B The resulting soil is poor and thin. However, mosses and ferns grow and slowly replace the lichens.

C The soil layer thickens, which means it can hold more water. Plants that need more soil and moisture, such as grasses and flowering weeds, take root and grow. They attract insects, such as bees and butterflies.

D Since the soil is now thicker and richer, bushes and trees take root. They provide shelter and food for birds, mammals, and other organisms, which now start moving in.

Figure 2.26 Succession is a long, slow process in which a natural ecosystem gradually develops and changes over time.

All the natural disturbances you read about on the last few pages (such as fires, winds, and avalanches) are followed by succession. In the succession of the burned forest in Figure 2.27 wildflowers and other plants that need strong sunlight are among the first to grow. Blueberry bushes also thrive, since they are adapted to grow better in soil that contains ash. In the next investigation, you will watch succession in action.

Figure 2.27 These wildflowers, called fireweed, are thriving in an area that has been recently burned.

CONDUCT AN

INVESTIGATION 2-F

SKILLCHECK
- Modelling
- Observing
- Interpreting Data
- Communicating

Succession in a Bottle

Succession can take place in any area, large or small, in a short period of time or over many years. For instance, weeds quickly grow when a patch of soil is left alone. Trees, however, take many years to grow back in an area that was cleared by a forest fire or logging.

Question

How does succession take place in an ecosystem?

Safety Precautions

Material

- 2 L clear plastic soda bottle (with the top cut off) or large-mouthed jar
- potting soil
- ruler
- water
- small aquatic plant
- 50 mL wild birdseed mix

Skill POWER

For tips on designing experiments, turn to SkillPower 6.

Procedure

1. **(a)** Put soil in the bottom of the container, to a depth of 5 cm.
   (b) Fill the container with water, to a depth of 7.5 cm, thus covering the soil.
   (c) Place the container, uncovered, close to a window. Allow the contents to settle overnight.
2. The next day, plant an aquatic plant in the container. Although the water will evaporate over time, do *not* add more water to the container.
3. **(a)** Once a week, add three or four seeds from the wild birdseed mix to the container. **Record** any observations.
   (b) Continue adding seeds weekly, even though the water evaporates. What, if anything, happens to these seeds?
   (c) After a few weeks, gradually start to add water again, as you would when watering a plant. Continue to **record** your observations.

Analyze

1. Describe what is occurring in your container.
2. **(a)** Describe your observations during step 3.
   (b) What was the significance of not adding water to your ecosystem?
   (c) What happened to the aquatic plant?

Conclude and Apply

3. Compare your ecosystem at the beginning of the investigation with your ecosystem at the end. How was your ecosystem similar at the beginning and the end of the investigation? How was it different?
4. How well does this investigation demonstrate succession?
5. Consider what you have learned about succession. What would you expect to happen after a fire burns through a forest, destroying most of the older trees and vegetation?

Extend Your Skills

6. Design your own investigation to determine the effects of different environmental factors on your ecosystem. Have your teacher approve your procedure before you carry out your investigation.

Section 2.3 Summary

A limiting factor is an abiotic or biotic factor that limits the number of organisms in a population. Three examples of limiting factors are

- predation
- disease and parasites
- competition for resources, such as food and habitat

Weather, climate change, and natural disturbances (such as avalanches, forest fires, floods, and extreme weather) can cause changes in ecosystems.

Ecological succession is the gradual change in the structure of a community over time. Succession occurs after changes in the environment, such as those caused by a forest fire or avalanche.

Key Terms

limiting factor
carrying capacity
global warming
ecological succession

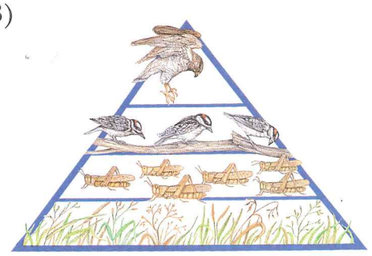
Check Your Understanding

1. How does carrying capacity influence the number of organisms in an ecosystem?
2. Explain the process of succession.
3. How would a shrinking habitat be a limiting factor for an animal population, such as a grizzly bear or wolf population?
4. What are four different limiting factors that might affect a population of organisms living in a lake? Describe each limiting factor.
5. **Apply** A rancher notices that shrubs and small trees are starting to fill in the pasture used for cattle. What could the rancher do to open up the pasture?
6. **Apply** In the early 1900s, many predators were hunted so much that their populations declined. Suppose that most of the cougars in an ecosystem were killed. How might this affect the deer population (the cougars' main prey) and the plants that the deer eat?
7. **Thinking Critically** Why do you think the supply of food and water in an ecosystem usually affects population size more than other limiting factors do?
8. **Thinking Critically** An avalanche removes all the plants and animals from a large area on a mountainside.
   (a) How is this natural disturbance a limiting factor for populations in the ecosystem?
   (b) What changes might take place over the next few years in the area that has been disturbed?

CHAPTER at a glance

Now that you have completed this chapter, try to do the following. If you cannot, go back to the sections indicated in brackets.

