Unit 1 Sustainable Ecosystems

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BIG IDEAS

- Ecosystems are dynamic and have the ability to respond to change, within limits, while maintaining their ecological balance.
- People have the responsibility to regulate their impact on the sustainability of ecosystems in order to preserve them for future generations.

Sustainable Ecosystems: Overall Expectations

- **B1** assess the impact of human activities on the sustainability of terrestrial and/or aquatic ecosystems, and evaluate the effectiveness of courses of action intended to remedy or mitigate negative impacts
- **B2** investigate factors related to human activity that affect terrestrial and aquatic ecosystems, and explain how they affect the sustainability of these ecosystems
- **B3** demonstrate an understanding of the dynamic nature of ecosystems, particularly in terms of ecological balance and the impact of human activity on the sustainability of terrestrial and aquatic ecosystems

Materials

Please see page TR-35 for a list of the materials required for this unit and other units.

In this unit, students will learn how sustainable ecosystems endure and support the organisms that live within them. They will learn that human activities can alter the nutrient balance within an ecosystem. Students will use and define the terms "trophic level," "bioaccumulation," "cellular respiration," and "photosynthesis."

Students will also understand that populations become limited when resources are limited, and that each species occupies an ecological niche defined by abiotic and biotic components. They will investigate how humans have broadened their ecological niche and altered their ecosystems, to increase their carrying capacity. Students will use the terms *predation, competition, mutualism,* and *parasitism.*

Finally, students will explore biodiversity. Threats to biodiversity include habitat loss, introduction of alien species, overexploitation, and breaking the connectivity among ecosystems. Students will learn about bioremediation and bioaugmentation, and how restoration techniques can offset damage to an ecosystem.

English language learners may benefit from a preview of the key ideas and vocabulary of the unit. Develop a simple concept map relating all three chapter topics to the idea of sustainable ecosystems. Use the map to introduce and define the terms *cycle, chain, ecosystem, abiotic, biotic, sustainability, organism, population, species, biodiversity,* and *resources,* and return to the map throughout the unit to introduce and reinforce Key Terms and to help students connect new understandings to prior knowledge. Include examples and non-examples in the concept map.

Using the Unit Opener (Student textbook page 1)

- Check what students know and believe already about sustainable ecosystems using **BLM 1-1 Unit 1 Anticipation Guide.** Then, when you have completed the unit, check again and have students reflect on how and why their understandings and attitudes may have changed.
- ELL The forest ecosystem is very familiar to Canadian students but may be unfamiliar to English language learners. Discuss the names and characteristics of common forest animals and plants. This activity could be done in partners or small groups.
- DI Ask spatial learners to draw some of the animal warning road signs they have seen either in the local area or in their travels. For example, students may have seen a duck-crossing or turtle-crossing sign if they were near a marsh. Students can use chart paper, mini whiteboards, or the front board to sketch their signs.
- DI For the benefit of linguistic and interpersonal learners, arrange students into groups of five or six. Have each group construct a placemat spider map (see page 566 of the student textbook), then brainstorm other ways of protecting animals from being hit by cars on highways. Appoint one person in each group to ensure that everyone has a chance to participate.

Assessment OF Learning for Unit 1		
Activity	**Evidence of Learning**	**Supporting Learners**
Unit 1 Inquiry Project	Student selects appropriate biotic and abiotic components for an aquatic ecosystem.	Review abiotic and biotic components using a sample ecosystem. Have students summarize information in a graphic organizer, for example, a Venn diagram.
	Inquiry design is effective, including a hypothesis, dependent and independent variables, a control, and a data collection plan.	Read Science Skills Toolkit 2, Scientific Inquiry, on page 532 of the textbook with students. Consider providing **BLM G-5 Scientific Inquiry Organizer,** and/or **BLM A-3 Designing an Experiment Checklist.** Assign a peer editor to assist with planning a thorough inquiry.
	Student describes observed effects of the chosen substance on the ecosystem.	Consider providing **BLM G-4 Making Observations and Inferences,** and **BLM A-1 Making Observations and Inferences Checklist.**
	Results of the inquiry are communicated clearly, using text and visuals.	Consider providing **BLM G-6 Recording an Investigation.** Refer students who have gathered numerical data to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs, on page 557 of the student textbook.
Unit 1 An Issue to Analyze Project	Students identify three factors that threaten a specific ecosystem, and write questions to learn more about these factors.	Using the Oak Ridges Moraine as an example, ask students to choose one human factor impacting this ecosystem and describe its effects. Support this discussion with illustrations that show the connectedness of organisms, including humans, within this ecosystem. Have students list things they know about their ecosystem, then review the potential threats listed in Section 3.3 to decide which ones likely apply to their ecosystem.
	Students gather and organize data to help answer their questions.	Refer students to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs, on page 557 of the student textbook. Consider providing **BLM G-12 Scientific Research Planner.**
	Students explain multiple perspectives related to issues affecting the ecosystem's health.	Consider providing **BLM G-17 Worksheet for Investigating Issues.** Encourage students to work in pairs to suggest alternative viewpoints to one another.
	Students propose and clearly explain practical, reasonable strategies to reduce the threat.	Consider providing **BLM G-18 Decision-Making Organizer,** and/or **BLM A-5 Investigating an Issue Checklist.**

Get Ready (Student textbook pages 2 and 3)

Prerequisite Learning

Students would benefit from understanding

- the relationships among plants and animals in habitats and communities and be able to explain the cause-and-effect relationships that take place and affect the ecosystem. (questions 4, 5)
- how human activities affect habitats and communities. (question 5)
- how a food chain works. (question 3)
- that ecosystems are made of interacting biotic and abiotic components. (question 1)
- the roles of producers, consumers, herbivores, carnivores, and omnivores. (question 2)
- how matter is cycled. (question 4)

Prerequisite Skills

Students need to be able to

- communicate in writing, verbally, and using a variety of media with different audiences for a variety of purposes. (questions 6, 7, 9, and 11)
- interpret a variety of literary, graphic, and informational text. (questions 1, 9, and 10)
- proofread and edit work to correct errors and refine their expression. (questions 8 and 11)
- predict the meaning of unfamiliar words using a variety of cues. (questions 4 and 7)
- record and organize data using standard measurements in tables, graphs, or charts. (question 10)
- make predictions based on prior knowledge, and identify patterns in data. (questions 7 and 9)
- represent the steps and results of an experimental procedure. (questions 8, 9, and 10)
- state a conclusion based on information gathered. (question 7)

Students can review some of these skills using **BLM 1-2 Skills for Unit 1.**

Answers

1. Biotic: bird, mammals, trees, berries, flowers, nuts and seeds, grasses
Abiotic: rocks, air, water

2. b. A vulture is a scavenger because it eats animals that it finds dead.

c. A tree is a producer because it uses energy from the Sun to create food for other organisms.

d. A chipmunk is a consumer because it gets energy by eating other organisms.

e. A deer is a herbivore because it eats only plants.

f. A wolf is a carnivore because it eats only animals.

g. A bear is an omnivore because it eats both plants and animals.

3. Students' food chains should show at least 3 organisms, including a consumer that eats a consumer that eats a producer.

4. Students' explanations should include the benefits that trees provide to different parts of the ecosystem.

5. Students' flowcharts should clearly show cause and effect.

6. Most collisions occur in spring and fall. This may be because animals are hungry at those times, so approaching roadways, or because they are expanding or moving their territories.

7. Every strategy could be effective. Students should provide a logical rational for the one they choose.

8. Students' strategies should include formulating a hypothesis; collecting data in an organized, unbiased way; and displaying and analyzing the data to formulate a conclusion.

9. Ottawa, Simcoe County, Kenora, Lanark County, Thunder Bay.

10. A bar graph or a pie chart would be appropriate. Students' graphs should be accurate and clearly labelled.

11. The message should state the dangers clearly, recommend strategies to avoid them, and communicate using simple, clear language.

Assessment FOR Learning		
Tool	**Evidence of Learning**	**Supporting Learners**
Get Ready Concept Check	Students catergorize and organize components of an ecosystem and their relationships.	Have students create a concept map based on the image on page 2 of the student textbook. Students should label part of the image as biotic or abiotic. Students should link and label the images further using the statements from question 2 and the terms from question 4. For question 3, English language learners could draw a food chain from an ecosystem that is more familiar to them.
Get Ready Inquiry Check	Students read the given passage and extract information to analyze and predict outcomes. Students write a step-by-step procedure that includes data collection.	Have students deconstruct sample procedures from the textbook by looking at the number of steps, particularly how data collection is described for each procedure. As a class, model a template for writing a procedure and then have students write and peer-edit their own procedures for the inquiry check. English language learners could write and edit with a partner.
Get Ready Numeracy and Literacy Check	Students are able to rank the data accordingly, select an appropriate graph, and write at least 300 words in the appropriate tone for the mayor.	To rank and graph the data, students can use spreadsheet software. Have students work in small groups to list features of effective graphs. Together, summarize this information using a concept attainment strategy in which students classify graphs as well designed or not. Check local radio station websites for news announcements. Provide students with examples of these announcements as samples of a suitable style. Have students work in groups of four to six. Ask them to brainstorm a list of features that make each announcement effective. Post their lists around the classroom, and conduct a gallery walk, in which students look at the ideas of the other groups. Create a class list of effective features of an announcement together and have students use this to guide their writing.

Using Making a Difference (Student textbook pages 11, 77, 101)

Throughout the unit, students will encounter examples of situations where humans' choices affect the health and sustainability of a species or an ecosystem. There are simple choices we can make as consumers, which drastically affect the habitats of other species (for example, choosing a specific type of coffee or using cellphones).

Just as Yvonne Su, Allyson Parker, and Severn Cullis-Suzuki were able to make a difference, so can students from any high school. Students can be encouraged to create an action plan for their class or school with the intention of reducing their impact on a specific species or ecosystem. Plans might include improving the songbird habitat on the school grounds, or helping their parents choose shade-grown coffee or even learning to make coffee in the morning so Mom and Dad do not have to go to the drive-through. Their action plans could be part of the school's EcoSchool initiative. Encourage students to realize that even small changes can make a big difference.

Using Science at Work (Student textbook page 124)

The significance of songbird decline was so important to Dr. Stutchbury that she incorporated it into her career as an author and a university professor. Reasons for songbird decline include deforestation in South and Central America and the fragmentation of forested areas in the United States. As the North American human population spreads to rural areas, the predators and competitors (for example, jays, crows, feral cats, foxes, and raccoons) that favour suburban habitats increase.

Songbirds are an important indicator of environmental health, biodiversity, and sustainability. With our growing population, we still require timber for the construction of new houses, and very little wood in North America is harvested from plantations. The origins of most medications (approximately 80 percent) commonly prescribed in North America are natural compounds.

To introduce this feature, consider playing a recording of local songbirds in the classroom and displaying photographs of the birds.

An extension to the career study is suggested in question 4 on page 125. Ask students to put themselves in the shoes of a person working in a career that they are interested in pursuing. Direct students to include in their answer what this person (for example a forester, an urban planner) could do to increase and protect songbird habitat.

Introducing the Unit 1 Projects (Student textbook pages 126 and 127)

Discuss with students one of the reasons scientists study ecosystems—to learn how to protect them. Explain that the Unit 1 Projects will give students the chance to apply what they learn to investigate some threats that humans pose to ecosystems and how we can protect the ecosystems. Preview the Unit Projects with students. Then, looking at the chapter titles in Unit 1, ask students to predict some things they may learn about that would help them complete one of the projects. As students work in Unit 1, draw their attention to concepts that may be helpful in completing one of the projects. For example, understanding the phosphorus cycle, on page 18, can help students complete the Inquiry Project. The investigations at the end of each chapter have been designed to help students develop both understandings and skills that will be useful to them as they complete the Unit Projects. Students can begin to plan their work on a Unit Project at any time after they begin the unit.

Most English language learners will find the Inquiry Project "Pollutants and Aquatic Ecosystems" less linguistically demanding than "Protecting Ecosystems." Hold mini-conferences throughout the unit, to ensure understanding and to establish a time line for completion of each task of the Inquiry Project. Peer support groups (homework clubs with older students) could also be used in this context. If possible, invite older students with the same first language to help your students.

Using the Case Studies

The suggestions below provide opportunities for students of multiple learning styles to engage in and explore issues. The strategies chosen support bodily-kinesthetic, spatial, and interpersonal learning styles. The strategies also serve as pre-reading strategies and scaffolds for English language learners.

Chapter 1 (Student textbook pages 8 and 9)

- Ask students to examine the graphic on page 9 and explain how the eels change in appearance. Ask, "What part of the eels' life cycle takes place in the great lakes?" Record the answers on the chalkboard.
- Before reading "The Disappearing Eel" case study, provide students with an opportunity to explore their views through a brief Four Corners activity. Post each of the following perspectives in one corner of the classroom, read them aloud, and invite students to move to the corner that best reflects their own view. The perspectives are the following:

  1. All species deserve equal protection.
  2. Eels are a special fish species of the Great Lakes and deserve more attention than other species.
  3. Eels are water snakes that are not that important in the Great Lakes.
  4. We should not intervene to protect any species.

  The perspectives are printed ready for posting on **BLM 1-3 Four Corners Activity.** Have students read the case ctudy, answer the questions, and then reflect on how their views on this issue have changed. You could repeat the Four Corners activity and allow students who changed their minds to explain why they chose a different corner this time.
- Provide students with **BLM 1-4 Eel Life Cycle,** for them to record information about the eel while they read.

Chapter 2 (Student textbook pages 72 and 73)

- Before reading the "Why Are Honeybees Disappearing?" case study, have students stand in a value line. One end of the line could be those students who would say, "I believe that we are doing enough to protect the bees," and the other end could be those students who would say, "I believe that we could do much more to protect the bees." Split the line in half and shift one side down so that there are now two lines of students, facing each other. The students in each facing pair must convince each other of their opinion, for one minute each.
- After reading the case study, either in pairs or groups of four, have students discuss any questions their group members have, then create a concept map with 10 connections for the disappearing honeybee, using **BLM 2-2 The Disappearing Honeybee.**

Chapter 3 (Student textbook pages 106 and 107)

- Brainstorm with students a brief list of plants and animals that must survive harsh conditions over the winter. Discuss the various strategies that these species use to survive (bears hibernate, frogs tunnel into mud, humans have developed central heating, and some seeds require a freezing period to germinate).
- Have students work in groups to brainstorm a list of other species that have a life cycle that completes itself in two distinctly different ecosystems.
- Remind students of the survival strategies that were discussed prior to reading the case study. Ask students to explain the survival strategy that Dolly Varden use.
- Use a Venn diagram to help students understand the similarities and differences between traditional knowledge and scientific knowledge. Use **BLM 3-2 Traditional Knowledge/Scientific Knowledge.**

Chapter 1 Nutrient Cycles and Energy Flow

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Order or purchase plant material, soil, and fertilizer for Investigations 1-A, 1-B, 1-C, and 1-D ahead of time.
- Supplies needed include *Elodea,* radish, and pea seeds; fertilizer; soil; and foam cups.
- Inquiry Investigation 1-C, on pages 40 and 41, and Plan Your Own Investigation 1-D, on page 42, will take several weeks to complete, so have students start them early in the unit, no later than the second week.
- Students can review the Key Terms in Chapter 1 using **BLM 1-5 Chapter 1 Key Terms.**

In this chapter, students will learn that all life depends on recycled matter and that all matter is interconnected within an ecosystem. Students will also learn how human interaction can interfere with the sustainability of an ecosystem.

Using the Chapter Opener (Student textbook pages 4 and 5)

- At the chalkboard, brainstorm with students to create a word family web starting with the word *sustain*. (Once you have modelled this process, students will be able to develop similar webs for other concepts on their own or in small groups.) Words that might be used in the web include *sustenance, sustainable, sustained, sustainedly, sustainer,* and *sustainability.* Ensure that all students understand the meanings of each word on the web. *Sustain* has a dual meaning—to provide nourishment and to maintain. Within the context of this unit, both meanings are applicable.
- Work with students to compare and contrast the importance of a provincial park versus a World Heritage Site. Some of the objectives of a World Heritage Site include protecting the cultural and natural importance of an area to all humanity, and protecting an area that contains habitat for threatened species. Some of the objectives for provincial parks include protecting representative ecosystems, and providing opportunities for ecologically sustainable recreation.
- As an alternative, tell students about two Canadian parks, and then ask students to compare them:

Algonquin Park was established in 1893 as a wildlife sanctuary and to protect the headwaters of rivers that were important for logging; it is one of Canada's oldest provincial parks. Since its creation, the park has been selectively logged, yet it still maintains a variety of wildlife including deer, wolves, and the largest population of moose in central Ontario. Algonquin Park is classified as a Natural Environment Park. The objectives of this type of park include protecting outstanding recreational landscapes, and providing high-quality educational experiences.

Even though the park supports moose, deer, wolves, and canoeists, it can be argued that the ongoing logging has frozen the ecosystem of the park in time, maintaining these optimal conditions without ever changing or evolving.

Woodland Caribou Park, on the other hand, is classified as a wilderness park. Wilderness parks are remote, and only accessible by boat or float plane. This type of park allows nature to exist freely and only promotes low impact recreation.

Ask students which of these two parks best fits the definition of sustainability.

Activity 1-1 How Disturbed Is Too Disturbed? (Student textbook page 5)

Pedagogical Purpose

This activity illustrates that a system can usually tolerate some disturbance, but after a certain point, the disturbance can cause the whole system to collapse.

Planning			
Materials	24 smooth rectangular building blocks, labelled with environmental disturbances:		
	Deforestation	Global climate change	Overfishing
	Disease, extinction	Habitat fragmentation	PCBs, DDT, excess nutrients in run-off
	Draining wetlands	Hurricane, tsunami, flood, ice storm	Pollution (air, water, light)
	Drought, desertification	Meteor strike	Volcanic eruption
	Exotic species	Nuclear bomb	Wildfire
Time	5 min to label the blocks 15 min to do the activity		

Background

Some environmental disturbances are natural, and others are caused by humans. In this activity, students treat all environmental disturbances equally. In many cases, natural disturbances such as fire are part of the ecosystem necessary to promote regeneration. However, forest fires can also threaten homes and communities. Students may want to develop their own opinions about whether humans should interfere with natural disturbances like forest fires.

Activity Notes and Troubleshooting

- It is important that students take turns, and remove the blocks smoothly and slowly.
- Inexpensive versions of this game can be found at some dollar stores.

Additional Support

- DI For linguistic learners, as well as English language learners, this game can be modified by showing different words on some of the blocks. For example,
  - Show several biotic and abiotic components of an ecosystem on the blocks. Use different colours for biotic and abiotic components.
  - List Key Terms on the blocks. In order to remove a block, students must define the word. Create a list of definitions of Key Terms for students to refer to.
- ELL After the activity, print and discuss the words *balance* and *interdependence.* Challenge students to draw a sketch to illustrate the meaning of these words. Share these sketches with a partner. Add these words to the concept map started at the onset of the unit.

Study Toolkit

Strategy	Page Reference	Additional Support
Previewing Text Features	Students can skim or scan the headings and subheadings throughout Chapter 1, in order to predict what each section will be about prior to reading.	Refer students to the Study Toolkit Appendix, in particular Study Toolkit 1, Preparing for Reading: Previewing Text Features, on page 563 of the student textbook.
Comparing and Contrasting	After reading pages 28 and 29, students can use a Venn diagram to compare and contrast photosynthesis and cellular respiration.	**BLM G-39 Venn Diagram** Have students write sentences using these comparing words: X and Y are alike because... X and Y are not alike because...
Word Families	Students can draw a word family web to record the meanings of the Key Terms *lithosphere, biosphere, atmosphere,* and *hydrosphere* on page 13.	*Think Literacy: Cross Curricular Approaches, Grade 9 Science* available at STAO.ca, includes strategies to help students make connections among words. Refer students to Study Toolkit 3, Word Study: Common Base Words, Prefixes, and Suffixes in Science, on page 565 of the student textbook. Work with English language learners to identify prefixes and suffixes that can help them understand important words throughout the chapter.

Section 1.1 Sustainability (Student textbook pages 7 to 20)

Sustainable Ecosystems: Specific Expectations

- **B1.2** evaluate the effectiveness of government initiatives in Canada, and/or the efforts of societal groups or non-governmental organizations, with respect to an environmental issue that affects the sustainability of terrestrial or aquatic ecosystems
- **B2.2** interpret qualitative and quantitative data from undisturbed and disturbed ecosystems, communicate the results graphically, and, extrapolating from the data, explain the importance of biodiversity for all sustainable ecosystems
- **B2.4** plan and conduct an investigation, involving both inquiry and research, into how a human activity affects water quality, and, extrapolating from the data and information gathered, explain the impact of this activity on the sustainability of aquatic ecosystems
- **B3.1** compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems
- **B3.4** identify the earth's four spheres, and describe the relationship that must exist between these spheres if diversity and sustainability are to be maintained

In this section, students will learn about the impact of human activities on sustainable ecosystems. Students will be able to explain what makes an ecosystem sustainable. They will compare and contrast the characteristics of an unsustainable ecosystem. Students will be able to describe the relationship between Earth's four spheres and how cycling of water, carbon, nitrogen, and phosphorus links Earth's spheres.

Common Misconceptions

- **Some students may believe that biotic components of an ecosystem are important to sustain life, but may not appreciate the importance of the abiotic components.** You could talk with them about what they need to survive (for example, food, water, oxygen) and point out that many of these requirements are abiotic.
- **Students may be somewhat familiar with the water cycle, but may believe that other components are static; that is, they do not move around in our environment.** Point out, for example, that carbon naturally cycles into and out of the atmosphere. Its movement is not caused by humans, but our actions affect the rate at which it moves, and thus upset the balance.
  - We can counterbalance our carbon emissions by carbon sequestering and with carbon taxes and carbon offsets. Encourage students to investigate the details of the different types of carbon offsets that are available, for example, where the project will be located, and how students can be assured that any projects they invest in will remain in place for a sufficient time period. For example, seedlings purchased as part of a carbon offset program may be destroyed in five years for a new shopping mall. Point out that instead of paying a "tax" for our indulgences, it may be more effective to make and demand better choices.

Background Knowledge

Easter Island was populated from the west by Polynesians. While the human population probably contributed to most of the deforestation, due to the island's fairly southerly latitude, it may also have been influenced by a climate change event called the Little Ice Age. It is often assumed that the population's drastic decline on Easter Island was due to starvation; however, the islanders were also the target of Peruvian slavers in the 1860s.

The west coast has a great variety of hummingbirds; in Ontario, we usually only see the ruby-throated hummingbird. Only the male has the distinct red throat; the female is iridescent green with a white throat. Occasionally a rufous hummingbird will stray east of the Rockies and may be seen in the fall. The male has an orange/red head and the female looks similar to the female ruby-throated hummingbird but with orange/red flanks. If you want to attract hummingbirds to your schoolyard, you need to put out a feeder in mid- to late April when they are returning. Be sure to have a lot of red flowers around.

Although many fungi have a symbiotic relationship with plants, not all fungi are beneficial to trees and plants. Beneficial fungi such as Basidiomycota, Ascomycota, and Zygamycota produce what are called mycorrhiza—fine hair-like strands that bond to the roots of plants, assisting them with water and nutrient uptake. Other fungi such as Armillaria are pathogens and cause root rot, among other symptoms. Armillaria can often be identified by mushrooms growing at the base of trees, usually with red or honey-coloured caps.

If you are going to a rock concert or another event, you may be asked to purchase carbon offsets to help counterbalance the band's carbon emissions from putting on an elaborate show and travelling around on tour. Carbon offsets may include investing in renewable energy production such as wind farms, or they may also include investing in forestry projects. Before spending money purchasing carbon offsets, it is wise to consider what they will be used for.

Living things depend on biotic and abiotic resources. A population will grow only as fast as its most limiting resource will allow. For example, algae in a pond may have access to a lot of water and sunlight, but limited access to phosphorus will slow down their growth. If phosphorus is dumped into the pond, the algae will grow until another resource limits their growth. Often this rapid growth upsets the balance of the ecosystem. An analogy for limited nutrients is a class barbecue. Imagine that you are going to host a barbecue for the entire class, and you are planning to serve cheeseburgers. There are 30 students in your class. You brought 31 frozen burgers, 25 burger buns, and 12 slices of cheese. Although there are more burgers than students, you can only serve 12 cheeseburgers because there are only 12 slices of cheese. The cheese is the limiting nutrient. Analogies of this sort are very beneficial to English language learners.

Literacy Support

Using the Text

- ELL The geography of North America may be very new to many English language learners. A large wall map of the world and of North America are essential teaching aids. Use these maps prior to reading this section to set the physical context for English language learners.

Before Reading

- Have students preview the text features, looking for headings and highlighted words. In pairs, have them predict what the main ideas of the section will be.
- ELL To help English language learners use the text features to navigate the textbook, have a scavenger hunt. Ask students to find a feature that
  - helps to understand the meaning of a word (boxes in the margin).
  - explains a diagram (a caption).
  - tells a big idea (a head or subhead).
  - summarizes important information (the section summary).

During Reading

- Have students create a personal glossary by making a three-column table, and listing new terms as they encounter them in the textbook, in the left column of their table. Students can write the definition for each term in the next column, and draw a diagram to represent the term in the third column. Tell them to pay attention to the Key Terms in sidebars and highlighted in the textbook, and to identify base words that will help them find the meanings of other words (for example, the base word *bio* means life, and can help define biology, biosphere, and so on). Students can continue to build this glossary as they work through the rest of the unit, and the rest of the course.
- ELL Instead of a glossary in chart form, English language learners can make flash cards with a picture on one side of the card and a definition on the other side. They can then use these cards to review new vocabulary.
- ELL To help English language learners relate to the concept of migration, discuss what migration has meant to them. Talk about how many families move to new locations for a variety of reasons. Listing the advantages that exist in Canada helps all students understand that humans migrate as well as animals often for similar reasons.

After Reading

- To consolidate their learning, have students create a word web or another graphic organizer to show the relationship between two key concepts they learned about in the section. They can use this graphic organizer as a starting point for the graphic organizer they develop in the Chapter Review.

Using the Images

- Before reading the passage on page 7, have students describe the image in Figure 1.1, on page 7. You can prompt them with questions such as, "How large are the statues?" "What does the vegetation look like?" "How could the statues have been put in place?" Describing the image will help to engage spatial learners.
- Connect to students' personal experience. For Figure 1.2, on page 8, ask students to imagine they are holding a hummingbird in their hand and to describe how large the hummingbird is in comparison to their hand.
- DI Table 1.2, Abiotic Characteristics of an Ecosystem, on page 12, shows an example of how students can set up their own glossaries, which spatial learners may find helpful.
- Have students complete **BLM 1-9 The Nitrogen Cycle,** to summarize the content of Figure 1.6, on page 16. Then have students create their own diagram of the carbon cycle based on page 15 of the textbook.
- ELL Use **BLM 1-10 The Phosphorus Cycle**, based on Figure 1.8, on page 18, to help students predict and explain what will happen in each stage based on what they already know. On **BLM 1-10,** students can record what they think is happening in the first column for each number in the phosphorus cycle diagram. They can then use the Think, Pair, Share strategy to refine their prediction and record that refined version in the next column, and in the third column verify what is actually happening, using the textbook.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check questions, pages 9, 19	Students • explain how the elements of an ecosystem interact • describe the process of eutrophication.	To help students identify the cause-and-effect relationships involved in eutrophication, have them complete **BLM 1-11 Cause and Effect.**
Section 1.1 Review questions, page 20	Students describe the role nutrient cycles play in a balanced ecosystem, and what can cause ecosystems to become unbalanced.	**Play a game** Divide the class into teams with members of diverse strengths and abilities. Each team must submit five questions similar to those in the review, with answers. Teams take turns choosing questions from other groups and answering them. Students can use notes for the Section Review to help them. Set a time limit for students to come up with an answer. Allow opportunities to "phone a friend."
Activity 1-2, What Symbol Would You Choose?, page 11 Create a Poster	Symbol meets the criteria listed, clearly represents one or more of today's issues, and increases awareness for the future.	Students may feel uncomfortable with their own artistic skills. Show them exemplars of varying artistic ability that all meet the criteria for the assignment and that would achieve the same level (3+ or 4). Allow students to use alternative media, such as computer drawing applications, or use mini whiteboards. The lack of permanence of mini whiteboards makes them less intimidating for students.

Instructional Strategies

- The Mystery of Easter Island is an engaging introduction to the idea of sustainability. After students have read about Easter Island, do a concept attainment activity for sustainability (see **BLM 1-6 What Is Sustainable?**). Give students a sample data set with examples of activities that do promote sustainable environments and activities that do not promote sustainable environments. Then give students several "testers," or examples, which they will have to decide for themselves where to place. A class discussion after this activity can help reveal that the answers are not always clear, but that there are several common factors to be considered in making each decision.
- Compare and contrast the biotic and abiotic components of the Canadian and Mexican ecosystems required to sustain the ruby-throated hummingbird population. This comparison can be done individually, in groups on whiteboards or chart paper, or as a discussion at the board.
- Have students do a jigsaw brainstorming activity before reading the Abiotic Characteristics of an Ecosystem section. Arrange students into five home groups. Within each group, have students choose a colour—blue, red, white, green, or black. Then have students gather into new groups of the same colour (all the greens together, for example). Assign each colour one characteristic (for example, white = light, red = oxygen, and so on). Have each new group brainstorm why their characteristic is important and its effects on sustainability. Each individual should record the information on a card. Then have students return to their home groups and combine the information from all the cards on a larger piece of paper to create a table summarizing all of the characteristics of an ecosystem. When this task is done, do some round-robin sharing, and then compare the groups' results to Table 1.2, Abiotic Characteristics of an Ecosystem, on page 12 of the student textbook.
- DI Spatial learners could create a graphic organizer to take notes if desired.
- ELL If necessary, appoint a student in each group to scribe for English language learners so that they will have accurate notes to take back to their home group.
- DI Bodily-kinesthetic learners might enjoy acting out the different nutrient cycles. Divide the class into groups and assign each group one of the nutrient cycles. Each skit should emphasize at least five stages in the cycle and should address the human impact on the cycle. Students could choose to present in the form of a talk show, a series of tableaus, or a "wildlife" documentary (for example, The Carbon Hunter).
- As an alternative activity, students could create a passport. Give students a blank template for one of the cycles (**BLM 1-7 The Water Cycle; BLM 1-8 The Carbon Cycle;** and **BLM 1-9 The Nitrogen Cycle**). Create stations around the classroom where students can collect stamps or stickers to complete their passports. At each station, include directions to the station where students can find the next sticker or stamp. Different tour groups (Carbons, Nitrogens, or Phosphoruses) will follow slightly different routes in the classroom (or around the school).

Activity 1-2 What Symbol Would You Choose? (Student textbook page 11)

Pedagogical Purpose

One of the big ideas of this unit is that people are responsible for regulating their impact on the sustainability of ecosystems. The first step in this process is to increase public awareness. One simple and effective way to do this is to create a symbol to spark public interest. In this activity, students activate the understandings of environmental issues and human effects on the environment that they will build on in this unit to design such a symbol.

Planning		
Materials	1 sheet construction paper Coloured markers Scissors	Tape or glue Internet access Computer lab
Time	20 min in class: 10 min to create a symbol and 10 min to discuss	

Background

Successful symbols are simple and easily understood, with a clear connection to the idea for which they stand, for example, the World Wildlife Fund's panda. Students may all choose to represent a different environmental issue, and so may produce different symbols.

Activity Notes and Troubleshooting

- Give students a time limit, if the assignment is an opener for discussion. "You have 10 min; it does not have to be a masterpiece."
- Make sure the criteria for the symbols are clear:
  - one symbol for current environmental problems
  - one symbol for a future of increased environmental awareness
  - no words are to be used
- Assign some time (for example, a 10-min period or some time at the beginning of class the following day) for sharing ideas.
- Discuss how the questions are to be answered, in notebooks for homework or as a discussion.
- Instead of paper, use small letter-sized whiteboards (the kind students stick in their lockers), which are available at dollar stores. Whiteboards suggest less permanence, reduce stress, and evoke greater participation.
- Some students may be more comfortable using a computer drawing application instead of drawing by hand.

Additional Support

- DI This is predominantly a spatial activity. To incorporate interpersonal and bodily-kinesthetic learning styles, encourage sharing and discussing of the results.
- ELL English language learners may prefer to use the Internet to refer to familiar symbols from their own culture for inspiration and clarification. They may also need more examples of what a symbol is versus a logo. Encourage all students to not include words in their symbol, and to try to make their symbol universally meaningful to all cultures.

Answers

1. Students' designs may differ in colour or size, and may be biotic factors or abiotic factors.
2. Students' symbols might show a very one-sided relationship, such as a balance scale with one side much heavier than the other.

Learning Check Answers (Student textbook page 9)

1. They used trees to make wooden frames to move and erect the statues, and to burn wood. They also cleared forests for agriculture.
2. *Sustain* means to endure and to support.
3. Ruby-throated hummingbirds live part of the year in a tropical rain forest, and then they stop in many ecosystems along the way as they migrate north in the spring. They spend the summer in meadows and wetlands in Canada.
4. Biotic parts could include people, pets, houseplants, crops, grass, insects, and bacteria.

Learning Check Answers (Student textbook page 19)

5. Eutrophication is a process in which nutrient levels in aquatic ecosystems increase, leading to an increase in the populations of primary producers.
6. Phosphorus was found to be the main cause of eutrophication.
7. fertilizer in run-off
8. In order to get the lawn looking healthy, you probably added fertilizer. The fertilizer improved the lawn, but it also leached into the pond, causing eutrophication and an algae bloom that depleted the oxygen and therefore killed the fish.

Section 1.1 Review Answers (Student textbook page 20)

Please also see **BLM 1-12 Section 1.1 Review (Alternative Format).**

1. a healthy environment that endures and supports a variety of organisms
2. Once the forest ecosystem on Easter Island was gone, all of the resources and processes associated with trees, such as lumber for building or fuel, and protection from erosion, also disappeared.
3. Students can describe any three of the following: water, light, oxygen, nutrients, and soil. Accept any reasonable response regarding the effect that human activity could have on the abiotic part.
4. Students' drawings should be similar to Figure 1.6, on page 16. Bacteria convert nitrogen from the atmosphere into forms that other living things can use.
5. **a.** Humans can add excess phosphorus to aquatic ecosystems through fertilizer in run-off. Phosphorus is naturally a limiting nutrient. When excess phosphorus reaches an aquatic ecosystem, the ecosystem becomes eutrophic.
   b. Farmers could participate in the Environmental Farm Plan to help reduce fertilizer in run-off.
6. Answers will vary. Generally, scientific research in the areas of environmental toxins and nutrient pollution causing eutrophication led to changes in laws designed to counter the problems that science revealed.
7. Answers will vary. Sample answer: Farmers may use less fertilizer or not apply it right before it rains. Fertilizer companies could make changes to their product, which may make it less destructive to an ecosystem. Governments could help educate people on the dangers of excess nutrients and require farmers to follow rules that would reduce the amount of fertilizer in run-off or require fertilizer companies to reduce the harmful chemicals in their fertilizers. Consumers can support farmers who are actively working to reduce this problem by buying their products.
8. Phosphorous levels decreased from the late 1960s until the early 1980s. From 1985 to the late 1990s, phosphorous levels increased almost to their 1960s levels.

Section 1.2 The Biosphere and Energy

(Student textbook pages 21 to 27)

Sustainable Ecosystems: Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems
- **B3.2** describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems, and explain how human activities can disrupt the balance achieved by these processes

In this section, students will learn about the relationship of energy to the biosphere. Students will describe photosynthesis and the transfer of energy through trophic levels. Students will also learn how bioaccumulation of certain manufactured toxins have affected bird populations in local ecosystems.

Common Misconceptions

- **Students may be under the impression that the boreal and temperate forests perform the majority of Earth's photosynthesis.** In fact, together they contribute less than 20 percent, as shown in Figure 1.14, on student textbook page 23.
- **Students may think that the amount of photosynthesis done by phytoplankton provides a buffer that regulates carbon dioxide (CO_2) consumption and oxygen (O_2) production on Earth.** In reality, this system is at serious risk due to overfishing of large predator species such as tuna, marlin, and shark, which leads to an overpopulation of smaller species that directly feed on phytoplankton.
- **Students may think that toxic chemicals have now been banned and are no longer in use.** Although we often speak of DDT being banned in the 1970s, DDT was not banned in Canada at the same time as it was in the United States. Rather, it was phased out in the mid 1970s, registration for use was discontinued in 1985, and it was not until 1990 that the use of DDT became a violation of the pest control act. While PCB production was banned across North America in 1977, the use of PCBs is still being phased out. PCBs are still in use in many electrical applications, such as transformers and capacitors. There are many other toxins that bioaccumulate in our environment, which are not yet banned or are only minimally controlled, such as mercury.

Background Knowledge

We tend to focus on humans' ecological impact on the lives of organisms that we can see, such as birds. What is neither well studied nor understood is how the ecosystems of our oceans have a direct impact on humans.

It is estimated that shark populations have declined by almost 90 percent since the 1970s due to overfishing. Sharks are the top predator in the oceans so they directly control the populations of smaller fish species. Most shark species prey on smaller fish that are direct consumers of phytoplankton. Therefore, as shark populations decrease, the populations of smaller fish increase, and the amount of photoplankton decreases sharply. The food chain that links sharks and photoplankton is very short, and the effects of any imbalance on oxygen and carbon dioxide levels are felt quickly.

DDT is still in production and in use today in some parts of the world. It is used to control insect-borne tropical diseases such as malaria. Its use to control the insects that carry the disease is very controversial, but it can be argued that DDT has helped to save millions of lives. DDT is fat soluble, so it can build up in fatty tissue, and it causes the thinning of eggshells in fish-eating birds. The mechanism of human toxicity is not as well understood, although severe overexposure will have adverse effects, most likely neurological.

The effect of PCBs on humans is more clearly understood than that of DDT. There have been more direct links drawn to reproductive and cognitive disorders, as well as cancer. It is interesting to note that although the production of PCBs has been banned, the use of PCBs has not yet been banned, likely because PCBs were used as coolant and lubricant in large transformers that are still in use. Other uses for PCBs have included plasticizers and pesticide extenders. The disposal of PCBs is extremely difficult. When incinerated, one of the byproducts is dioxin. Dioxin is one of the most toxic environmental contaminants known.

Mercury still seems to get more coverage in the media than DDT and PCBs, and students may ask about it. The use of mercury is regulated, but it is certainly not banned. You can still get dental fillings that have mercury in them, and mercury does enter the ecosystem naturally. By far, the large majority of mercury entering the food chain is from atmospheric mercury, the result of burning fossil fuels—coal in particular. The mercury then enters our waterways as rain and bioaccumulates in fish, including fish that is caught as food.

Literacy Support

Using the Text

- Preview the Key Terms with English language learners before reading. Discuss the meanings of the root words *synthesis, accumulation,* and *mass.* Draw students' attention to words they already know that share prefixes with each Key Term, for example, *photo…, bio…*). Then have students make connections to predict the meaning of each Key Term.

Before Reading

- To set students up to make connections to prior learning, use an Anticipation Guide for this section (see **BLM 1-13 The Biosphere and Energy**). Students are given a series of statements related to the section. Before reading the section, students indicate whether they agree or disagree with each statement. You could read each statement aloud for English language learners, and allow them sufficient time to process what you have said, ask questions, and record their answers. Arrange students in pairs to discuss which statements they agree with and why. Encourage English language learners to ask their parters for clarification about what is being read aloud, when needed.

During Reading

- Students should have their anticipation guide beside them as they read, to record corresponding page numbers from the textbook for each statement on the guide.
- Choose some confident readers to read parts of the section aloud for the class.
  - To enable less confident readers to participate, pre-assign some short passages for them to practise before reading aloud.
  - ELL Pause the reading at any time to direct students to record an important point, to discuss a point, to ensure that English language learners understand a complicated sentence or new term, or to redirect the reading.

After Reading

- Have students make connections to prior learning by revising their agree/disagree ranking. Students should also correct or revise the statements with which they disagree. Students can share their revisions with their learning partner. Using mini-whiteboards, chart paper, or the chalkboard, have each pair of students share one of their revisions with the class.

Using the Images

- For some students, it is difficult to connect a graphic to an actual cross section. For Figure 1.12, on page 22, provide students with some actual views of a leaf cross-section, either by using an LCD projector or by setting up some pre-prepared slides or microviewers. Have students locate the labelled parts of the leaf cross-section in the view you provide.
- Have students reconstruct the bar graph from Figure 1.14, on page 23, into two circle graphs, one showing the percentage of Earth's surface area, and one showing the percentage of Earth's photosynthesis. This task will allow students to internalize the data and practise their graphing skills. Then have students discuss why the data are displayed in the textbook as a bar graph.

- For Figure 1.15, on page 24, have students construct their own pyramids with data supplied (see **BLM 1-14 A Food Pyramid**). This activity is designed to walk students through the process of constructing an Energy Pyramid. To reinforce the concept, students could complete **BLM 1-15 Consumers and Producers**, or **BLM 1-16 Consumers and Producers (Alternative Version).**
- Now that students have had practice constructing Energy Pyramids, have them construct an upside down pyramid based on the data in Figure 1.16, on page 25, to illustrate bioaccumulation.
- To reinforce the effect of biomagnification on PCB concentration, students could complete the calculations on **BLM 1-17 Understanding the Mathematics of Biomagnification.**

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check questions, page 23	Students correctly describe the process of photosynthesis, including inputs, outputs, roles of the leaf parts, and how it benefits us.	To reinforce the elements in the process of photosynthesis, make several cards, each one with a term to be guessed at the top, and a short list of words students are not allowed to use when giving clues, below it. Tape a card to each student's back. Students must ask their classmates to give clues in order to guess their own word. This activity will be appealing to the bodily-kinesthetic and interpersonal learners, as well as helpful for English language learners. Students can complete supplemental worksheet **BLM 1-18 Photosynthesis,** to help them organize the inputs, outputs, and other important elements of the process.
Section 1.2 Review questions, page 27	Students explain the process of photosynthesis (questions 1 and 2) and its importance (question 3). Students describe how energy and contaminants move through trophic levels (questions 5, 6, and 8).	Create a series of at least 30 cloze (fill-in-the-blank) statements related to photosynthesis and bioaccumulation. Provide students with a blank bingo template and a list of all the potential answers to the cloze statements. Students will randomly fill in the bingo template with 24 answers and include a free space in the middle. When students are ready, choose one cloze statement at a time and read it aloud. The first student who has five answers in a row yells "bingo!" and has you check if he or she is a winner.