(a) Define the terms "food chain" and "food web." (2.1)
(b) Explain how energy flows in a food chain. (2.1)
(c) Explain energy flow. (2.1)
(d) Describe a pyramid of numbers. What information does it provide that a food chain or food web does not? (2.1)
(e) In what states of matter can you find water in the environment? (2.2)
(f) List three sources of carbon dioxide in the carbon cycle. (2.2)
(g) Describe the four main processes in the water cycle. (2.2)
(h) Give an example of bioaccumulation in a food chain. (2.2)
(i) Explain why species of plants and animals that reproduce quickly do not spread and take over Earth. (2.3)
(j) Describe the different kinds of limiting factors that are found in nature. (2.3)
(k) Suppose that a landslide clears all the plants from part of a hillside. Will this part of the hillside still be without plants in 50 years? Explain your answer. (2.3)



Prepare Your Own Summary

Summarize this chapter by doing one of the following. Use a graphic organizer (such as a concept map), create a poster, or write a summary to include the key chapter ideas. Here are a few ideas to use as a guide:

- Draw a diagram that illustrates energy flow. In your diagram, show the source of the energy and include at least five organisms. Indicate what happens to the energy as it is transferred from one organism to the next.
- Why do most humans have more food choices than many animals have? Brainstorm answers to this question, alone or in a group. Summarize your answers in a written report.
- Make a travel log of the journey of a water droplet as it goes through the water cycle.
- Use diagrams to show ways in which energy is transferred and matter is cycled through ecosystems.
- Imagine that you are a real estate agent, advertising a piece of newly burned forest to animals. In your sales pitch to potential "land owners," describe why this burned area might be a great place to live in a few years.

CHAPTER

2 Review

Key Terms

food chain
chlorophyll
photosynthesis
top consumer
cellular respiration
food web
energy flow
pyramid of numbers
carbon cycle
water cycle
evaporation
transpiration
condensation
precipitation
ground water
run-off
pollution
pollutants
bioaccumulation
limiting factor
carrying capacity
global warming
ecological succession

Reviewing Key Terms

If you need to review, the section numbers show you where these terms were introduced.

1. In your notebook, match each description in column A with the correct term in column B. Use each description only once.

A	B
(a) a change from a gas to a liquid	• condensation (2.2)
(b) transfer of energy through ecosystem	• transpiration (2.2)
(c) forest renewal is an example	• food web (2.1)
(d) need other organisms to survive	• consumers (2.1)
(e) water that falls to Earth	• succession (2.3)
(f) interconnected network of organisms in an ecosystem	• food chain (2.1)
(g) make food using energy from the Sun	• producers (2.1)
(h) evaporation from a plant	• precipitation (2.2)

2. For each of the following pairs, how are the meanings of the two terms different? Explain.

   (a) limiting factor, carrying capacity (2.3)
   (b) condensation, evaporation (2.2)
   (c) food web, food chain (2.1)
   (d) energy flow, pyramid of numbers (2.1)

Understanding Key Ideas

Section numbers are provided (if you need to review).

3. Why do *all* consumers depend on producers for food? Explain your answer. (2.1)

4. What are your three favourite foods? Explain how these foods provide you with energy from the Sun. (2.1)

5. Based on your knowledge of cycles, explain the slogan "Have you thanked a plant today?" (2.1)

6. Why is a food web a better model than a food chain for describing the relationships among what an organism eats and what eats the organism? (2.1)

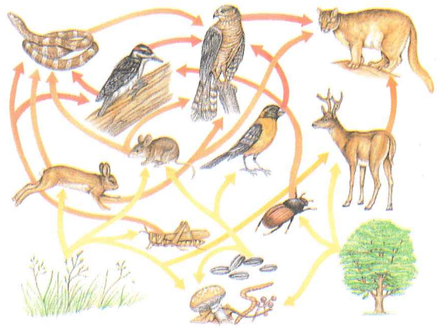
7. Water is not always a liquid. In what other states of matter can it exist? How does water change during the water cycle? (2.2)

8. Label this diagram with explanations of what is happening in each stage of succession. (2.3)

9. What limiting factor(s) might affect a population of fish living in a lake? (2.3)

Developing Skills

10. Use arrows and words to draw five food chains, based on the food web below.



11. Imagine that you are teaching a class of younger students about food webs. How could you explain this idea to them?

12. Design a poster, game, or model to explain bioaccumulation.

Problem Solving

13. Group Work Why do some people in the world have limited food choices? Discuss this question in a group or as a class. What might happen if their food supplies were damaged by a natural disturbance, such as a hurricane or a drought?

14. A sailor survived a shipwreck. She managed to save several hens and a bag of grain from the cargo. She is now on an island that is far from the closest mainland, in an area where there are no other people. It may be months before she is rescued. To survive as long as possible, what should she do? Explain why you think your ideas will help her survive.

15. Imagine that you have just eaten a meal consisting of a salmon sandwich (with lettuce and tomato), a cup of mushroom soup, an almond cookie, and a glass of apple juice. What niche in the food chain was occupied by each organism that made up your meal? Draw and label a food chain that shows possible relationships among the organisms.

Critical Thinking

16. Why is there a limit to the number of links in a food chain?

17. Think about a food chain that includes grass → field mice → snakes → owls. Describe what would happen if many mice died as a result of disease. What would happen to the owls? What would happen to the snakes? What would be the probable result in the ecosystem?

18. Think about the food web shown in question 10. What would happen if each of the following changes occurred?
   (a) The number of deer decreases due to disease.
   (b) A subdivision of new homes is built in the habitat, reducing its size by one half.
   (c) An insect pest kills many of the trees.
   (d) A poison is used on the grass to kill weeds.

Pause & Reflect

Go back to the beginning of this chapter on page 34, and check your original answers to the Getting Ready questions. How has your thinking changed? How would you answer those questions now that you have investigated the topics in this chapter?