Instructional Strategies

- DI Provide spatial learners with actual photographs of leaf cross-sections and plant cells. You can use pre-prepared slides, microviewers, or images from the Internet. Students should then draw and label their own diagrams from the slides.
- Have students use model kits to balance the photosynthesis equation. Divide the class into groups of four and provide each group with 6 carbons, 12 hydrogens, and 18 oxygens.
- DI For the logical-mathematical students, make this a problem-solving activity. Have groups build a glucose molecule, $C_6H_{12}O_6$, and then ask them to determine how many CO_2 molecules and water molecules were required to make the glucose.
- DI For bodily-kinesthetic learners, play an abbreviated version of the "Predator Game." Use four different colours of tokens to represent four trophic levels. Designate approximately two thirds of the class primary producers, one quarter primary consumers, one sixth secondary consumers, and just one or two tertiary consumers. Give each primary producer 10 green tokens to represent the energy they store through photosynthesis.

- Have primary producers stand, and have direct primary consumers ask the primary producers for tokens. They may give all or some to each consumer. When all tokens have been transferred, invite primary consumers to trade the green tokens for white tokens, which represent the energy they gain by consuming plants, using a ratio of 5 green:1 white.
- Have primary consumers stand, and direct secondary consumers to ask them for their white tokens. When all tokens are transferred, invite secondary consumers to trade five white tokens for one red token, to represent the energy they gain by consuming animals.
- Finally, repeat the exchange with the one or two tertiary consumers asking secondary consumers for their tokens, then trading five for one blue token.
- Debrief the game by asking students to comment on what represented the energy transferred through trophic levels, and on what changed as the energy moved up from one level to the next.

- Enrichment—Have students do some supplemental research on the Internet about bioaccumulation, or provide students with some articles or websites you have found. Students can research DDT or PCBs to find out the history, and current locations, of their use. Once students have done some brief research, divide the class into groups of four and have students perform quick debates. An example resolution statement could be the following: Be it resolved that DDT should be banned globally.
  - In one style of academic debate, each group of four has two A's and two B's. The A's take the pro position, and the B's take con. Each side debates for a maximum time length of 2 min. English language learners may require some time to prepare the language they will need for this debate and should have the opportunity to rehearse.
  - Once both sides have had a turn, all the A's gather at one side of the room, and all the B's gather at the other side, to share information briefly.
  - Have the groups return to their tables, but rotate the B's around the room so each pair of A's is debating with a new pair of B's.
  - Repeat the debates, but this time the B's are pro and the A's are con.
  - This activity should appeal to the linguistic and interpersonal learners. You can incorporate a literacy component by asking students to write a short position paper or letter to the editor voicing their personal opinion after the debate has concluded. Provide English language learners with sentence starters to use as a scaffold for their writing. Be sure to offer ample practice to English laguage learners prior to having them present their positions to others.

Learning Check Answers (Student textbook page 23)

1. Chlorophyll is the pigment that gives leaves their green colour and it uses energy from the Sun to assemble sugar molecules from water and carbon dioxide in the process of photosynthesis. *Chloros* means green and *phyllon* means leaf.
2. carbon dioxide + water + light energy → sugar + oxygen
   Carbon dioxide comes from the atmosphere. Water comes from the soil. Light energy comes from the Sun.
3. Drawings should include details and labels of stomata. If stomata were damaged, gas exchange could not occur.
4. During the winter, we continue to be able to breathe oxygen, even though very little oxygen is being released in Canada from plants. About 30 percent of the world's photosynthesis occurs in tropical forests. Wind moves air around Earth, and it is likely that some of the oxygen we breathe in January in Canada has been generated by photosynthesis in tropical forests.

Section 1.2 Review Answers (Student textbook page 27)

Please also see **BLM 1-19 Section 1.2 Review (Alternative Format).**

1. In the process of photosynthesis, chlorophyll in plant leaves receives solar energy and uses it to assemble sugar molecules from water and carbon dioxide. Besides sugar, oxygen is also produced by photosynthesis.
2. The three chemical elements that are the building blocks of carbohydrates are carbon, oxygen, and hydrogen.
3. Students' answers will vary, but they should explain how the process of photosynthesis is crucial to life on Earth because it puts together carbon, hydrogen, and oxygen to make sugar, which is life's universal energy supply.
4. A producer is an organism that can make its own food. A consumer cannot make its own food. Consumers must eat other organisms to get the matter and energy they need to survive.
5. bunchgrass: 2543 energy units
   grasshopper: 254.3 energy units
   spotted frog: 25.43 energy units
   red-tailed hawk: 2.543 energy units
6. Most of the energy in organisms is used by them to function, some is lost as waste, and some is lost as heat. Therefore, most energy cannot get transferred to the next trophic level.
7. Bioaccumulation: the toxins do not harm the organism. Example: a monarch butterfly ingested toxins from the milkweed that it ate as a caterpillar. The toxins do not harm the butterfly, but the butterfly would be poisonous to eat.

   Biomagnification: the concentration of toxins increases as it moves from one trophic level to the next, so that the animals at higher levels contain many more toxins, and may be affected by them. Example: DDT affecting reproduction in fish-eating birds.

   Both: processes in which toxins are ingested more quickly than they are eliminated; result in accumulations of toxins.
8. I would expect the larger fish to have more chemicals in their tissues. The smaller fish may get some chemicals in their bodies by eating zooplankton. Since the larger fish eat the smaller fish, they probably have higher levels of toxins due to biomagnification.

Section 1.3 Extracting Energy from Biomass

(Student textbook pages 28 to 36)

In this section, students will describe the processes of cellular respiration and fermentation. Students will identify factors that have contributed to acid rain, and explain how acid rain has impacted the viability of selected ecosystems. They will also analyze and represent graphically the effectiveness of recycling programs in Ontario.

Common Misconceptions

- **It was once common practice to remove plants from hospital rooms at night. It was thought that at night, the plants removed the oxygen from the room and produced carbon dioxide. During the day, plants were thought to add oxygen to the room because of photosynthesis.** We now know that the amounts of oxygen and carbon dioxide produced by the plants are not sufficient to be of any harm or benefit to patients.
  - We also now know that cellular respiration takes place both during the day and at night.
- **Students often link together the greenhouse effect and ozone depletion.** In fact, they are two entirely separate effects. Ozone depletion does not cause global warming, and the greenhouse effect does not cause ozone depletion. Ozone in the upper atmosphere contributes to the greenhouse effect, but the ozone produced by humans only becomes smog; it does not reach the upper atmosphere. Ozone depletion is caused by CFCs, chlorofluorocarbons, human-made refrigerants, and propellants.
- **Students may think that landfills will slowly decompose all the garbage and eventually convert the garbage to soil and useable land.** While landfills do slowly decompose some garbage, they are not giant compost sites, which is often the assumption. Landfills are intended for long-term garbage storage, while some of the garbage does break down and produce methane gas. Landfills are designed to "seal" in the waste by covering it in layers of soil, which slows the decomposition by cutting off oxygen.
  - Landfills are designed to be land reclamation projects—a completed landfill is eventually turned into parkland or a golf course. Problems with leachate usually prevent landfills from having housing or office space built on them.
- **Some students believe that landfills are an untapped source of methane that until now has been underutilized. There is also some concern that landfills will not produce significant amounts of methane due to recent green-bin diversion programs, as there may not be enough organic material to decompose.** While landfills do produce some methane, they are not intended to function as a major energy source.
- **Students may believe that the agreement between Canada and the United States in the 1980s to reduce acid-rain-causing emissions has caused the significant decrease in acid rain.** However, it is difficult to assess the effectiveness of acid-rain-reduction programs when many of the major plants and industries responsible for sulfur dioxide and nitrogen dioxide emissions shut down entirely. It is difficult to say whether the initiatives that started in the 1980s, or our economic climate, has been responsible for the reduction in acid rain.

Sustainable Ecosystems: Specific Expectations

- **B1.2** evaluate the effectiveness of government initiatives in Canada, and/or the efforts of societal groups or non-governmental organizations, such as Aboriginal communities, environmental groups, or student organizations, with respect to an environmental issue that affects the sustainability of terrestrial or aquatic ecosystems
- **B2.3** plan and conduct an investigation, involving both inquiry and research, into how a human activity affects soil composition or soil fertility, and, extrapolating from the data and information gathered, explain the impact of this activity on the sustainability of terrestrial ecosystems
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Background Knowledge

All plants and animals perform cellular respiration. Plants produce glucose from photosynthesis and animals acquire glucose from consuming plants and other animals. Energy is produced with the addition of oxygen, and the other product of cellular respiration includes carbon dioxide. To eliminate the carbon dioxide that we produce through cellular respiration, we exhale it through our lungs.

Greenhouse gasses include nitrous oxide (N_2O), methane (CH_4), oxygen (O_2), ozone (O_3), water vapour (H_2O), and carbon dioxide (CO_2). Sources for atmospheric carbon dioxide include decaying vegetation, volcanic eruptions, exhalations of animals, deforestation, and the burning of fossil fuels.

There has been extensive scientific debate over the use of biofuels as a supplement or replacement for fossil fuels. The reasoning behind the debate is that the growing plants will remove carbon dioxide before they are converted to fuel, which in effect counterbalances the carbon dioxide emissions when finally burned. Exactly how much arable land would be needed to produce biofuels is still not clear, and this question has generated the food vs. fuel debate. Many farmers who should be growing crops to feed their communities are often more willing to grow crops for biofuels, as they can make a larger profit doing so. It has been speculated that the increasing interest in biofuel production has led to a global food shortage. Nevertheless, there have been successful and balanced programs where the stems and stocks left over from a harvested crop are turned into biofuel.

Visit **www.scienceontario.ca** for more information about the Kyoto Protocol and Canada's Climate Change Plan.

Landfills are essentially garbage-storage facilities. They are usually lined to prevent leachate from leaking into ground water. The leachate that develops in landfills contains many toxic organic compounds, many of which come from household products. Leachate is usually drained off the bottom of a landfill and pumped into a separate pond. The Fresh Kills Landfill on Staten Island is reported to be the largest human-made structure on Earth. The Fresh Kills Landfill is now closed and plans are underway to convert it into a municipal park.

Ontario regulations have made the collection of methane from new landfills mandatory.

Damage caused by acid rain costs millions of dollars per year. Some research suggests that acid rain may also be a contributing factor in asthma, Alzheimer's, and cancer.

Literacy Support

Using the Text

- ELL To preview the section with English language learners, return to the web you created at the beginning of this unit. Add ideas for Sections 1.1 and 1.2 to the web, and introduce the Key Terms for this section, describing how they relate to the concepts already on the web.

Before Reading

- To help students connect to prior knowledge, create a K-W-L chart for this section on the chalkboard.

Topic	What I **Know**	What I **Want** to Know	What I have **Learned**
Respiration Greenhouse effect Biomass and fuel Landfills Acid rain			

  - Work with students to fill in the first two columns of their charts, showing what they already know about each topic and what they want to learn.

During Reading

- Students should fill in the last column for themselves, showing what they have learned from the textbook. Students may read the textbook alone or aloud in a group. For some subsections, you may decide to present the information that is in the textbook to the class yourself.
- ELL Provide English language learners with sticky notes. They can use them to indicate words or ideas that they do not understand as they read. Later, discuss these words or phrases with the students.

After Reading

- Have students identify items about which they wanted to know, but to which they did not find answers in the textbook, and items about which they thought they knew, but that changed after reading the textbook.
- Students should compare charts with a partner and try to help each other find the answers to the things about which each student wanted to know.
- Have each pair share with the class one thing they learned, and one thing they still want to learn.

Using the Images

- Referring to Figure 1.19, on page 29, direct students to create their own graphic organizer for photosynthesis and respiration. The graphic organizer could take the form of a concept map. Have students connect the following concepts and terms: carbon dioxide, green plants, decay, fossil fuel, glucose, animals, oxygen, and water. The words they should use along the connecting lines would include combustion, respiration, and photosynthesis.
- For Figure 1.21, on page 30, ask students to describe the correlation between carbon dioxide concentration and global temperature. Have students use **BLM 1-20 Carbon Dioxide and Temperature,** to predict what the values will be in the following 10 and 20 years.
- Ask students to create their own table similar to Table 1.3, Reducing Carbon Dioxide in the Atmosphere, on page 31, which includes actions they could take at home and at school to reduce carbon dioxide in the atmosphere. Their tables should follow the same format as Table 1.3 with a description in the middle column and an accompanying picture in the right column.
- For Figure 1.24, on page 34, set up a demonstration on the lab bench. Include items similar to those listed in Figure 1.24 and arrange them in order. Display small amounts of each substance in beakers and test each one with universal pH paper, or invite a student to do some of the testing. Ensure that protective gloves are worn, and that nothing is spilled or splashed.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check questions, page 31	Answers include an accurate description of respiration, a link from the Sun to all energy on Earth, and some effective ideas to reduce carbon dioxide emissions.	Form a value line in the classroom. At one end is "I understand the questions completely" and at the other end is "I do not understand any of the questions." Direct students to form a single-file line, with no bunching. When students have placed themselves along the line, fold the line in the middle, so that each student is facing another, as a pair. Now have the pairs explain their questions and answers to each other.
Section 1.3 Review questions, page 36	Answers show an understanding of how plants capture energy from the Sun, and how organisms use the energy through respiration, fermentation, or combustion. They also include evidence of the relationship between fossil fuel combustion, greenhouse gases, and acid rain.	Students can complete the flowchart on **BLM 1-22 Extracting Energy from Plants**, to help them understand the sequence of events related to extracting energy and the environmental effects of combustion.
Activity 1-3, Recycling in Ontario, page 32	The *x*- and *y*-axes are labelled correctly. Students have chosen an appropriate scale for the *x*-axis for all the data to fit. Students have chosen to draw two bar graphs using a different colour for each material. Students' descriptions of trends are based on their graphs and include some speculation about why recycling may be increasing or decreasing.	Have students work in pairs or groups of four to complete the graphs on graphing chart paper. They must agree on every decision the group makes, including how to label the axes, what scale to use, and how high each bar should be. Alternatively, have students work in a computer lab and complete the graphs using a spreadsheet. Students who are unsure of the most effective ways to display the data can try different types of graphs. The software should also take care of scaling the axes for them.

Instructional Strategies

- Ask students to recall "reverse engineering" photosynthesis, which they did in Section 1.2 using model kits. Arrange students into groups of four and have them construct all of the molecules for respiration: 1 glucose ($C_6H_{12}O_6$), 6 oxygen (O_2), 6 carbon dioxide (CO_2), and 6 water (H_2O). Each group will need one symbol or token representing an arrow and another symbol representing energy. This activity should appeal to bodily-kinesthetic and spatial learners. Ensure that students with these learning styles are distributed among the groups.
- DI To engage logical-mathematical thinking, have students arrange the balanced equation for cellular respiration on their table. In their notebooks, each student should write down the equation. Under the equation in their notebooks, students should create a table to summarize the number of atoms on each side of the equation.

Number of Atoms	Left Side	Right Side
Carbon Hydrogen Oxygen		

- DI To engage interpersonal and linguistic thinking, ask students to reflect on movies or documentaries they have seen, or articles they have read recently about the environment or global warming. Allow a few minutes for discussion. Then ask students to create a T-chart in their notebooks with the following title: Myths and Facts about the Greenhouse Effect. (This chart could be created on chart paper or the chalkboard). One column of the chart will be for the myths and the other will be for the facts. Have students record as many points as they can for each column, and then ask them to trade papers with a partner. The partners can add information or make corrections to the charts. Trade the papers one more time. Once papers have been

traded twice, students should return all papers to their original creators. Have students share some of the results with the class.

- DI Have linguistic learners create an editorial on alternative fuels. Tell students that an editorial states a point of view, and then supports it. Show them a couple of examples from a local newspaper or magazine. Students should compare and contrast two different fuels and their ability to reduce carbon emissions. Students should also comment on the social and economical impacts that the alternative fuels could have. Suggested topics could include biofuel, clean coal, landfill methane, and hydrogen fuel cells. They can use a copy of **BLM 1-21 Alternative Fuels,** as a template.
- Conduct a classroom debate about fermentation, methane, and landfills. Allow students some time to do research on the Internet. English language learners could conduct research in their first language. Each student should complete a graphic organizer to prepare for the debate on this topic: Be it resolved that the province should discontinue the use of landfills for waste management. Allow students to choose their own graphic organizer such as a Venn diagram, concept map, or T-chart. Conduct a brief and informal debate after students have completed their graphic organizers. This activity should appeal to the naturalistic, linguistic, and interpersonal learners.
- ELL Assign Learning Check questions that require less language output to English language learners. For example, question 3 requires students to list, which is easier than explaining or describing. Question 4 is more open-ended and will allow students to share the necessary content knowledge without requiring specific language.
- Enrichment—Have students do some independent research on how scrubbers work to reduce the amount of acid rain caused by industries. Ask students to complete a hand-drawn and labelled diagram showing how scrubbers work. Alternatively, bodily-kinesthetic and spatial learners may prefer to build a model.

Activity 1-3 Recycling in Ontario (Student textbook page 32)

Pedagogical Purpose

Graphing allows students to internalize the information and see relationships in it. By examining and manipulating the data, students find the information more meaningful.

Planning	
Materials	Graph paper Ruler Computer lab with spreadsheet software (optional) Coloured pencils
Time	20 min

Background

Students should notice that the amount of newspaper recycled had decreased. The amount recycled depends on many factors, such as that more people rely on alternative sources for their daily news, and that fewer people are buying newspapers.

Activity Notes and Troubleshooting

- Students can work independently.
- Students may have difficulty scaling the *y*-axis. Have them look at the greatest number that they will need to graph. For the first graph, the greatest number is 479 473, so the scale should go to 500 000.
- The graphs are intended to be bar graphs with three or four bars for each year—one bar for each material.
- Students can compare bar heights for the same material to identify trends or draw a line from the top centre of each bar to create a line graph.

Additional Support

- This activity could be completed in a group using markers and chart-sized graph paper. Have students work in groups of four, and have one pair of students work on the first graph, and the other pair work on the second graph.
- ELL Some English language learners may need to see a sample bar graph before they begin. Refer to Figure 1.27, on page 35. Discuss what the labels should be on the bar graph that they create, how many bars there might be, and so on.
- Students with weak mathematical or small-motor skills may be more comfortable using the computer to create the graphs. You may still have to walk them through setting up and labelling the axes by modelling the process, perhaps by using a projector.
- If students are using a computer, it will be easy for them to change the graphs from line to bar for comparison.

Answers

1. Students should notice that the trend for newspapers, tires, and electronic waste decreased. The data trend for glass, and aluminum and copper, increased and then decreased slightly. The recycling trend for cardboard and plastic increased.
2. Perhaps fewer people purchase newspapers. Instead they rely on the Internet and television for news. There has not been a recent surge in computer technology to cause people any need to upgrade. More people may be purchasing winter tires, causing both sets of tires to last longer because they are only used for half the year. Fewer products that are packaged in glass are available in the grocery store. Manufacturers may be switching to plastic packaging to save transportation costs.
3. The government could pass legislation making it mandatory for all communities to provide recycling pick-up for all residences. The government could also pass legislation for all apartment buildings to provide recycling bins for its tenants.

Learning Check Answers (Student textbook page 31)

1. Cellular respiration is a process in which oxygen and sugar are consumed and energy and carbon dioxide are produced.
2. The greenhouse effect occurs because greenhouse gases trap heat within Earth's atmosphere. This effect keeps Earth considerably warmer than it otherwise would be, allowing life to flourish.
3. Answers will vary, but should include the idea of ways to reduce the use of fossil fuels, such as carpooling, walking or biking instead of driving in a car, or turning off lights when you leave the room.
4. The energy used to operate a pen or a keyboard comes from the food we eat. That food includes energy-containing carbohydrates made by plants as well as additional energy sources in meals that include meat. Plants used photosynthesis to convert solar energy into the high-energy molecules of carbohydrates. Energy sources from meals that include meat came from animals' consumption of plants (or other animals that ate plants). The following example is the simplest route to show how the energy we use to operate a pen or a keyboard is traced back to the Sun:

   solar energy from the Sun → carbohydrate energy in the plant → energy available from the body to operate a pen or a keyboard

Section 1.3 Review Answers (Student textbook page 36)

Please also see **BLM 1-23 Section 1.3 Review (Alternative Format).**

1. Two processes that organisms use for energy extraction are fermentation and cellular respiration.
2. Oxygen is necessary for the aerobic breakdown of sugars.
3. Students' diagrams should be similar to Figure 1.22, on page 32 of the student textbook.
4. Humans have released much of the carbon dioxide that had been converted to biomass by ancient plants in the last 200 years or so (which seems sudden compared to the millions of years it took to make the carbon dioxide), by burning fossil fuels.
5. Nitrogen oxide and sulfur dioxide are released from burning fossil fuels and from acids that make precipitation acidic.
6. Since the pH of water in an acidic lake is between 4.0 and 5.0, none of these organisms would be able to survive.
7. Answers will vary and this question could lead to a debate. Presumably, students will recognize that they often make purchases based on price (and perhaps quality), but that as consumers, there may be other considerations based on environmental values.
8. Commuting by car uses fossil fuels that still produce oxides that tend to make precipitation acidic. This acidic precipitation can kill trees by interfering with their uptake of nutrients.

Plan Your Own Investigation 1-A Fertilizers and Algae Growth

(Student textbook page 37)

Pedagogical Purpose

Students will plan and conduct their own investigation into the effects of fertilizer on algae growth, with your support and direction. In this investigation, students will manipulate variables and describe the changes they have observed. This is students' first chance to develop important skills related to the investigation. They will build on the skills they develop here in other investigations and in the Unit Projects.

Planning	
Materials	Balance 50 mL graduated cylinder Five 250 mL beakers Algae culture (enough for 5 samples) Distilled water Marker Scoop Small funnel Liquid fertilizer that contains nitrogen and phosphorus (enough for 5 samples) 5 adhesive labels **BLM 1-24 Plan Your Own, Investigation 1-A Fertilizers and Algae Growth** (optional) **BLM G-23 Data Table** (optional)
Time	25–30 min for students to write a plan, set up a data table, and have the plan checked by you 10–15 min for each student or group to set up beakers with algae and fertilizer 1 week to monitor the experiment; it would be advisable to start the activity on a Monday.
Safety	• Fertilizer can burn sensitive skin, so instruct students not to touch the fertilizer, or provide gloves for students to use.

Background

This lab is intended to model the process of eutrophication. Nutrient levels in lakes and ponds increase from agricultural run-off, increasing the algae growth. The excess algae use much of the oxygen needed for other plants and animals in that ecosystem, causing them to die.

Activity Notes and Troubleshooting

- If this is the first unit of the year, order the fertilizer and algae early.
- If your school has a pond nearby, you may be able to collect algae from it.
- Read the investigation together. Have students identify the parts of this investigation that are different from activities within the sections. (There is more analysis and communication, there is a central question or hypothesis, and there is a chance to extend the investigation.)
- Designate a space in the classroom where students can leave their experiment and return to check on it.
- If students decide to apply the fertilizer over several days, set aside time each day for students to monitor their experiment.
- If the experiment is running over several days, set aside the equipment and materials for students to measure out their fertilizer as they need it.
- Make sure students understand the difference between dependent and independent variables, before they write their plans.

- As you review students' plans, ensure that they include the following:
  - a control beaker (algae with no fertilizer)
  - a plan for regular observations
  - several different amounts of fertilizer
  - a plan to observe and describe the amount of algae present (perhaps describing colour or opacity)
- If there is a limited supply of beakers, purchase some clear disposable plastic cups, which can be washed and reused.

Additional Support

- DI Intrapersonal learners can become overwhelmed when the whole class is out of their seats doing activities. As students set up their experiments, allow a limited number of groups to set up at a time. Have only one person from each group monitor the experiment each day. This person can be a different group member each day.
- ELL English language learners may have trouble distinguishing between independent and dependent variables. Use an example to illustrate the concept with something students will be familiar with, such as food or drink items.
  - For example, a student is purchasing juice bottles for herself and her friends. She purchases 5 bottles for $1.50 each, and the total cost is $7.50. The independent variable is the number of drinks purchased, and the dependent variable is the total cost—it *depends* on the number of drinks bought.
- ELL To ensure English language learners understand the instructions, have the class suggest simple verbs to replace the directions in the investigation. For example, *brainstorm* could be *list*, *carry out* could be *do*, and *analyze* could be *look at the parts*.

Answers

Analyze and Interpret

1. The independent variable was the amount of fertilizer added. The dependent variable was the algae growth.

2. Students should notice different amounts of algae growing in each beaker.

Conclude and Communicate

3. a. The number of producers would increase, except for deeper plants because the algae would decrease the amount of light reaching them.

b. Consumers of algae would increase for a short time until the oxygen levels became too low to support them.

c. The decomposer population would increase as plants and animals start to die off from the lack of oxygen.

4. Improvements might include the use of a control, and measuring the oxygen content in the water.

Extend Your Inquiry and Research Skills

5. After brief research, students should record in their notebooks why potassium is added to fertilizer and be able to answer this question in class. (Among other uses, it helps with the movement of starches, the formation of proteins, efficient water use, and efficient use of nitrogen.) On a test, students could be asked to design an investigation to determine the effects of potassium on plant growth and/or the ecosystem.

Inquiry Investigation 1-B The Chemistry of Photosynthesis

(Student textbook pages 38 and 39)

Pedagogical Purpose

In the investigation, students examine the change in pH of a system to provide evidence of photosynthesis.

Planning	
Materials	250 mL beaker Bromothymol solution 2 test tubes with stoppers 1 sheet black paper 2 freshwater plant sprigs (*Elodea* or a similar species) Water Drinking straw Test-tube rack Masking tape **BLM 1-25 Inquiry Investigation 1-B The Chemistry of Photosynthesis** (optional)
Time	15 min for students to set up plants and test tubes Unless a strong light source is used, it will take more than one period to see a colour change.
Safety	• Students should be cautious to not get the indicator solution on their hands, as it could make them quite ill. • Students should only blow into the test tube; if they ingest the indicator solution, they will become extremely ill. • Students should wear goggles and aprons to avoid splashing in their eyes and spilling on their clothes.

Background

Bromothymol solution is yellow when the pH is below 7, indicating an acidic solution, and blue when the pH is above 7. Students' breath forms a weak acidic solution. The evidence of photosynthesis occurs when the plants use the carbon dioxide in the water, moving the pH back to 7 and changing the indicator back to blue.

Activity Notes and Troubleshooting

- *Elodea* can be ordered from a local aquarium store. Because the demand for *Elodea* is seasonal, call the aquarium store well ahead of time to order it.
- *Hornwort* will work as well as *Elodea,* and it is a more durable plant.
- Depending on the availability of plant material, this activity should be done in groups or possibly as a demonstration.
- A very strong light source is needed; use a grow light on a plant stand. If a grow light is not available, this activity may take a full day.
- Large test tubes are preferred to accommodate the plants. Larger test tubes can be supported by an Erlenmeyer flask.
- Any indicator that changes around pH 7 will work, including phenolphthalein and bromocresol purple.

Additional Support

- Some students may wonder where these plants are used outside of the classroom. They are used most often in aquariums and backyard ponds to help oxygenate the water.
- ELL Appoint a confident reader to work with each English language learner. English language learners may wish to prepare a time line, a poster, or another product instead of a report in Extend Your Inquiry and Research Skills step 8.
- When students use straws, they are usually drinking. Demonstrate blowing bubbles with the straw, only touching your mouth to the dry end so as not to have any contact with the solution.

Answers

Analyze and Interpret

1. The gas added was carbon dioxide.
2. The gas created weak carbonic acid when mixed with the water. Acidic conditions change the colour of the blue indicator to yellow (when bromothymol solution is used).
3. In the uncovered test tube, students should have observed the indicator solution change back to blue. In the covered test tube, the indicator solution should have remained yellow.
4. In the uncovered test tube, the plant was able to perform photosynthesis and use the carbon dioxide in the water, therefore, changing the pH. In the covered test tube, the plant was unable to perform photosynthesis.

Conclude and Communicate

5. The control was the test tube covered with black paper.
6. Students' sketches should indicate carbon dioxide being exhaled by humans, absorbed by the water, and then consumed by the plant during photosynthesis. The sketch could also include the plant expelling carbon dioxide into the water during cellular respiration.

Extend Your Inquiry and Research Skills

7. An extension of this lab could be to investigate how much light exposure the plant needs to consume the carbon dioxide. Students could cover several test tubes containing plants and expose each one to different amounts of light. Students should be able to clearly write out the procedure, and be given enough time to conduct their inquiry, if possible.
8. Students will require time to research in the library and on the Internet. They should be able to produce a one-page report on one of the scientists listed.

Inquiry Investigation 1-C Soil-water Acidity and Plant Growth

(Student textbook pages 40 and 41)

Pedagogical Purpose

This inquiry allows students to investigate how human activity affects soil fertility. In this case, students are investigating the effects on plants of different acidity levels, resulting from acid rain.

Planning	
Materials	5 small plastic or paper cups Marker Tray Ruler Pencil 500 mL potting soil 50 mL graduated cylinder 5 stoppered Erlenmeyer flasks, containing water with pH levels of 3, 4, 5, 6, and 7 5 seeds (such as beans, radish, or Brassica) Grow light (optional) **BLM 1-26 Inquiry Investigation 1-C Soil-water Acidity and Plant Growth** (optional) **BLM G-23 Data Table** (optional)
Time	1–2 h of preparation by the teacher 15 min for students to plant and water the seeds, and to place the cups on the trays 2–4 weeks to complete the investigation 5 min each day to water, and to record growth
Safety	• Students must wear safety goggles and acid-resistant gloves. A lab apron is also recommended to protect clothing. • Acid solutions should be stored in a fume hood or acid cabinet when not in use. • Always pour acid into water, instead of the reverse.

Background

While acid rain contains sulfuric acid, it is will be easier for teachers to control the pH of their solutions using hydrochloric acid or acetic acid.

Activity Notes and Troubleshooting

- Start this activity early in the unit, preferably in the first or second week, in order to allow enough time for students to observe growth.
- Order seeds early, and purchase potting soil that has not been augmented with fertilizer.
- Prepare enough pH solution for students to water daily for at least two weeks, possibly three weeks. Each group will require approximately 150 mL of each solution.
- To prepare pH solutions, start with a solution of pH 3. Each subsequent pH is a dilution by a factor of 10. Use hydrochloric acid or acetic acid to prepare the solutions (they are monoprotic acids). A concentration of 0.001 mol/L will result in a pH of 3, 0.0001 mol/L will result in a pH of 4, and 0.00 001 mol/L will result in a pH of 5. Continue in this fashion until all of the solutions are prepared, and test each solution with a pH meter or indicator paper before dispensing. Clearly label, date, and initial the prepared solutions. If you prepare 2.5 L of pH 3, then you can use 250 mL of that solution to create 2.5 L of pH 4, and use 250 mL of the pH 4 solution to create 2.5 L of pH 5 solution, and so on.

- Take care in preparing the acid solutions. Wear proper safety equipment including goggles, acid-resistant gloves, and a lab coat. Always pour acid into water. If you are unsure how to dilute stock solutions, ask your department's chemistry teacher for assistance.
- Set aside an area of the classroom for students to conduct the lab; a plant stand with grow lights may be required.
- Have students work in pairs or groups, depending on the space and resources available.
- The procedure for preparing the plants is straightforward. Have a student read each step aloud as you demonstrate the step to the class.
- Radishes grow very quickly and provide the best results. If radishes are unavailable, black oil sunflower seed (from birdseed) will grow fairly quickly.
- Some plants will die prematurely. It may be acceptable for groups to merge or share data if this happens. Students will need enough data to analyze and make predictions.
- To conserve space in the classroom, save garden centre cell packs from your own gardening for students to start their plants in. Students can label the plants with craft sticks.
- It will be safe for students to take home plants grown in pH 6 or 7.

Additional Support

- Some students will become upset when their plants die, especially if they die prematurely or fail to germinate at all. You should have your own set of plants as backup, or allow groups to merge to ensure enough data are collected.

Answers

Analyze and Interpret

1. Answers will vary depending on results.
2. Radishes prefer a pH of 6.5 or higher for optimal growth. Students should have recorded the best results for pH 7, but may have seen good results for pH 6 as well.

Conclude and Communicate

3. Students' statements should reflect their results, and will most likely state that lower pH inhibits the growth of radishes. Please note that some plants prefer slightly acidic soils, including some types of berries.
4. Students' results should support the hypothesis that plants will grow best in neutral soil and not grow as well in soils with more acidity. If their results do not support their hypothesis, they must have hypothesized a different relationship, for example, that more acidity would lead to greater growth, or that more acidity would have no effect.

Extend Your Inquiry and Research Skills

5. Students could collect rain in the schoolyard and at their home and bring it into the classroom to test with universal pH paper. They should record the pH from several different rain events over a month. Ask, "Does the pH change on different days?" "What could be an explanation for your area?"
6. Students could conduct research in the library and on the Internet to identify the effects of rocks in neutralizing acid rain. Students could write a one-page report or fact sheet summarizing their findings.

Plan Your Own Investigation 1-D
Can a Plant Have Too Much Fertilizer? (Student textbook page 42)

Pedagogical Purpose

Based on what students have learned in this chapter, they should be able to make some predictions about the effects of fertilizer on plant growth. This activity provides an opportunity for students to design their own investigation, with teacher support, to support or refute their predictions.

Planning	
Materials	5 green pea seeds 750 mL soil Marker Fertilizer that contains nitrogen (enough for 3–5) Soil test kits for nitrogen 3–5 large cups Garden trawl Water **BLM 1-27 Plan Your Own Investigation 1-D Can a Plant Have Too Much Fertilizer?** (optional)
Time	15 min to create the data table and have a plan approved by you 20 min to plant the seeds 10 min to prepare the fertilizer 5 min daily to monitor the plants 2–4 weeks to collect the data
Safety	• Fertilizer can burn sensitive skin. Students should wear goggles and gloves when handling fertilizer.

Background

Fertilizer run-off from our lawns and farms is the major contributor to eutrophication. However, without fertilizer, we would not be able to grow enough food to support the current population of our planet. Plants will thrive within a range of fertilizer concentrations. Too little and they will not get enough nutrients. Too much and they will be damaged by the chemicals in it.

Activity Notes and Troubleshooting

- Teachers should start this activity early in the unit so students have enough time to collect and analyze the data.
- Purchase soil that has not been augmented with fertilizer.
- Set aside an area in the classroom for students to conduct the experiment and monitor it.
- You may want to start the seeds under a damp towel first; then students can plant the seeds that have germinated.
- Remind students that they should have a control as part of their plan.
- Students have a tendency to over-fertilize all of their specimens at the beginning, and then have no results at all. Read the directions on the fertilizer and the seed packages to determine the recommended amount. Have students try more than, and less than, this amount.

Additional Support

- ELL Write the terms *dependent variable, independent variable,* and *control* on the chalkboard. Discuss the meaning of each term, and record a definition or example beside each one.
- Students have a tendency to take plant mortality too seriously. If their plants die prematurely, students take this death as a personal failure. Allow enough time for students to start over if their plants die too early to collect enough data.
- Allow groups to merge or share data if some plants die early.

Answers

Analyze and Interpret

1. Answers will vary depending on students' results.

Conclude and Communicate

2. Too much fertilizer will have the opposite effect of what was intended. The fertilizer could run off and cause damage to surrounding gardens and ecosystems.

3. The trees could experience an unseasonable burst in growth; however, if too much fertilizer ran off, the roots could be burned and the tree would die.

Extend Your Inquiry and Research Skills

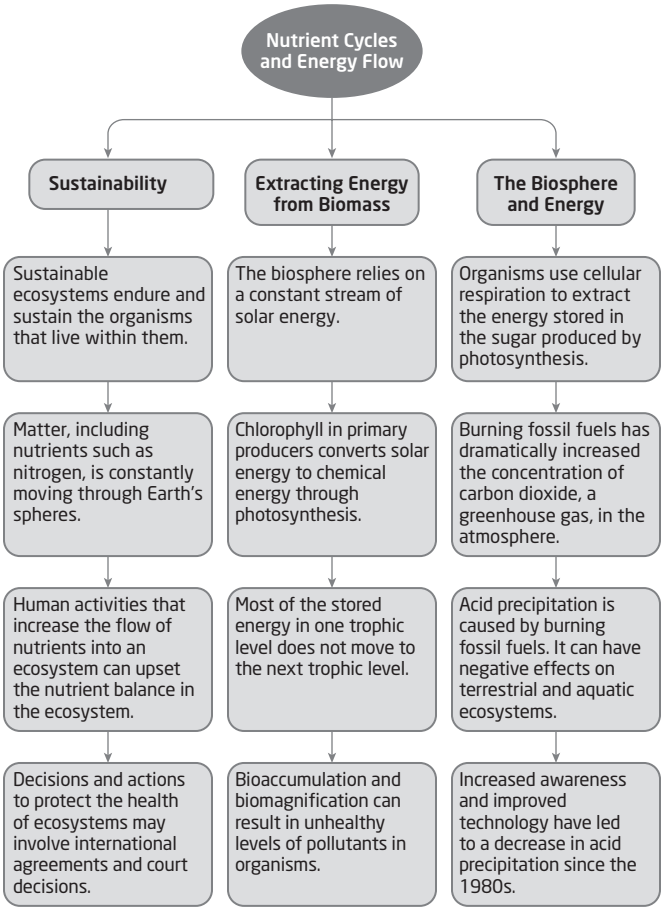
4. Students should be able to write the procedure for an investigation using compost instead of fertilizer. Students may also want to compare compost to fertilizer. Conducting this investigation may not be practical for all students, as they may not have composters at home. All students should be able to write a procedure for this type of inquiry, however.

Chapter Review Answers (Student textbook pages 44 and 45)

Please also see **BLM 1-28 Chapter 1 Review (Alternative Format).**

ELL Consider asking English language learners to group the review questions. Have the students pick the questions that they feel they can answer independently. Then have them select the questions for which they are not sure of what they are being asked. Clarify these questions by restating them. Let students select the questions for which they may need some language support, and finally, those questions for which they need peer support or reteaching.

Make Your Own Summary



Reviewing Key Terms

1. biosphere
2. eutrophication
3. ecosystem
4. photosynthesis
5. trophic level
6. cellular respiration
7. greenhouse effect

Knowledge and Understanding

8. Interacting parts of a biological community and its environment are called an ecosystem.
9. A sustainable ecosystem endures and supports, which means it maintains the same condition for a long period of time and supports various different organisms.
10. Aquatic ecosystems are responsible for 30 percent of the world's photosynthesis to produce oxygen. Animals in terrestrial ecosystems depend on this oxygen to survive.
11. Organisms, such as plants, which can make their own food, are called primary producers. They are at the first trophic level within the biosphere, are the only organisms that can produce sugar to store the Sun's energy, and are therefore important for all other organisms to survive.
12. Step 1: the Sun
    Step 2: evaporation
    Step 3: condensation
    Step 4: precipitation
    Step 5: run-off
    Arrows should follow a cycle through Steps 2, 3, 4, 5, and 2 again.
13. The Industrial Revolution resulted in an increase in the burning of fossil fuels—such as coal, petroleum, and natural gas—as a source of energy. Burning these fossil fuels adds carbon dioxide to the atmosphere.
14. Fossil fuels are decomposed plant and animal matter. The energy stored in fossil fuels comes from the photosynthesis that the plants underwent when they were alive.
15. Cellular respiration takes place when oxygen is present; fermentation takes place where oxygen is not present.
16. **a.** Three examples of greenhouse gases are water vapour, carbon dioxide, and methane.
    b. Greenhouse gases increase the temperature of the atmosphere by trapping heat. Earth would be much colder without greenhouse gases in the atmosphere. The increased burning of fossil fuels in the last few centuries has released a lot of carbon dioxide in the atmosphere, and many scientists believe that this increase has led to problems such as global warming.
17. **a.** The Kyoto Protocol is an agreement signed by over 180 countries to reduce greenhouse gas emissions. Countries are encouraged to reduce emissions or to plant trees in non-forested areas to remove carbon dioxide from the atmosphere.
    b. Through government initiatives, countries can reduce carbon dioxide in the atmosphere by reducing gas emissions, planting trees, protecting existing forests, and recycling.

Thinking and Investigation

18. Students' examples will vary. Example: The Brock West Landfill Site in Pickering, Ontario, collects and uses methane gas to generate electricity.

19. Students' answers will vary but might include the following: using vehicle transportation to get to school (petroleum); using electricity for lights, heat, air conditioning (coal, oil, and gas); and using manufactured product like cellphones, food packaging, and so on (coal, oil, and gas). Instead, students might walk, cycle, or carpool to school; turn off lights in rooms that they are not using; turn down the heat or the air conditioning; and try to buy products that have less packaging.

20. To reduce the emissions of sulfur dioxide and nitrogen oxide, individuals can ensure their cars meet the motor-vehicle emissions tests. Students may also mention that they can walk, cycle, carpool, or take public transit; they can travel by air as little as possible; and they can buy products that were produced locally.

Communication

21. Students' diagrams should be similar to Figure 1.6, on page 16 of the student textbook. Their diagrams should show that nitrogen is converted to usable forms, such as ammonium and nitrate, which are absorbed by plants. Organisms then eat the plants and use the nitrogen in their bodies. Excess nitrate and ammonium enter the lithosphere and become part of rocks. It does not return to the atmosphere for many centuries. Students should also show that fertilizer is a human factor that alters the balance of nutrients.

22. Students' e-mails will vary but should include the idea that trees and plants absorb carbon dioxide from the atmosphere and produce oxygen, so protecting forests and planting new trees is important.

23. first trophic level: Phytoplankton are primary producers.
second trophic level: Zooplankton are primary consumers.
third trophic level: Crabs are secondary consumers.
fourth trophic level: Sea otters are tertiary consumers.

24. Students' diagrams should be similar to Figure 1.3, on page 13 of the student textbook, including placing the biosphere all around everything.

25.

Reaction	Photosynthesis	Cellular respiration
Organisms in Which Reaction Occurs	Plants, algae, some bacteria	Plants, animals, fungi, other organisms
Reactants	Carbon dioxide, light	Oxygen, sugar
Products	Oxygen, sugar	Carbon dioxide, water
Is Energy Absorbed or Released?	Absorbed	Released

26. It does not matter where in the atmosphere the gases are released. Nitrogen oxide and sulfur dioxide combine with water in the atmosphere, producing nitric acid and sulfuric acid. The acids can travel far in the wind and will eventually fall back down to Earth's surface in the form of precipitation.

27. The greenhouse effect is produced by greenhouse gases warming Earth by trapping energy. The enhanced greenhouse effect is produced by humans adding too many greenhouse gases to the atmosphere, possibly resulting in global warming.

Application

28. An animal living far away from an area sprayed with DDT might get DDT in its body through the processes of bioaccumulation and biomagnification. It might eat contaminated birds or fish that travel great distances.

29. If a pesticide is stored in the body of an organism and remains toxic for many years, it can be passed on to other organisms for years to come. Instead, it would be better if pesticides were easy to break down and dispose of.

30. Eating a plate of rice and vegetables would make you a primary consumer, because primary consumers are herbivores and eat only plants. Eating a hamburger would make you a secondary consumer, since you would be eating part of a cow, which is a primary consumer.

Chapter 2 Populations and Sustainable Ecosystems

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Compile a list of as many indigenous species of animals in Ontario as there are students in your class. Students can each choose one species to research in section 2.1.
- Book a computer lab for Activity 2-2, on page 52 of the student textbook.
- Order owl pellets for Activity 2-3, on page 60 of the student textbook.
- Field guides to birds of Ontario will be useful to have in the classroom in section 2.4.
- Order butterfly chrysalis kits, if you wish to use them in section 2.4.
- Consider beginning Inquiry Investigation 2-B, on page 80 of the student textbook, early in the chapter, as it will take three weeks to complete.
- Students can review the Key Terms in Chapter 2 using **BLM 2-1 Chapter 2 Key Terms.**

In this chapter, students will learn that populations will increase until they reach their carrying capacity, and that specific factors will affect the carrying capacity. Students will be able to explain that no two species can occupy the same niche. Students will also be able to describe services that many species provide to other members of an ecosystem.

Using the Chapter Opener (Student textbook pages 46 and 47)

- You might poll students and ask how many have seen an owl in the wild. Ask, "What did the owl look like?" "If it was flying, what sound did it make as it swooped by?" (Their wings make a distinctive whoop-whoop sound.)
- Ask, "What else might owls eat?" (A large owl can eat an average-sized house cat.)
- Ask students where they think the photograph on pages 46 and 47 was taken: on a farm, in the forest, or in a park. Can they tell what season it is from the picture?

Alternatively, focus on an often overlooked service that local forests provide. Many of us are happy to know that the forest still exists somewhere in the province providing habitat for wildlife. We may not realize the importance of our local urban and suburban forests in regulating rain and meltwater run-off. The deep roots of trees allow water to percolate down through the soil, often to be stored in underground aquifers. Many of us draw our water directly from these aquifers using wells. Others draw our water from rivers or lakes, ultimately fed by streams and springs that originate from the ground. Water that reaches aquifers is naturally filtered and often stored for years. It is local trees that provide this service. For example, local woodlots and small tracts of forest on the Oak Ridges Moraine provide clean water for the Greater Toronto Region. Unfortunately, the proximity of these pockets of forest to the city make them highly appealing for development.

Activity 2-1 Reducing Wildlife Mortality with Fences

(Student textbook page 47)

Pedagogical Purpose

This activity provides students with an opportunity to examine how human activity has made an impact on an ecosystem, specifically wildlife.

Planning	
Materials	Chart paper and markers (optional)
Time	15 min

Background

The controversy with fencing is that it intersects wildlife habitat, possibly reducing the amount of habitat normally available to an individual. When we consider fencing of highways, we also must consider ways for animals to safely get to the other side, which may be in the form of tunnels or underpasses.

Activity Notes and Troubleshooting

- Get students up and moving as they engage their prior knowledge:
  - "Stand up and stay up if you have
    - driven through Algonquin Provincial Park.
    - seen fencing along park roads.
    - seen animals from your car while driving.
    - seen a dead animal on the road or by the road."

- By this time, most of your class will be standing. Then ask them to sit down and discuss with a classmate how they felt or how they would feel about seeing dead animals on the road.

- The graph in this activity is more complex than most students will be used to. Before students begin the activity, read the introduction together and display the graph for all students to see, if possible. Then ask questions to ensure all students come to understand the many features of the graph, such as the following:
  - Is this a bar graph or a line graph?
  - Which axis tells us about the bar graph? Which axis tells us about the line graph? How do you know?
  - Why are there two bars for every year?
  - What do *first fence* and *second fence* mean? (They refer to the first section of fenced road, and the second section of fenced road, where data were gathered.)
- Teachers in urban areas could ask students which animals are often in roadside collisions within a city, and what can be done to prevent these types of collisions.

Additional Support

- ELL Preview the vocabulary in this activity with English language learners. Words like *mortality, traffic, annual, vehicle,* and others may be new to some students. Explain what the Trans-Canada highway is and/or show pictures of animals commonly seen near a road. English language learners could answer orally or in point form.
- Some students will need additional support to interpret the graph. Discuss with students some of the information that the graph shows. For example, ask students why the light bar for most years might be taller than the dark bar.
- DI Pair logical-mathematical learners with others to ensure students are able to obtain the information that they need from the graph.

Answers

1. The mortality rate along both sections started around 30. The rate for the first section then dropped in 1987 and has remained around 10. The rate for the second section jumped to more than 90 in 1988, then decreased to also settle around 10.
2. The amount of daily traffic increased steadily until it had almost doubled in value.
3. Probably because the current mortality rates are less than the original values, even though daily traffic has nearly doubled.
4. It is a good indicator of the impact humans have on wildlife.

Study Toolkit

Strategy	Page Reference	Additional Support
Making Connections to Visuals	Student textbook pages 49, 54, 75	Have students fold a piece of paper into four parts and number each part to record their answers to the questions on page 48.
Base Words	Student textbook page 62 (mutualism), page 63 (parasitism), page 70 (desertification, watershed), and page 76 (connectivity)	Refer students to Study Toolkit 3, Word Study: Common Base Words, Prefixes, and Suffixes in Science, on page 565 of the student textbook.
Interpreting Line Graphs	There are many line graphs in this chapter for students to interpret, including on pages 49, 51, 58, 59, 60, 66, 70, and 74.	Following the procedure to create a line graph in Math Skills Toolkit 3, on page 557 of the student textbook, will help students build an understanding of the different parts of a graph and what we can learn from each part. See also **BLM G-25 Constructing a Line Graph** and **BLM G-26 Interpreting Line Graphs.**

Section 2.1 Populations and Resources

(Student textbook pages 49 to 55)

Specific Expectations

- **B1.1** assess, on the basis of research, the impact of a factor related to human activity that threatens the sustainability of a terrestrial or aquatic ecosystem
- **B3.3** describe the limiting factors of ecosystems, and explain how these factors affect the carrying capacity of an ecosystem
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

In this section, students will learn about patterns of population growth for a variety of species, including humans. Students will describe the factors that limit an ecosystem's carrying capacity. They will learn how the human population has been able to grow exponentially by manipulating the carrying capacity of Earth. Students will understand how urban sprawl has affected the populations of local wildlife as well as how humans have been successful at re-introducing some species.

Common Misconceptions

- **A population will increase exponentially to fill in a new habitat.** This is true at first; however, students may not realize that a population can increase too rapidly and "overshoot" the carrying capacity of an area, which then leads to rapid population decline.
- **Students may believe that re-introduction of a species results in a return to a balanced ecosystem.** In fact, species re-introduction cannot go unmonitored, and human intervention is often required to maintain population stability. As one species disappears from its habitat, so do its natural predators. For example, wild turkeys were successfully re-introduced into southern Ontario. While the wild turkey population of southern Ontario is no longer threatened, their story is not entirely successful. Ottawa-area farmers have complained that the turkey population is interfering with their crops. There is some evidence that the wild turkey population did not extend this far north originally, and the turkeys have now expanded into areas where they never existed before.
- **Students may think that initiatives, such as the Oak Ridges Moraine Conservation Act, are innovative ideas to protect southern Ontario's fragile ecosystems.** In fact, the Oak Ridges Moraine Conservation Act compliments the Greenbelt Act of 2005. The desire to create a zone surrounding the Greater Toronto Area and Golden Horseshoe, which is exempt from commercial and residential development, dates back to the 1970s. There is not much undeveloped land left from the Greenbelt that was originally envisioned at that time. The Oak Ridges Moraine Conservation Act and Greenbelt Act are the last stand to try to protect the green space that is left.

Background Knowledge

Not all re-introductions of endangered species are successful. While the genetics of the species are preserved, the survival techniques that must be taught by parents are not passed on. There is also a possibility that the re-introduced animals will be too familiar with humans, which could be dangerous.

There has been much controversy over the re-introduction of wolf populations to eastern North America, including Algonquin Park. The original species of wolf was most likely the red wolf; however, red wolves interbreed too easily with feral dogs and coyotes, increasing the chances of negative human interaction. Wolves keep the deer populations in the eastern forests at healthy numbers, so grey wolves were chosen for re-introduction as they are far less inclined to interbreed outside their species. Grey wolves are larger than deer, however, and are more efficient hunters, so there is a chance that they could decimate the deer population. Therefore, both populations are being carefully monitored.

Southern Ontario's wild turkey re-introduction has been so successful that the turkey population has now expanded beyond its original boundaries. When the wild turkey was re-introduced, some of its natural predators were long gone from the area. To keep the population under control, the Ontario government has had to expand the turkey hunting season to include both fall and spring.

Literacy Support

Using the Text

Before Reading

- Have students skim the section, focussing on the headings, Key Terms, and visuals and captions, to predict the main ideas and to develop definitions of the Key Terms. Discuss the meaning of each term, and have students share where they found the information to help them understand each term.
  - ELL Display definitions in students' own words for English language learners to refer to throughout the section and the chapter.

During Reading

- Place students in groups of five or six, and assign each member of the group a passage to read.
  - ELL Choose the length and complexity of the passages you assign based on students' reading abilities.
  - Allow each group time to share the information that they have read. Students can take turns and verbally summarize their passage for the rest of the group. Others in the group can ask questions.

After Reading

- Students can respond to their reading by participating in a "graffiti" activity. Emphasize to students that graffiti is an expression of personal thoughts and feelings.
  - Give each group markers and a piece of chart paper with a statement or question in the middle, and ask students to respond to that statement. After three to five minutes, each group will pass their paper to an adjacent group until all the groups have responded to all of the statements.
  - The statements can come from the Section 2.1 Review questions on page 55 of the student textbook.
    - Exponential growth is not sustainable in nature.
    - Limited resources will affect the growth of a population.
    - Carrying capacity can be manipulated with positive and negative outcomes for different populations.
    - Intensification can limit the human impact on wildlife populations and habitats.
  - When the groups have responded to all the statements, and their original statements have been returned to them, each group will select the three most interesting or important responses. They can then write the page numbers of the information in the student textbook to which each response relates. Then each group can present their question and three statements to the class.
  - All students in the class should record the question and statements presented by each group, with the corresponding student textbook page numbers, in their notebooks. Each presenting group could circle the three statements they selected and display the chart paper for others to copy at their own pace.

Using the Images

- For Figure 2.1, on page 49 of the student textbook, ask questions to ensure everyone understands what the graph shows, and then ask students to predict what the elephant population is today, and explain what led them to that conclusion. Some students may extend the graph and predict millions of elephants, and some may rationalize that the population will eventually level off.
- For Figure 2.2, on page 50, have students describe the habitat requirements of the turkey that are suggested in the picture. For example students may mention open fields next to forest.

- Have a volunteer describe the graph in Figure 2.5, on page 51, and then ask students why the fur seal population did not continue to grow after 1935. Ask, "How would the line change if hunting were to increase, or if habitat were to decline?"
- Compare the two maps from Figure 2.6, on page 52, and Figure 2.7, on page 53. Ask students to explain why the remaining dace are found where they are. Students should notice a slight correlation between the green areas shown in Figure 2.6, and the redside dace populations shown in Figure 2.7. Ask students if they think the population is increasing or decreasing, and what we can do to protect the population.
- For Figure 2.8, on page 54, ask students to brainstorm ways to increase human population density other than building higher. The answers can be recorded on the chalkboard for students to copy into their notes. Answers may include the following: divide houses into apartments, build on undeveloped and abandoned land in the city, re-purpose abandoned land and buildings, place parking underground, or provide less parking.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Selected Response Learning Check questions, page 51	Students describe the relationship between population growth and limits.	Arrange the class into groups of four for **Pass, Pass, Trade:** Assign each student in a group a different question to explain. Have each student explain his or her question and answer to a partner, using written notes and diagrams as appropriate; the partner does the same. When both are confident that the other understands his or her question fully, they trade cards, papers, or white boards, and repeat the process with a new partner. Continue in this manner until all students in the group have heard and explained all the assigned questions.
Section 2.1 Review questions, page 55	Students explain relationships among population growth, limits, and carrying capacity, and provide examples.	Ensure that students understand the Key Terms in each question. Students can label graphs or sketch and label graphs instead of writing sentences for many of the answers. Refer to Figure 2.1, on page 49, to see how a labelled graph can provide an explanation of population trends.
Performance or Product Activity 2-2, Graphing Population Change, page 52	Students are able to accurately represent the data on a graph by selecting the appropriate scales, drawing a line of best fit, and extending the line to make predictions for the year 2020.	Demonstrate how to draw a line of best fit. On the chalkboard, plot 16 points, Model how to select the position for the line; an equal number of points should be on either side of the line. Lines of best fit do not have to be straight. Plot new points, and invite students to trace a line of best fit with their fingers and tell why they would draw it where they indicated. Refer students to the Math Skills Toolkit 3, on pages 557 to 560 of the student textbook. Students can practise with **BLM G-25 Constructing a Line Graph** and **BLM G-26 Interpreting Line Graphs.** Students can use spreadsheet software to plot the points, but they should draw their best-fit line on their own. Students should draw three separate graphs, selecting different scales for the *y*-axis so that the data fill most of a page. In this way, they will be better able to extrapolate the data.

Instructional Strategies

- To introduce this section, talk about an animal whose population changes are familiar to some students, for example the elephant (after reading page 49 of the student textbook). As you talk about it, sketch a rough line graph and label the parts of the graph that show its decline, exponential growth, protected status, equilibrium, and so on. Leave this graph on display for students to refer to.
- Data Analysis Investigation 2-A, on page 79 of the student textbook, provides students with opportunities to apply what they have learned as they draw and interpret a graph to draw conclusions about the winter skate population in Nova Scotia.
- Enrichment—Using one of many available web resources, assign each student in the class a different animal indigenous to Ontario. To find information about indigenous animals, see **www.scienceontario.ca**.
  - DI Have each student prepare a fact sheet outlining the habitat requirements for their animal. The fact sheet should include where the animal is found in Ontario; its estimated population; who its predators, prey, and competitors are; the limiting factors for its survival; and whether the animal is at risk or endangered. Students can create their fact sheets on **BLM 2-2 Ontario's Indigenous Animals.** This activity will appeal to linguistic and logical-mathematical learners.
  - DI Spatial learners could also create a letter-sized poster depicting the animal in its habitat, illustrating some of the points on the fact sheet.

Activity 2-2 Graphing Population Change (Student textbook page 52)

Pedagogical Purpose

Students will assess the impact of urban sprawl on bird populations by graphing and interpreting the data provided for a 12-year period.

Planning		
Materials	3 pieces of graph paper Coloured pencils **BLM G-25 Constructing a Line Graph** (optional) **BLM G-26 Interpreting Line Graphs** (optional)	Ruler Computer lab (optional)
Time	Total: 50–60 min	

Background

Mourning doves are related to pigeons. Students may notice that the population of mourning doves increases, which is because suburbia and backyard feeders provide an ideal habitat for these birds.

Downy woodpeckers are not bothered by human activity as much as other species are, and they can be found at backyard feeders. When surrounding forests reach maturity, they provide optimal habitat for woodpeckers (from old and dead standing trees).

After 1999, much of the forest surrounding Barrie was cut down to accommodate a housing boom. Ruffed grouse are very sensitive and reclusive, which is why their numbers have only decreased.

Activity Notes and Troubleshooting

- In order for students to extrapolate data with some accuracy, the scale for each graph should be different. Students should make each graph fill the page. The greater the scale is, the more detailed their graphs will be and the better their estimations will be. Comparing the populations of different species in the same year is not meaningful in this activity. Even a healthy ecosystem may be able to support different numbers of each bird because of the birds' needs.
- If you are evaluating this assignment, give feedback promptly so students can use the feedback for Data Analysis Investigation 2-A, on page 79 of the student textbook, which requires similar skills.
- If possible, arrange a field trip and have students participate in the bird counts in their area.

Additional Support

- While some students may prefer to use a computer to graph the data, students are usually better able to internalize the information and make better estimations when graphing by hand. In the event that a student will not be successful unless he or she uses a computer to plot the data, encourage the student to draw the best-fit line by hand.
- If needed, students can practise drawing and interpreting line graphs using **BLM G-25 Constructing a Line Graph** and **BLM G-26 Interpreting Line Graphs.**

Answers

1. Overall, the downy woodpecker population is in equilibrium because the line of best fit is almost horizontal.

Overall, the mourning dove population is increasing because the line of best fit is sloped upward.

Overall, the ruffled grouse population is decreasing because the line of best fit is sloped downward.

2. predators and lack of food
3. abundance of food and lack of predators
4. Yes. The lack of space may have contributed to the declining ruffled grouse population. The mourning doves may be more comfortable in urban areas and find food easier where people are around.
5. No. The ruffled grouse population would be negative in a few years if the population continued along the line of best fit.

Learning Check Answers (Student textbook page 51)

1. Populations tend to increase when individuals reproduce at rates that are greater than what is needed to replace individuals who have left the area or died.
2. There were no limiting factors such as predators. There was an abundance of resources.
3. nutrients, space, light, predators, or dissolved oxygen (in aquatic ecosystems)
4. Answers will vary. Resources that quickly became limited were gasoline, other fuels, water (if electrically pumped), some food (refrigerated), batteries, candles, and so on.

Section 2.1 Review Answers (Student textbook page 55)

Please also see **BLM 2-3 Section 2.1 Review (Alternative Format).**

1. The population will be slowed or stopped by limiting factors. It cannot grow beyond the carrying capacity.
2. The carrying capacity would decrease because flying squirrels depend on the holes in dead trees for roosting.
3. The first female will produce 10 offspring and then each daughter as well as the female herself will produce 10 in the second year. The population goes from 1, to 11 (10 + 1), to 121 (10 + 1 + 110).
4. Growth of shade-intolerant plants reduces space for the dace. The decline in the numbers of dace's prey due to change in habitat limits the growth of the dace.
5. The population undergoes exponential growth between 0 and 40 days, then begins slowing down toward its carrying capacity. After 90 days, the population growth is in equilibrium. Possible limiting factors for the population could include food and space.
6. The objective stops all actions that would decrease the carrying capacity, such as urban sprawl, and promotes action that would improve the supply of water, shelter, and natural food in the area. These actions should maintain or increase the carrying capacity of the area.
7. Intensification requires that a large percentage of new development occurs on land *within* the built boundaries of a city.
8. **a.** Answers will vary depending on the community. Students may have examples of urban sprawl, intensification, or construction designed to increase the carrying capacity in an area.
   b. Answers will vary depending on the community. Limiting factors may include humans, predators, space, and access to resources.

Section 2.2 Interactions Among Species

(Student textbook pages 56 to 64)

Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed*
- **B3.3** describe the limiting factors of ecosystems, and explain how these factors affect the carrying capacity of an ecosystem

In this section, students will learn that each species occupies an ecological niche, which has biotic and abiotic components, and many species occupy a narrow niche for which they are highly adapted. Students will use the terms *predation, competition, mutualism,* and *parasitism* to describe relationships between species. Students will explain how these relationships define a species' niche and affect its distribution and abundance.

Common Misconceptions

- **Students may believe that each species is ideally adapted to its one specific niche, and that different species co-exist in an ecosystem because they get along.** Niches are not species-specific. Orcas in different pods will occupy different niches; some pods hunt only fish, while others will hunt larger animals such as seals. Most species occupy a niche that is much narrower than what they are adapted to, most likely because of competitive exclusion.
- **Students may believe that predators only affect the population of their prey.** However, the predator and prey are part of a larger food web. For example, wolves prey on deer; deer browse deciduous saplings; deciduous saplings compete with coniferous saplings for light and nutrients. If wolves are removed from this food web the forest cover eventually changes from mixed conifer deciduous to predominantly deciduous.
- **Students may think that the higher a species is in a food chain, the larger the species is.** This belief implies that the more links there are in a food chain, the larger a predator will be. A predator does not need to be larger than its prey. Wolves outnumber their prey to overcome it, and a lone wolverine is capable of taking down a moose. The largest predator on the planet is at the top of a very short food chain. Blue Whales eat krill, and krill eat phytoplankton.
- **Students may think that relationships that seem mutualistic are always mutualistic.** At some point you may have learned the saying, "Alice algae took a likin' to Freddy Fungus." This pneumonic helped you remember that lichens were a result of a mutualistic relationship between algae and fungi. The relationship is more parasitic than mutualistic, however; the fungus seeks out the alga and traps it within its own structure, and the alga is "forced" to work for the fungus.

Background Knowledge

No two species can occupy the same niche. One species will be forced to adapt its requirements and move to an adjacent niche; in essence, one species will have to settle for less. For example, nuthatches live in the same habitat as woodpeckers, and the nuthatches will nest in abandoned woodpecker cavities. Both species eat small insects and larvae; however, the nuthatch does not bore large holes into the tree as the woodpecker does. Instead, the nuthatch moves down the tree, facing the opposite direction, and pries out what other birds have missed. Competitive exclusion is the process of one species pushing a competing species out of the environment to which both are adapted.

Literacy Support

Using the Text

Before Reading

- Have students scan the section and create a list in their notebook of Key Terms, as well as other words that they find in headings or definitions, which seem important. Tell them that as they read, they will be looking for relationships among these ideas. Students can create these lists on their own or in pairs. Have students list approximately 20 terms.
  - Ask students to predict what they might learn about these terms as they read the section.
  - ELL English language learners can work with a fluent English speaker. Have them also identify words that they do not understand, and use the glossary or ask their partner for clarification.

During Reading

- Have students make notes or draw diagrams to show how groups of the words they wrote are connected. For example, *predation, competition, mutualism,* and *parasitism* all describe ways in which species interact. No two species can occupy the same niche. If students have trouble identifying connections, brainstorm a few together as examples.

After Reading

- Have students create a concept map. Students may want to attach two pieces of notebook paper to make a larger piece of paper, or work in a group and use chart paper, for this activity. It is useful to have some coloured pencils or markers on hand. Students should include on their maps the terms they listed before reading. They can then indicate how the terms are connected, on the lines that join them. Unlike a mind map, each concept can have many connections, and the connecting phrases are as important as the terms. See **BLM G-34 Concept Map** and **BLM A-11 Concept Map Checklist.**

Using the Images

- For Figure 2.10, on page 57 of the student textbook, ask students to list the similarities and differences between the sundew and pitcher plant in their notes. They can draw a Venn diagram or use **BLM G-39 Venn Diagram.**
- For Figure 2.11, on page 58, ask students to verbally describe the trends in the graph. Ask, "Why is the hare population usually higher than the lynx population?" "Is there any time when it is not higher?" "Does the lynx population peak at the same time as the hare population?"
- For Figure 2.12, on page 59, ask students how the wolf/moose graph differs from the lynx/hare graph. Students may volunteer answers verbally, and you can record their answers on the chalkboard for students to copy. Ask students why the wolf population can exceed the moose population, when the lynx population does not usually exceed the hare population.
- For Figure 2.13, on page 60, students should be able to identify a linear relationship, and make the connection to carrying capacity. Ask students if the total number of eggs laid for all female song sparrows increases or decreases as the number of females increases.
- For Figure 2.16, on page 63, ask students to find and record the answers to the following questions: How many hosts do the brainworms require; how many organs do they infect; and which parts of their lifecycle take place in the deer? Students can record on **BLM 2-4 Brainworms and White-tailed Deer.**

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Selected Response Learning Check questions, page 61	Students define and apply the concept of an ecological niche.	To help students build an understanding of *niche*, brainstorm some characteristics of the niches of familiar animals or plants, for example, squirrels, dandelions, or honeybees. Have students consider all of the organisms' needs when listing elements of their niche. Ask them how the niche of one organism might be different from the niche of a similar organism, for example, rats, clover, or wasps.
Section Review questions, page 64	Students use examples to explain how relationships with other species help to define a niche.	Divide the class into eight equal groups. Assign each group a question to answer. Students in each group should discuss the answer until everyone in the group understands and agrees with it. Then they should record their answer on chart paper or an overhead transparency. After 10 to 15 minutes, have each group quickly present their answer. All students should copy the answers into their notebooks. Answers could be left on display for students to copy at their own pace.
Performance Activity 2-3, What Was for Dinner?, page 60	Students are able to separate the smaller pieces from the owl pellet and use a key to identify them.	Some students may be squeamish about using actual owl pellets. Owl pellets are the indigestible parts of the meal that the owl later regurgitates. There are many online virtual versions of this activity, which students can complete as an alternative activity or as preparation for this activity. See **www.scienceontario.ca**.

Instructional Strategies

- DI In groups of three, students can do a predator-prey simulation using playing cards and paper clips. See **BLM 2-5 Predator-Prey Simulation.** Students drop paper clips and cards from a fixed height to simulate the predator-prey relationship. A card landing on paper clips represents rabbits that have been consumed. Each group should delineate a 50 cm by 50 cm area and drop three paper clips (rabbits) and one card (lynx) from a height of 50 cm. Repeat the drops 25 times. Each drop represents a generation of rabbits and lynx. Cards and paper clips that fall outside the 50 cm by 50 cm square have died. Students will record the number of surviving rabbits and lynx after each generation. After 25 generations, each group can graph their results. This activity should help spatial, bodily-kinesthetic, and logical-mathematical learners understand the predator-prey relationship.
- Have students respond to the following statement by placing themselves along a value line for the following statement: Competition between two species is always beneficial to both species. After students have placed themselves along the line from *agree* to *disagree*, divide the line in half. The two halves of the line will form an inside circle and an outside circle. The *agree* side forms a tight circle facing outward, and the *disagree* side forms a larger circle around the first one facing inward, so that students are facing each other. Allow each side 20 seconds to argue their position. When the inside and outside circles are finished, rotate one of the circles to the right by one or two students. Continue in this manner until students in the rotating circle have moved around the stationary circle once. Students can then write the statement in their notebooks and draw a value line. They should place an *A* on the value line to represent where they stood before the activity and a *B* on the value line to represent where they stood after they had discussed the issue with classmates. They should also write a brief explanation of how their opinion changed or why it did not change.
- Inquiry Investigation 2-B, on pages 80 and 81 of the student textbook, provides students with an opportunity to carry out an experiment to determine the effect of a limiting factor on the growth of a bacteria population.

- DI For interpersonal and bodily-kinesthetic learners, arrange the class into groups of four to six. Have each group create a brief role-play to demonstrate mutualism and parasitism. Students could use situations from their own experience at school. For example, a skit about a student who is always borrowing pens and paper, and who never returns them, might illustrate parasitism.
- ELL English language learners may know of other animals that share interesting predatory, parasitic, or mutualistic relationships. Invite them to tell the class about these animals.

Activity 2-3 What Was for Dinner? (Student textbook page 60)

Pedagogical Purpose

This activity provides students with an opportunity to directly observe and investigate evidence of a predator-prey relationship.

Planning	
Materials	Owl pellet Paper towel Forceps, tweezers, or probe Magnifying glass **BLM G-40 Activity 2-3, What Was for Dinner? Identification Key**
Time	30 min 10 min to view on-line simulation
Safety	Ensure students wear safety goggles if they are using a squirt bottle with alcohol to disinfect. Ensure students wear gloves. Students with allergies to latex should not wear latex gloves. Emphasize hand washing and wiping down work surfaces afterward. Tell students how and where to dispose of waste. Some students with animal allergies or asthma may have reactions while doing this activity.

Background

Some students may be squeamish about this activity as they assume the pellets are fecal matter. The pellets are the indigestible animal parts that are regurgitated by the owl. There are on-line versions of this dissection readily available. See **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- Project an on-line simulation to introduce the procedure.
- It is best for students to work in pairs for this activity, so that students have opportunities to closely examine the contents of the pellet.
- Form pairs by asking who would prefer to pull apart the pellet (dissector) and who would not (recorder). Pair the dissectors with the recorders.
- Some students may want to record the dissection with their cellphone cameras. The recordings could be uploaded to a class website.

Additional Support

- While the Internet is a great supplement to any dissection, it is not a substitute. Encourage students to participate in the activity, and establish varied levels at which they can participate. If students are absolutely unable to participate, ensure that they have the opportunity to watch an Internet simulation.

Answers

1. An owl's prey depends on the size of the owl. Smaller owls eat insects and spiders, and larger owls will eat small animals including other birds. Owls are predators.
2. Answers may vary depending on the owl pellets. The prey is probably very abundant in the owl's ecosystem and easier to catch than other potential prey.
3. fish bones and cartilage

Learning Check Answers (Student textbook page 61)

1. An ecological niche is the way that an organism occupies a position in the ecosystem, including all the necessary biotic and abiotic factors.
2. The moose population is influenced by exceptionally cold winters, tick infestations, and predation by wolves. The wolf population is significantly influenced by the number of moose.
3. The advantage would be that it is a simpler system so there are not so many other factors that might be involved. The disadvantage is that the patterns might not apply to natural situations where there are additional predators and herbivore prey.
4. On the single-bird island, you might expect the bird to feed in both pines and maples, but on the two-bird island, because of competition, you might expect that one species will forage in maples and the other will forage in pines.

Section 2.2 Review Answers (Student textbook page 64)

Please also see **BLM 2-6 Section 2.2 Review (Alternative Format).**

1. An ecological niche is like a job because organisms must go about the business of surviving and reproducing and in doing so provide services to the ecosystem. It is not like a job in the sense that organisms do not have obligations or responsibilities to their ecosystems.
2. The niche would shrink over time.
3. The plants are carnivorous. They capture and consume insects. Bogs have relatively acidic soil and water, and they are nutrient-poor environments.
4. Bats import nutrients into cave ecosystems through their droppings. Carnivorous plants import nutrients into the bog by capturing and digesting insects.
5. You would have to consider what resources elk need and whether these resources are available or not. You would have to consider the potential predators in the ecosystem and what competition for food the elk may have. You would have to consider whether the brainworm in white-tailed deer would affect the elk.
6. Since the plant food is never in short supply, the best explanation for the periodic decline in hare numbers is that there are a lot of lynx at that point. This result would suggest that it is top-down regulation. Top-down regulation means that the number of predators affects the prey population. Bottom-up regulation means that the amount of food, such as plants or animal prey, affects the population of the animals that eat them.
7. By having the two sexes consume different kinds of prey, their offspring have access to more resources. This result may increase the carrying capacity in a certain area. Although they are not different species, this size difference might also reduce competition between the two sexes.
8. The coral provides protection for the algae inside its tissues and coral skeleton, and the algae photosynthesizes and provides food (energy) for the coral. Marine algae can be colourful and when they die, their colour disappears along with them, causing bleaching.

Section 2.3 Human Niches and Population

(Student textbook pages 65 to 68)

In this section, students will learn how we have broadened our niche by altering the ecosystem that supports us. Even though our intellectual and technological abilities have enabled us to alter our ecological niche, human societies are still subject to the principle of carrying capacity. Students will learn about doubling time and that the human doubling time is now less than one lifetime. Students will calculate their own ecological footprint, and make suggestions to reduce their footprint.

Specific Expectations

- **B3.3** describe the limiting factors of ecosystems, and explain how these factors affect the carrying capacity of an ecosystem
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Common Misconceptions

- **Students may believe that humans have adapted to nearly any environment on Earth due to humans' intellect and technology.** We have not physically adapted; instead, we alter our environment.
- **Students may believe that we know how many humans Earth can support.** Estimates for the carrying capacity of Earth range from 1 billion to 15 billion. There is currently no accurate estimate of what the current carrying capacity for humans should be. The population of Earth at this time is over 6.5 billion.
- **Students may believe that the rate of human population growth is increasing.** In fact, the rate of population growth has steadily decreased since the 1960s; however, it is still above zero, so our population continues to grow.

Background Knowledge

The actual number of humans that Earth can support is a debated number that ranges between 1 billion and 15 billion. Around 1 A.D., it is estimated that Earth's population was only a few hundred thousand people. Advances in agriculture, sanitation, and medicine have extended our life spans, decreasing our death rate. The human genome has not significantly changed in that time. Although there is anecdotal evidence of ancient Patagonians who adapted to the cold and who could sleep in the snow, recent research has shown that there may have been some genetic drift due to the isolation of this population. This population is now all but extinct.

It is commonly felt that the lack of available fossil fuels will be the limiting factor to human population growth. We should be more concerned about the availability of fresh water and its ability to irrigate crops. Irrigation and its affect on soil salinity are too often overlooked. We are dependent on irrigation to supply enough food to nourish 6.5 billion people; however, once soil has become infertile due to salinization, it cannot be recovered. This information leads us to question whether or not our planet can support the estimated 9 billion people who live on it.

Literacy Support

Using the Text

Before Reading

- ELL Preview the vocabulary with English language learners. Make a word web for the term *sustainable,* since it comes up in many forms in this section. In English, *sustain* can mean carry, bear, or maintain.
- Help students connect to prior knowledge. Present students with a statement such as the following: We need to live in a more sustainable way without changing our environment to increase its carrying capacity.
  - In their notebooks, students will prepare a T-chart with one side for ideas that support the statement, and the other side for ideas that oppose the statement. At the bottom of the page, have students leave two spaces—one for Decision, and the other for Reasons.

- After a brief class discussion, and after scanning the text, have students record one idea for each column of their T-chart.

During Reading

- Students can read the text to themselves, or take turns reading as a class. On their T-chart, have them summarize what they read by recording supporting and opposing ideas in the appropriate columns.
- ELL To ensure English language learners understand what they read, have them use sticky notes to indicate problematic words and phrases, and then discuss them as a group.

After Reading

- Students can review the statement they were presented with before reading, and decide which viewpoint they would take. Then they can record their decision in the appropriate space on their T-chart.
  - Students should discuss and share their decision with a classmate. Afterward, each student will record the reasons for his or her decision in the appropriate space on their T-chart.

Using the Images

- For Figure 2.17, on page 65 of the student textbook, ask students to explain the physical advantages that the human brain and hand have over other animals, for the niche we inhabit. Students may notice that the human brain occupies about 50 percent of the scull, and has more surface area because it is wrinkled; and that the bones in the human hand are separated into fingers much farther down the finger joints than in the bear paw.
- Project the graph at the left of Figure 2.18, on page 66, for the class, or sketch it (with labelled axes) on the chalkboard. Poll students as to when the industrial revolution began based on what they see on the graph. As well, ask what might have happened around 1400, and what major scientific advances were made between 1800 and 2000.
- For Figure 2.19, on page 67, ask students which two countries are below the global average, why this might be, and whether they think these countries will stay this way.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Selected Response Learning Check questions, page 67	Students describe reasons for, and effects of, rapid human population growth.	In groups of four, have students respond to the questions on chart paper or mini white boards. Allot a few minutes for the groups to respond to the questions. Afterward, post the questions around the classroom and have students conduct a "gallery walk" to view all of the answers posted. After viewing all the answers, discuss them as a class and have students record the correct answers in their notebooks.
Selected Response Section 2.3 Review questions, page 68	Students describe how humans have increased their carrying capacity and list factors that contribute to our ecological footprint.	Have students use a cause-and-effect map to record the effects of increased intellectual abilities as they reread page 66. Have them work in pairs and create a T-chart to list sustainable activities and unsustainable activities. See **BLM G-33 Cause-and-Effect Map** and **BLM G-38 T-chart.**
Data Analysis Investigation 2-C, Putting Your Foot in Your Mouth, page 82	Students describe strategies to reduce their ecological footprint.	Have students list five things they have done today, and the impacts on the environment of each one. They can use a cause-and-effect map to record these activities and impacts. Then ask students how they could change their activities to reduce the impact on the environment.

Instructional Strategies

- DI Have students do an Internet search and critique for this section. This activity can be done in groups, pairs, or individually, and should appeal to linguistic, logical-mathematical, and spatial learners. Assign students a category to research, such as brain size and intelligence, human population growth, ecological footprint, or human carrying capacity. Students should find three to four websites that are related to their topic. They can then write a critique for each website, answering the following questions:
  - Is the Web page informative? What can you learn from it?
  - Is the language clear and easy for a typical high school student to understand?
  - Do the interactive illustrations and animations work, and do they add to your understanding of the topic?
  - How current is the information? What type of institution or organization is responsible for providing the information?

  Students can briefly share their findings with the class.
- As a class, create an action plan to reduce the class's ecological footprint for one month.
  - Students must suggest ways that the class as a whole and each individual can reduce the ecological footprint.
  - Students must decide how they will monitor and encourage participation. They must also determine how they will evaluate the success or failure of the plan. Then have them carry out the plan.

Learning Check Answers (Student textbook page 31)

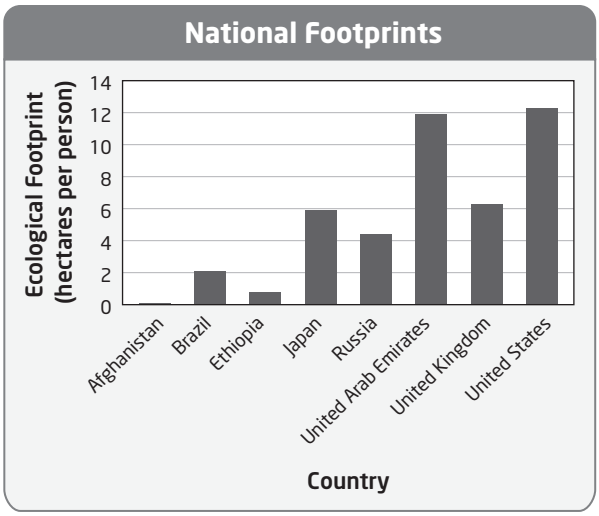
1. By building complex tools, controlling external forms of energy, and expanding the use of resources, humans have been able to live successfully in many different ecosystems.
2. Sustainable use is use that does not lead to long-term depletion of a resource or affect the diversity of the ecosystem from which the resource is obtained.
3. The current doubling rate is about 60 years.
4. No one knows what the sustainable carrying capacity is for humans, but many scientists believe that it is around 9 or 10 billion.

Section 2.3 Review Answers (Student textbook page 68)

Please see also **BLM 2-7 Section 2.3 Review (Alternative Format).**

1. We have been able to redefine and expand our niche, allowing us to go everywhere on the globe. By learning to control energy and resources, we have increased the biosphere's carrying capacity for humans, at least for now.
2. Answers will vary. Students may describe street boundaries, neighbourhood, school, and/or their home. Their niche may include places where they regularly shop, visit, or play sports. A sketch would contain similar information. It would be interesting to compare the different sizes and complexities that students come up with.
3. by increasing the availability of energy and resources for consumption, or by reducing consumption
4. Humans made great advances in increasing carrying capacity by being able to control fire; make clothes; make weapons; plant crops; domesticate animals; and improve public health, education, agriculture, medicine, and technology.
5. Answers will vary; Possible answer: Toes: recycle, compost, ride a bicycle, am a vegetarian, grow vegetables, take short showers; Heel: do not eat imported fruit and vegetables; Middle: get a ride to school every day

6. **a.**



b. largest: United States and United Arab Emirates; smallest: Afghanistan and Ethiopia

c. Differences occur due to the way resources are being used. There may be a conscious effort to reduce the footprint through sustainable use of resources or simply a lack of resource use, making a footprint low. For countries with large footprints, resources are plentiful and may not be used in a sustainable manner.

7. The vast landscape of Canada and seemingly unlimited natural resources may have encouraged us to be over-consumptive and wasteful. Canada also has a cold climate for much of the year, which requires us to use more energy for heating than in warmer countries.

Section 2.4 Ecosystem Services (Student textbook pages 69 to 78)

In this section, students will learn that when a species occupies its niche, it is able to support or provide services for other organisms. Examples of ecosystem services provided by a species include the forests' influence on climate and watersheds, and insects' ability to provide pollination and decomposition. Students will understand that the health of a population may depend on more than one ecosystem, as is the case with migratory birds. Maintaining the health of the ecosystems required by migratory birds requires international co-operation. Students will also be able to express how ecosystems have provided them with recreational benefits due to the beauty of the natural environment.

Specific Expectations

- **B3.1** compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Common Misconceptions

- **Students may believe that ecosystem services are freely provided by nature.** However, we need to protect and preserve the environment necessary to maintain these services. For example, we enjoy breathing oxygen, but we must ensure that we do not damage the forests and aquatic ecosystems that, through photosynthesis, produce oxygen.
- **Students may believe that most of the ecosystem services do not directly impact humans, and that they are just exchanges between other species of plants and animals.** The fresh water that most of the Greater Toronto Area (GTA) population consumes comes from Lake Ontario, which is fed by several rivers whose headwaters are located on the Oak Ridges Moraine. In order to continuously supply the rivers and the lake with fresh water, the springs and headwaters need forest cover. This requirement comes at a cost to GTA residents who want more housing each year that is within commuting distance of the city.
- **Students might think that mosquitoes and black flies do not provide any ecosystem service at all, and that they are nuisances that humans and animals could do without.** Only female mosquitoes consume blood; the males consume nectar and are pollinators for many plants. Mosquitoes are also the main food for many bird and fish species, and black flies pollinate wild blueberries.
- **Students might have heard that domesticated cats are to blame for the migratory songbird decline.** While cats do prey on birds, they more often hunt and catch small rodents and amphibians. The leading cause of songbird decline is more likely due to habitat degradation both in the boreal forest and tropical forest.
- **Rivers and streams that drain a watershed are commonly protected with a narrow band of trees and vegetation, and students might think that this band of trees and vegetation will protect water quality and prevent erosion.** While these buffers do provide some protection and are necessary, the importance of protecting the headwaters of the river cannot be overlooked. Without forest cover, the headwaters will dry up. Deeply rooted trees help water to percolate down to the aquifer, and they act as a sponge, often helping to hold groundwater for decades. Building communities with low densities and surrounding golf courses adds to the problem because mowed lawns result in almost the same amount of run-off as a paved parking lot.
- **Students might think that by designating an area as protected, we can preserve tracts of natural areas and exclude them from human recreation.** Unfortunately, designating an area as protected does not preserve it. People will continue to use it for a variety of purposes if it makes their lives more convenient or enjoyable. This result is due to our anthropocentric (human-centred) way of thinking. It is also true that areas depend on one another. If protected areas are separated by roads or communities, they may deteriorate.

Background Knowledge

Songbirds are keystone species that are indicators of environmental health, particularly forest health. We often think about the forest as a faraway place that provides us with products such as wood and paper, but we forget to think of the forests that surround and intersect our cities and communities. As our communities intersect the natural community more, other wildlife species are impacted as well.

One of the most important benefits provided to us by a healthy forest, including the urban and suburban forest, is clean drinking water. Forests and natural environments prevent rain and meltwater from running off, washing away nutrients and soil. The deep roots of trees provide the best retention of water, sometimes for decades. Agricultural land provides less retention than forest, and mowed grass provides as little water retention as a paved parking lot. It is important to maintain large, continuous tracts of forest around headwaters of major streams and rivers.

As well as protecting fresh water, forests can provide corridors to link isolated ecosystems and communities. One such example is the Yellowstone-to-Yukon corridor, proposed to protect the genetic diversity of the often-too-isolated grizzly bear population.

Literacy Support

Using the Text

Before Reading

- To help students make connections between the text and their own experiences and opinions, provide them with a template of a T-chart with a summary box at the bottom. Title the left side of the chart, "I Read," the right side of the chart, "I Think," and the bottom "Therefore."
  - Using a projector, model how to use the chart for the first few paragraphs of text. In the "I Read" column, write a couple of points to summarize a subsection of text. In the "I Think" column, write an opinion or a question that a reader may have in response to the points in the left column.

During Reading

- Individually, have students fill out their own T-charts. They can read silently or use a read-aloud strategy, such as reading tag or reading in pairs. Tell them to write at least one point in the left column for the text under each heading in the section. Then have them fill in the second column for each point in the first column.

After Reading

- Students can reread their own T-charts and identify similarities and differences between the two columns. They may want to use highlighters to compare the two columns.
- Students can then write a concluding or summary statement in the "Therefore" box at the bottom of the page. Students can share their concluding statements with their group or the class.
- Students can summarize what they have learned about ecosystem services using **BLM 2-8 Ecosystem Services** or **BLM 2-9 Ecosystem Services (Alternative Version).**

Using the Images

- In Figure 2.21, on page 70, students are provided with another opportunity to interpret a graph. Invite students to share one thing they can learn from this graph, until most of the information has been conveyed. Ask students why the run-off did not start as soon as the cutting was finished. (The cutting finished in mid-winter, and the run-off started with the spring thaw.)

- For Figure 2.24, on page 73, ask students what the significance is of the name of the beetle. Ask why the beetles bury their finds and what we can tell about the beetle's niche from this diagram.
- For Figure 2.25, on page 74, you may need to provide some more information about the four bird species, either from the Internet or a field guide. Ask students to speculate why there might be such a sharp decline in the bank swallow population compared to the common nighthawk. The answer could be related to their nesting preferences, and the impact that habitat destruction has had on these species. Bank swallows dig out hollows in the sides of river banks, while nighthawks roost high in trees.
- For Figure 2.26, on page 75, ask students to describe the diversity of the plants shown in each photograph. Ask students to look only at the photographs (and to not read the text above), and ask them which situation looks to be better for mass production, and why.
- For Figure 2.27, on page 76, ask students if the girl is snowshoeing in a natural area, park, ski resort, or farm, and why they think that.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Selected Response Learning Check, pages 71 and 74 Section 2.4 Review questions, page 78	Students describe examples of ecosystem services and explain the effects on the ecosystem if these services were removed.	Have students work in pairs on just one of the three main topics of the section–forests, insects, or birds. Have pairs create a main idea web to show the ecosystem services that each organism provides. How many ideas can they include? Students who have created different webs can share their results.
Performance Activity 2-4, Ecotourism and Monarch Butterflies, page 76	Students describe the importance of the monarch's winter ecosystem and the threats to it. Students create a pamphlet that promotes sustainable ecotourism to this region.	Pre-select several websites to direct students to. Check that students have answered all of the questions before starting the pamphlet. Students may want to use publishing software for this assignment. For students who have difficulty organizing information on their pamphlet, you can specify what to include in each section.

Instructional Strategies

- For this section, it may be helpful to have a class set of field guides for the birds of Ontario. If the school does not have any field guides, the school board's outdoor education centre may be willing to lend some.
- DI Plan a watershed top-to-bottom field trip. Choose a local stream or river and plan a field trip that makes several stops along its course, from headwaters to the mouth. Students can make observations of water quality and of the surrounding ecosystem, and take measurements and water samples if possible. This field trip should appeal to the bodily-kinesthetic learners as well as naturalistic and logical-mathematical learners (if data are collected).
- Plan a field trip to a museum where students can see displays of local insects and/or birds. Alternately, plan a visit to a conservation/outdoor education area that has a program about songbirds or insects.
- Have students research a local park or conservation area and ask them to compare and contrast the uses or purpose of the park. Ask, "Is it primarily used for recreation or environmental conservation?"

- Students can create a landscape design for songbirds in a portion of the schoolyard or in their own yard at home. The design should be accompanied by a plant list, including whether the plant provides food or shelter, and in which season the plant is grown.
- Making a Difference, on page 77 of the student textbook, encourages students to think about ways to share what they know about wildlife with others.

Activity 2-4 Ecotourism and Monarch Butterflies

(Student textbook page 76)

Pedagogical Purpose

This activity provides students with the opportunity to consider the ecological connectivity between two countries, and how ecotourism allows a region to protect an ecosystem that otherwise might be put to less sustainable use.

Planning	
Materials	Book a computer lab where students have access to a publishing program and the Internet. Obtain a few relevant resources from the library, such as books and magazines with information about monarch butterflies and ecotourism.
Time	40 min, plus possible time at home to complete the pamphlet

Background

Monarch butterflies that breed early in the summer do not migrate, as they die shortly afterward. Those that do not breed migrate to Mexico and live for another year. The journey from Canada to Mexico is around 3000 km. Monarchs also overwinter in California and Cuba. Canada provided technical assistance to Mexico to assist in the development of a strategic plan for ecotourism in the monarch's wintering area.

Activity Notes and Troubleshooting

- List a few websites for students to start their research with. Assist students with search-engine queries, and in evaluating the results of those queries. See **www.scienceontario.ca**.
- Students could use publishing software to design their pamphlet, or they could use paper and coloured markers or coloured pencils.
- Provide some alternative resources, such as books and magazines.
- Check that students have answered all of the questions before they create a brochure.

Additional Support

- DI Order butterfly chrysalis kits and watch them develop in the classroom. Then release the butterflies in the schoolyard. Students can observe and record the development of the chrysalises. This activity will appeal to the bodily-kinesthetic and naturalistic learners.
- DI Spatial learners may prefer to create a poster project on the life cycle of monarch butterflies, including models of each stage.
- ELL Pre-selecting websites will assist English language learners focus their research on appropriate Internet sites.
- ELL English language learners could create their pamphlet in their first language, and explain it to you.

Answers

Procedure

a. Answers may vary. One sanctuary receives approximately 200 000 visitors between November and March each year.

b. Mexico has developed a strategic plan for ecotourism and set aside 780 000 hectares of forest.

c. Illegal logging will decrease the amount of habitat available for the butterflies, and decrease the opportunities for tourists to view the butterflies in a scenic, pristine environment.

Questions

1. Butterflies are important pollinators in Canadian ecosystems.

2. Answers will vary but may include the ideas that increased pollution (from car exhaust) could affect the butterflies, increased car traffic could reduce the butterfly population (if they are hit and killed by cars), or that the butterflies may be stressed by the increased human presence in the forest.

3. Student's pamphlets should include information about the region, about the butterflies' migration and life cycle, and about tourist practices that support the fragile ecosystem.

Learning Check Answers (Student textbook page 71)

1. Ecosystem services are the benefits experienced by organisms, including humans, which are provided by sustainable ecosystems.

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

3. severe droughts and erosion

4. The concentration of nitrates in run-off can increase from less than 1 mg/L to around 40 mg/L.

Learning Check Answers (Student textbook page 74)

5. pollination and decomposition

6. negative effects of pesticides, interference from cellphone radiation, parasites, negative effects of relocation

7. regulating the numbers of insects

8. a steady decrease in the numbers of all four species of birds over time

Section 2.4 Review Answers (Student textbook page 78)

Please see also **BLM 2-10 Section 2.4 Review (Alternative Format).**

1. maintaining the economic activities of some communities, influencing climate, reducing erosion, and providing habitat for thousands of species
2. Desertification is the change of non-desert land into desert through processes such as climate change and unsustainable farming or water use. It was important to designate 2006 as the International Year of Deserts and Desertification to draw attention to this problem worldwide. Raising the profile of the issue could result in funds being directed to this problem or to international co-operation to reduce it.
3. Pollination is the process of getting pollen from the male part of a flower to the female ovary of a flower. Butterflies, bees, and birds are good examples of pollinators.
4. Colony collapse disorder is the widespread loss of honeybees from hives. Possible causes are an Asian mite, a South African beetle, insecticides, and even radiation from cellphones and cellphone towers.
5. The decline in their population is complicated to figure out because it is difficult to determine where the problems may be. In Canada, where the birds live during the summer, the cutting of trees could be affecting the population by removing habitat. In tropical regions, where the birds live during the winter, the population could be affected by insecticide use, as well as the cutting of trees to grow coffee.
6. In the deforested area, the concentration of nitrates in run-off increased from less than 1 mg/L to around 40 mg/L. Without trees keeping water in watersheds, the nutrients in the water are lost.
7. Governments should support plans that recognize the concept of connectivity. It makes sense that countries that share ecosystems should have arrangements to protect shared species within those ecosystems—not just next-door neighbours like Canada and the United States, but countries far away with whom we share migrating species.
8. The Haida people constructed tall totem poles that expressed their reverence for the things depicted in these cultural features. The totem poles were artistic and showed the respect the people had for the ecosystems they lived in.

Data Analysis Investigation 2-A Is the Winter Skate Endangered in Nova Scotia? (Student textbook page 79)

Pedagogical Purpose

Students will be able to analyze and evaluate the effect of commercial fishing on the winter skate population in Nova Scotia. Students will interpret the data provided and decide whether the winter skate population should be considered at risk.

Planning	
Materials	Graph paper Computer lab (optional) **BLM 2-11 Data Analysis Investigation 2-A, Is the Winter Skate Endangered in Nova Scotia?** (optional)
Time	50 min

Background

Skates are species of rays, and their wings are edible. At one time, they were used primarily as fish meal or pet food, and sometimes to produce imitation scallops. As the cod fishery declined, the popularity of alternative fish increased. Skate are caught on longlines, gill nets, and trawls.

Activity Notes and Troubleshooting

- Using a projector or printed pictures, show students what the winter skate looks like, and identify its body parts. In particular, show students the "wings," as those are the edible parts of the fish.
- Students may need assistance with understanding the groundfish industry. Groundfish live near or on the bottom of a body of water. Common species include cod, halibut, and sole. You may want to provide pictures of these fish as well.
- Show a few examples of scatter plots and model drawing a line of best fit on the chalkboard. Remind students of the graphs they drew in Activity 2-2, on page 52 of the student textbook. When drawing a line of best fit, there should usually be an equal number of data points on either side of the line.
- Students may need assistance selecting the values and scale for the x- and y-axes.

Additional Support

- If necessary, refer students to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs, on pages 557 to 559 in the student textbook.
- Students may prefer to complete this assignment on the computer. Direct students to print off the scatter plot but to draw the line of best fit by hand.
- ELL Ensure English language learners understand what the Species at Risk Act is, and that an act is similar to a set of laws.
- Pair students who have strong graphing skills with those who need support.

Answers

Analyze and Interpret

1. The line will generally be placed so that one end is at the 1971 point and the other end is at the 2004 point.

2. The values do not decrease every year, but generally decrease from 1973 to 2004.

Conclude and Communicate

3. There is more than one justifiable guess because most points do not fall on the line of best fit. But if you extrapolate, the biomass will be zero in about 2007, meaning that in the annual samples, none will be caught.

4. Answers will vary, but presumably the trend is enough to have students think it should be listed.

5. Students will have to weigh the benefit of protecting a species in trouble against the economic cost of restricting an economically important commercial fishery. Considerations might be impacts on fishery-supported households, fishery-supported communities, cultural traditions, Aboriginal fishing, and government costs in enforcing protection.

Extend Your Inquiry and Research Skills

6. a. In 1992, at the Earth Summit in Brazil, the Convention of Biological Diversity was established to promote sustainable development. As part of Canada's promise to fulfill this convention, the Species at Risk Act became law in late 2002.

b. Evaluations will vary; however, it has been less than a decade since the Species at Risk Act was proclaimed, and that may not be enough time to assess its effectiveness. Visit **www.scienceontario.ca** to find more information about this issue.

Inquiry Investigation 2-B What Happens When Food Is Limited? (Student textbook pages 80 and 81)

Pedagogical Purpose

Students will conduct an investigation to determine the impact on a population when the resources are limited.

Planning	
Materials	2 plastic cups with labels Felt marker 50 mL graduated cylinder 20 mL paramecium culture Medicine dropper 1 drop yeast culture 1 toothpick 2 mL methyl cellulose 6 microscope slides Scissors 30 cm cotton thread Tweezers 6 cover slips Light microscope Plastic wrap 2 rubber bands 50 mL distilled water **BLM 2-13 Inquiry Investigation 2-B, What Happens When Food Is Limited?** (optional) **BLM G-23 Data Table** (optional) **BLM A-15 Data Table Checklist** (optional) **BLM G-20 Parts of a Microscope** (optional)
Time	40 to 70 min (initial set-up) 3 weeks to run
Safety	Remind students to use care with the electric cord of the microscope. Ensure students wear proper safety clothing, including gloves and lab aprons. Have students clean up any water spills immediately. Students should never direct the mirror of a microscope toward the Sun.

Background

This is a very simple model of how population size is related to the availability of food. It is easy to conduct and easy for students to interpret the results.

Activity Notes and Troubleshooting

- Before commencing the experiment, ensure students have created their data tables. Give them copies of **BLM A-15 Data Table Checklist** to help guide them.
- Model the set-up first, which will provide a backup set of paramecia, in case one is needed.
- Some colonies will die; be prepared to collapse groups if this happens.
- When counting organisms under a microscope, it is a lot easier to keep a tabulation either with tick marks on a piece of paper or with a hand clicker. If students try to count in their heads, it is very easy to lose count.

Additional Support

- Show students a prepared slide of a paramecium so that they know what they are looking for.

- If students have trouble organizing an effective data table, refer them to Science Skills Toolkit 7, on page 545 of the student textbook.
- If students have never used a microscope before, they will need to practise making slides and focussing first. Banana cells are easy to view; just dab a piece of banana on a slide, stain it with iodine, and apply a cover slip. Using a microscope to view a banana cell will allow students an opportunity to practise before they move on to viewing live organisms. Students can refer to Science Toolkit 8, on pages 546 and 547 of the student textbook, to review the proper procedure for using a microscope. See also **BLM G-20 Parts of a Microscope.**

Answers

Analyze and Interpret

1. Possible answer: By taking the average of the three, I get a better sense of how many paramecia there are.

2. Food slows population growth a lot.

Conclude and Communicate

3. Predictions will vary. Some students may predict that the population may double because the food supply has doubled. Others may predict that the growth is at its maximum because the food supply is plentiful.

4. Determine how many drops are in the paramecium culture, and multiply the sample size by that amount.

Extend Your Inquiry and Research Skills

5. a. *Paramecium aurelia:* 800 paramecia/mL
Paramecium caudatum: 200 paramecia/mL

b. The carrying capacity for *Paramecium aurelia* decreases to about 600 paramecia/mL and the population of *Paramecium caudatum* drops to zero.

c. *Paramecium aurelia* competes better and wipes out the population of *Paramecium caudatum.*

Data Analysis Investigation 2-C Putting Your Foot in Your Mouth (Student textbook page 82)

Pedagogical Purpose

Students will analyze how human activities and choices have impacted the carrying capacity of Earth. An ecological footprint is a measure of demand on Earth's resources.

Planning	
Materials	**BLM 2-13 Data Analysis Investigation 2-C, Putting Your Foot in Your Mouth** (optional)
Time	30 min

Background

There are many different tools and tables for calculating ecological footprints; each will provide a different answer. The important message is that our North American lifestyle is not sustainable for the entire population of the world, and sometimes it is the many small choices we make that can have the greatest impact.

Activity Notes and Troubleshooting

- Refer students to the Science Skills Toolkit 1, Analyzing Issues—Science, Technology, Society, and the Environment, on page 529 of the student textbook.
- Many students will have difficulty estimating some of the items on the table. They might have the most difficulty with imported food (especially if they do not participate in grocery shopping). Discuss examples of imported food (fresh fruit and vegetables in the winter, tropical fruit, rice, and so on).
- Students often have trouble estimating distances travelled and car efficiency. Help students make reasonable estimates.
- Stress that the accuracy of students' estimates is not as important as how they plan to reduce their footprint.

Additional Support

- There are many on-line versions of this activity available, which students may be more comfortable with. See **www.scienceontario.ca**.
- Assign this activity for students to complete at home with their family members.
- Enrichment—This activity could be tied in with an energy-conservation Family Action Plan for the entire electricity unit.
  - Once students have come up with suggestions to reduce their footprint and reduce their electricity use, have students ask their family members to implement the suggestions for a month. Record the electric meter readings each week and determine if the family has reduced the household footprint.
- ELL Explain the meaning of the idiomatic expression *ecological footprint*, and of the investigation title "Putting Your Foot in Your Mouth."

Answers

Analyze and Interpret

1. Answers will vary. Many students will be surprised by how much eating meat contributes to their footprint.

Conclude and Communicate

2. Reduce the amount of meat eaten, and travel less by car and plane.

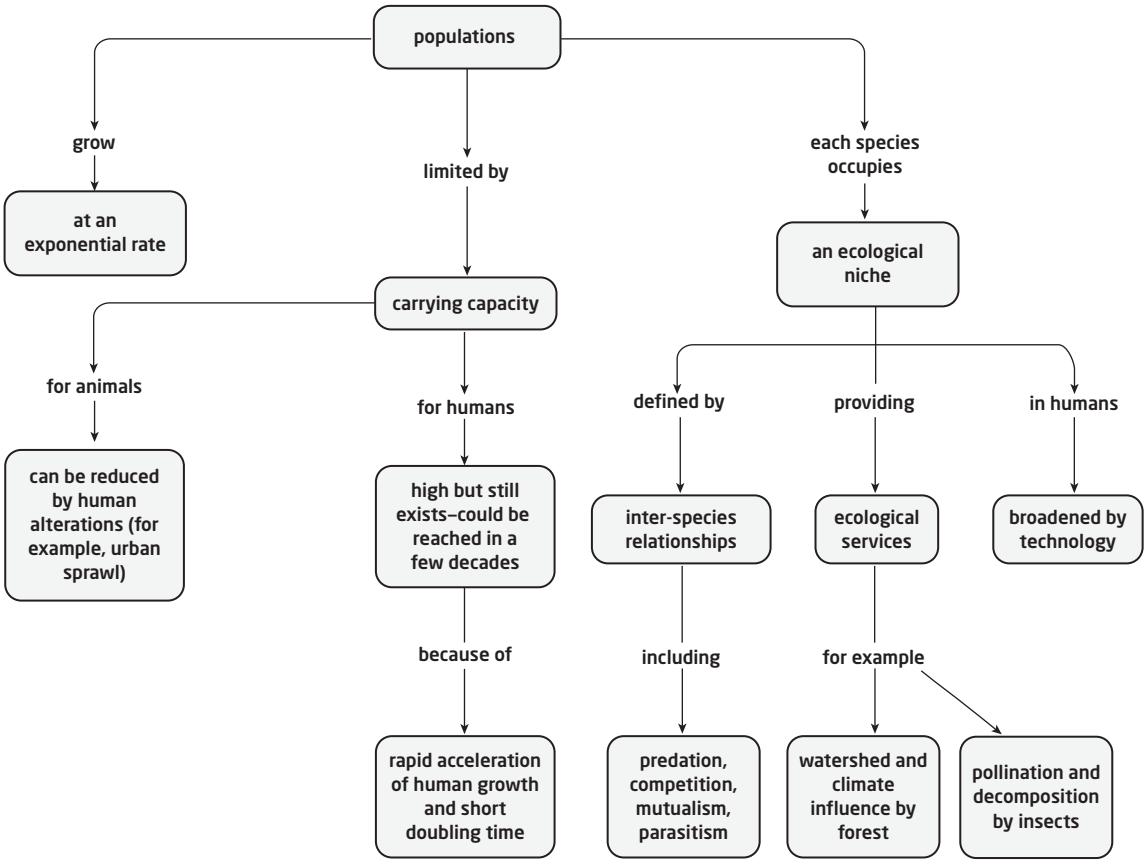
Extend Your Inquiry and Research Skills

3. Answers will vary.

Chapter Review Answers (Student textbook pages 84 and 85)

Please see also **BLM 2-14 Chapter 2 Review (Alternative Format).**

Make Your Own Summary



Reviewing Key Terms

1. **e.** mutualism
2. **g.** population
3. **d.** ecological niche
4. **a.** carrying capacity
5. **f.** parasite
6. **c.** ecological footprint
7. **b.** connectivity

Knowledge and Understanding

8. **a.** pack ice for feeding from
   b. caves
   c. material for building nests
9. hunting and the removal of forest
10. Intensification is one way to reduce the impact of rapid population growth, so that the density of urban areas increases and the outer edge does not have to grow.
11. The algae leave the coral, possibly in response to increased water temperatures. The mutualistic relationship between the coral and the algae breaks down and the coral bleach and die.
12. The doubling time now is about 60 years; the population growth is not as fast now as it was then.
13. The population grows about 300 000 per day. So, it would take about 110 days to increase to 33 million people and between three and four more days to increase another million people.
14. When large forested areas are cleared, the local annual precipitation drops and the climate gets hotter and drier. Clear-cut forestry can also dry out soil and increase erosion where soil is lost.
15. They help control the population of the insects they eat.

Thinking and Investigating

16. Starlings are also cavity nesters and they compete with native birds like the eastern bluebird for limited nest sites.
17. You could collect the same kind of data from a different area that has not experienced such tremendous population growth. You could research the types of nests and locations that these birds prefer and how urban sprawl affects them. You could research the change in food availability for the bird species.

18. Wind-pollinated flowers do not need to attract insects or other animals by being bright, large, and fragrant, so they are likely to be dull, smaller, and non-fragrant.

19. a. The more seeds planted per square metre, the fewer seeds produced by individual plants.

b. There is increased competition among individual plants, so each plant has less energy to dedicate to seed-production.

20. A straight line would be unreasonable and contrary to the idea of carrying capacity. It is likely that the pattern would be more like that shown in Figure 2.5 for the fur seal, on page 51 of the student textbook.

Communication

21. Answers will vary. Problems may include pollution and competition among people and nations for space for homes, access to fresh water, land for crops and livestock, food supply, electricity needs, and so on.

22. Answers will vary. Students will need to balance what is ecologically responsible with what is economically possible.

23. Answers will vary. Activities could include things like canopy-walking, white-water rafting, swimming with the dolphins, zip-lining in the forest, whale watching, hiking, scuba diving, and so on. Students may recount some interesting stories.

24. An animal that is hunted by humans may not reach carrying capacity because numbers are harvested each year, preventing the population from reaching the maximum. It is probably not a problem for the ecosystem, but arguments could be made both ways. Hunting might reduce numbers that could be used to feed natural predators. On the other hand, hunting might prevent some wild turkeys from starving if the carrying capacity is reached.

25. Answers will vary. Plants and algae photosynthesize; feathers can be used for nests of various animals; insects aid in decomposition; decomposing plants and animals contribute nutrients; woodpeckers provide access to trees for insects, and so on.

Application

26. The redside dace populations are restricted to upper reaches of streams because of unsustainable conditions downstream. These conditions mean that the populations are isolated and cannot move from one stream to another.

27. Answers will vary. Humans have been able to expand their carrying capacity through technology. There are other animals who will have population growth that is beyond their carrying capacity (as in the predator-prey relationships in Figure 2.11, on page 58, and Figure 2.12, on page 59) and who will then experience a sudden drop in population.

28. It would mean a greatly increasing population (a population boom) because not so many people are dying but the birth rate is remaining high.

29. The presence of the trees provides shade and reduces erosion so that water is retained longer in the soil.

30. This species is migratory and so it may not be experiencing any difficulties in Canada but it may be finding circumstances difficult in its wintering grounds or along the way there.

Chapter 3 Biodiversity

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Begin assembling groups of small items for the model ecosystems in Activity 3-2, on page 93.
- Students can review the Key Terms in Chapter 3 by using **BLM 3-1 Chapter 3 Key Terms.**

In this chapter, students will discover that Earth's biodiversity includes millions of species. They will learn that ecosystems are dynamic, particularly in terms of maintaining ecological balance and the impact of human activity on that balance. Students will be able to explain the role of certain species within a community or ecosystem. They will also be able to explain how human activities can affect biodiversity.

Using the Chapter Opener (Student textbook pages 86 and 87)

- The protection of Alfred Bog, just east of Ottawa, was a publicly driven project. Poll the class and ask if students are aware of any similar projects in their area (not necessarily wetland-related), and whether students have been involved in these projects. For example, some students may have planted trees or built bird boxes with scouts, or been involved with the yellow fish program.
- Research the local wetlands in your area, and find out if any provide interpretive programs. Plan a field trip or encourage students to visit one of the wetland areas. Wetlands are excellent places to view birds and wildlife—students will have more wildlife sightings in a wetland than in a forest.
- Have students learn the word origins for *biodiversity* and *ecology. Bio* means life; therefore, *biodiversity* means the diversity of life. *Eco* is from the word for house, and *logy* means the study of.
- Another example of publicly driven wetland protection is Oshawa's Second Marsh. This is the largest wetland in the Greater Toronto Area and is an example of how a coastal wetland functions, as it is on the shore of Lake Ontario. Second Marsh itself is 123 ha in area and is flanked by Darlington Provincial Park and McLaughlin Bay Wildlife Reserve, bringing the total area of protected wetland up to 400 ha. This type of wetland provides natural floodwater protection, filters contaminants from the water, provides habitat for birds and wildlife, and provides spawning beds for fish. In the 1970s and 1980s, the special interest group Friends of Second Marsh was responsible for saving the marsh from development. In the 1990s, Friends of Second Marsh participated in restoration projects. By 2000, Environment Canada and the Canadian Wildlife Service granted the Friends group the responsibility of developing educational and stewardship programs. Second Marsh is a sharp contrast to what most urban shorelines look like, and sets an example for what they could become.

Activity 3-1 Biodiversity in Canada (Student textbook page 87)

Pedagogical Purpose

This activity will emphasize the importance of models in representing an idea or a concept. Students may only associate the term *model* with something like a model airplane. Students will learn that models can be two-dimensional, three-dimensional, or simply a thought or an idea. This activity will also make students aware of the amount of diversity that exists in some groups of organisms.

Planning	
Materials	Markers Chart paper Construction paper (optional) Computer lab Modelling clay, or other materials for constructing 3-D models
Time	30 min

Background

As informed citizens, we can influence and have an impact on how our natural resources and ecosystems are utilized. These efforts may take decades, but the impact will be much longer lasting. Education is often the first step of an effective strategy.

Activity Notes and Troubleshooting

- This task has the potential to run overly long, but its function is really just to introduce the central concept of the chapter, so limit the time you spend on it.
- Be very clear about what is acceptable as a model. Depending on your students, you might tell them to construct, an appropriate type of graph, and graph the data. This activity would be less time consuming in a computer lab, where students could then select different charts and decide for themselves which would be most appropriate.
- As students evaluate their own and others' models, have them consider how effectively the model communicates the key ideas about biodiversity.

Additional Support

- Depending on students' skills and learning styles, you may want to direct students specifically to create a graph of the data using a computer.
- DI Bodily-kinesthetic learners could create physical models using either modelling clay or paper and scissors. For example, students could make a cutout of each organism and use the size of the cutout to represent the number of known species. This way, the largest cutout would be an insect and the smallest cutouts would be amphibians or reptiles.

Study Toolkit

Strategy	Page Reference	Additional Support
Identifying the Main Idea and Details	page 93 page 105	Students can use sticky notes and the strategy described in Study Toolkit 2, Reading Effectively: Monitoring Comprehension, on page 564 of the student textbook. If this is the first time they are using this strategy, you might want to model the process for them. English language learners may benefit from planning their summary on **BLM G-31 Summarizing.**
Word Origins	page 112 (restoration, reforestation) page 115 (bioremediation, bioaugmentation)	The meanings of common prefixes and suffixes are given in Study Toolkit 3, Word Study: Common Base Words, Prefixes, and Suffixes in Science, on page 565 of the student textbook. English language learners can benefit from listing other words that include the same prefix, for example, *biologist,* and *biodiversity.*
Interpreting Tables	page 90 Activity 3-3, page 104	Have students practise in pairs using any table. One student identifies a cell by stating the row and column headings, and the other student reads the information found in the cell. Also, ask questions about the tables in the textbook, such as, "What trend to you see?", "How many years are shown?", and "What unit is the zebra mussel population measured in?"

Section 3.1 Measuring Biodversity (Student textbook pages 89 to 94)

Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed*

In this section, students will explain how biodiversity is calculated, and understand that it represents the variety of organisms found within a specific region. Students will learn that there are places on Earth with exceptionally large numbers of species in a small area, and that some of these areas are so significant that they are labelled as hotspots.

Common Misconceptions

- **Students may think that large, empty spaces, such as vacant lots and hydro corridors, do not contain any biodiversity.** This belief is often used as the reason to keep these areas mowed and "under control." However, these areas provide habitat for small animals and birds, which are food for hawks. The wildflowers also provide food and a habitat for insects and butterflies. In most cases, hydro corridors can be excellent places to encourage the growth of wild berries. Only the trees need to be managed to prevent damage to the power lines.
- **Students may feel that biodiversity is only relevant to wildlife and their habitats, and has no direct impact on humans other than to provide us with the reassurance that animals have been saved and protected.** Biodiversity gives an ecosystem the flexibility and genetic resources to adapt to environmental changes. Biodiversity also applies to agricultural practices. We have bred out the diversity in most of our food in favour of monocultures. In order for crops to adapt to disease or pests, scientists often have to reach back to ancient crop species to introduce a greater diversity of genetic material.
- **Students may be concerned about protecting some species (for example, polar bears) but not others (for example, lichen).** In the past, conservation ecologists often chose a "poster" species to evoke emotional reactions and encourage support in protecting that species' environment. Not all poster species are keystone species: otters fulfill both categories but wolves, while handsome, are not keystone species. If we manage to meet wolves' needs for habitat and prey, we do not necessarily take into account the needs of more sensitive species, such as pine marten or lynx; however, the public has a more emotional attachment to wolves than to pine marten.

Background Knowledge

The term *biodiversity* comes from the concept of biological diversity. Biodiversity refers not only to the number of species in a given area, but the genetic diversity of those species as well. It is difficult to apply a numerical value to biodiversity because its nature varies from ecosystem to ecosystem. We cannot compare the diversity of the Canadian Arctic to the Amazon rainforest. A biodiversity index, as in Activity 3-2 (on page 93), is one way of quantifying the diversity of species in an area.

Biodiversity hotspots refer to areas that have a significantly larger number of species in comparison with the surrounding areas. Hotspots in Ontario include the Carolinian forest, which has endangered orchids, snakes and fish, and a large number of unique tree species. Other Ontario hotspots include the Algoma Highlands, home to old growth maple and birch trees, and a habitat for wolves, lynx, and bald eagles. The Great Lakes can be considered hotspots because they contain one fifth of the world's fresh water. The short and tall prairie grasslands in Manitoba, Saskatchewan, and Alberta—once home to the extirpated plains grizzly and black-footed ferret, and the endangered swift fox, is another Canadian hotspot. (Extirpated species are locally extinct but still exist elsewhere.)

Literacy Support

Using the Text

Before Reading

- Have students preview the text features. Students can create a three-column table in their notebooks. The first column is for terms, the second is for definitions and explanations, and the third is for pictures. The students can then scan the text for Key Terms and headings (there are three Key Terms and five headings) and copy them into the first column. The table can be modelled on Table 3.1, Methods of Measuring Biodiversity, on page 90 of the textbook.

During Reading

- Divide the class into groups of four, and have group members compare their lists, so that all members have the same terms and headings listed. Each member of the group will be responsible for finding definitions or explanations of one quarter of the terms and headings listed. Each member of the group reads the corresponding portion of the textbook and fills in the second column of the table for the parts that he or she is responsible for.

After Reading

- Monitor comprehension and summarize. Group members can share their explanations with each other, and ask clarifying questions to ensure that everyone understands the main idea of each chunk of text. Students can copy each explanation or rewrite it in their own words, so that the second column of everyone's table is complete. After reflecting on the explanations, each individual student can complete the third column, by creating an illustration for each term or heading.

Using the Images

- Ask students to examine Figure 3.1, on page 89 of the student textbook, and describe the habitat of the shark. Based on the appearance of the shark and its habitat, what do students suppose that it eats? How do they think it might hunt?
- In Figure 3.4, on page 92, what can students infer from the map, photograph, and caption about the species found in the Carolinian forest? What are the species' unique and specific requirements? What can students infer from the map, photograph, and caption about the eastern massasauga rattlesnake's habitat requirements?
- Have students examine Figure 3.5, on page 93, carefully and determine how many different species of fish there are in the small area shown in this photograph.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Selected Response Learning Check questions, page 92	Students define biodiversity and explain one method of measurement. Students explain the importance of wetlands.	• Use the Word Origin strategy from the Study Toolkit on page 88 to define biodiversity. • Have students use the photographs in Table 3.1, Methods of Measuring Biodiversity, on page 90, as cues to help them explain. • Ask which has the greater biodiversity within the same region, a wetland or mature forest? Provide some accompanying photographs, or direct students to images from the text (for example, Figure 3.10, on page 98, and Figure 3.22, on page 112). Very often, the wetlands have greater diversity.
Selected Response Section 3.1 Review questions, page 94	Students select the appropriate method for sampling biodiversity and justify their choice. Students explain the importance of sampling and data collection and how it assists with ecosystem protection.	• Direct students to Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 567 of the textbook, for directions in constructing a Venn Diagram to compare and contrast biodiversity measuring methods. • Ask students to choose a sampling method to determine an accurate representation of the actual number of students, furniture, and equipment in the room. This activity can be done individually or in groups. Students can plan their sampling method, and carry it out if you wish. • Have students form a line in the classroom. At one end is, "Sampling is very important in ecosystem protection." At the other end is, "Sampling does not help protect ecosystems." Direct students to place themselves along the line. Then fold the line in half, so that pairs of students with opposing views are facing each other. Have the resulting pairs of students discuss the issue.
Activity 3-2, Biodiversity Index, page 93	Students accurately record data and make biodiversity calculations.	• If data recording is not a priority because students have done this task elsewhere in the unit, have students work in groups and record their data on chart paper or mini whiteboards. • It will probably be easier (and quicker) for students to record the information in column 3 in the following way (assuming beads were used): Red = 3 Blue = 2 White = 5 Total number of organisms = total number of beads in all containers.

Instructional Strategies

- As a class, measure the biodiversity of the schoolyard, or a nearby park. Organize students into groups of two to four, and have the students in half the groups use quadrat sampling, and the others use transect sampling. After returning to the classroom, compare the results of both methods, and have students decide which method they thought was better for the schoolyard. Students can briefly present their results to the class. This activity will appeal to students with a variety of learning styles. As much as possible, create groups that include students with strengths in many areas.
- DI Spatial learners can create a postcard or sports card for a Canadian hotspot or species at risk. Students may need some time to do research on the Internet before creating their product.

Activity 3-2 Biodiversity Index (Student textbook page 93)

Pedagogical Purpose

This activity will demonstrate how biodiversity is calculated, by allowing students to make their own calculations using a model of an ecosystem.

Planning	
Materials	Model ecosystems provided by you Large number of coloured beads or other very small objects, such as dried beans or pasta (20–30 each of 10 different colours if possible) Plastic containers of some kind or large resealable plastic bags Mini whiteboards (optional)
Time	45 min

Background

Canada has 15 terrestrial and 4 aquatic ecozones. Visit **www.scienceontario.ca** to find out more about each one, including the plants and animals that are native to each. As a general rule, the farther north an ecosystem is, the less diverse it is.

Activity Notes and Troubleshooting

- You can assign each bag a name, such as "Arctic Cordillera" or "Boreal Plains," and place appropriate numbers of each "species" in the bags. Alternatively, to simplify preparation, you can label the bags "Ecosystem A," "Ecosystem B," and so on. If you decide to set up each bag to represent an actual ecosystem, visit **www.scienceontario.ca** to learn about the species present in each.
- You could use any type of counter you wish, such as dried beans and pasta or coloured bits of paper with different symbols—whatever is most cost effective and easily available as long as you have a sufficient number of shapes and colours to represent the number of species you want to have.
- Use large resealable plastic bags, so that students can flatten out the contents and count them without having to dump out the contents. You could write on the outside of the bag with a permanent marker. Plastic resealable bags can easily be stored and transported for future use.
- Students may obtain slightly different results for a given ecosystem, due to difficulty counting large numbers of small items in a bag. If this difference occurs, remind them that this will also be the case for real life ecosystem sampling, and talk with them about ways to obtain the best possible data, including averaging the results of several counts.

Additional Support

- Decide which set of skills and knowledge are important to you and your class before setting aside the time for this activity.
  - If you want students to practise their data-collection skills, then you might want to make sure each group records the information for all of the ecosystems themselves, and each student has a made their own copy of the data in their notes.
  - If you are only interested in the concept attainment (because students have had other opportunities to record data), then you may want to conduct this activity where the groups share their information with the class.
    - In this case, you might want to use mini whiteboards, and summarize the information at the front of the class.
    - Students could still copy the summarized information into notes.
  - Some students may find the headings on the table confusing. For those who do, have them use the headings "Ecosystem," "Number of Colours," "Number of Each Colour," "Total Number of Beads," "Number of Colours/Total Number of Beads" to organize their observations. After students have collected their data, have them replace the headings in their table with the original headings.

Answers

1. Students' answers will depend on how the ecosystems were prepared. The ecosystems with the highest biodiversity could possibly include the Southern Ontario Wetland or Carolinian forest.
2. The strengths are that biodiversity is represented as a simple number. The weakness is that it is unfair to compare very different ecosystems such as an Arctic ecosystem with the Carolinian forest.
3. An abiotic factor could be the lowering lake levels that are drying up a shoreline wetland. A biotic factor could be the introduction of an invasive species such as purple loosestrife.

Learning Check Answers (Student textbook page 92)

1. Biodiversity is the number and variety of organisms found in a specific region.
2. Methods to measure biodiversity include canopy fogging (spraying a low dose of insecticide up into the top of a tree, and collecting the insects for observation), quadrat sampling (counting species in a marked area), transect sampling (recording the type and number of species along a transect line at set intervals), and netting (capturing, identifying, measuring, genetically analyzing, and tagging birds and bats in ecosystems).
3. Scientists should record information about biodiversity to protect Earth's biodiversity. It is also helpful for land-use planners to know the location of different species.
4. When ecosystems are protected, developers are not allowed to use the land for building houses or industries, so the ecosystem's biodiversity is preserved.

Section 3.1 Review Answers (Student textbook page 94)

Please see also **BLM 3-3 Section 3.1 Review (Alternative Format).**

1. Students' sentences will vary. A possible example is, "It is important to protect an ecosystem so its biodiversity will be maintained."
2. Both quadrat sampling and transect sampling involve counting species in specific areas. In quadrat sampling, species are counted in an area marked with a piece of plastic or stakes and string. The counting is repeated to ensure the representation is accurate. In transect sampling, a transect line is marked at set intervals, and the species found at each interval are observed and counted.
3. canopy fogging
   a. The advantage of canopy fogging is that it is an effective way of collecting information about the biodiversity of insects. The disadvantage is that insecticide is used, which could harm some insects and other animals or vegetation in the ecosystem.
   b. Students' answers will vary. Some students might say that they would use one of the sampling methods (quadrat or transect) because there is no direct contact with the species.
4. Information about biodiversity is used to protect Earth's ecosystems, and scientists need funding for their research.
5. Lake Malawi is home to about 1000 species of fish. This lake is about the same size as Lake Erie, but Lake Erie has only about 150 fish species.
6. Students' answers will vary. Scientists may not have an accurate count of the number of species on Earth because insects and animals move around and hide, making them difficult to study. Many ecosystems are also in remote or inaccessible locations.
7. Students might say that most of the world's hotspots are in tropical areas because there is less development and industry in the developing nations where these hotspots are located or because more species on Earth are adapted to live in warm climates than in cold climates.
8. Canada has initiatives to protect ecosystems in developing nations because protecting all ecosystems is important for Earth's biodiversity.

Section 3.2 Communities (Student textbook pages 95 to 99)

Specific Expectations

- **B1.1** assess, on the basis of research, the impact of a factor related to human activity
- **B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed*
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

In this section, students will learn that species live in communities where relationships among different species are very important. Students will be able to explain in what ways keystone species are significant in maintaining an ecosystem through their relationships with other species. Students will understand that ecosystem engineers are species that alter a landscape, and they are part of the natural succession that occurs over time.

Common Misconceptions

- **Students may have seen television and magazine advertisements that have led them to believe that preventing forest fires protects the wilderness and wildlife.** In fact, forest fire prevention and suppression are important to protect communities and industry, but do not necessarily protect the forest. Fire is a natural and important part of the boreal forest succession and regeneration cycle.
- **Students may believe that captive breeding programs are capable of increasing populations of animals so that species will no longer be at risk.** However, captive breeding programs are not always successful. Many species do not respond well to captive breeding programs. In particular, large predators that must learn hunting skills from their parents and migratory birds are not as successful in captive breeding programs as some other species are.

Background Knowledge

The impact of a keystone species is often greater than would be expected. If a keystone species is removed from an ecosystem, the entire ecosystem may shift or collapse. Grizzly bears are a keystone species in the transfer of nutrients from the ocean to the forest. They do this by consuming salmon. Elephants are a keystone species in that they prevent shrubs and brush from encroaching on African grasslands.

Some species, called ecosystem engineers, actually transform their ecosystem. For example, trees that grow in direct sunlight create a shady environment for other types of vegetation. In forest succession, birch, poplar, and maple trees are well adapted to take advantage of open spaces. Birch and poplar are short-lived species and do not thrive well in shady forests, while maples will continue to grow in a mixed forest. Other species of trees require shade in order to establish themselves. White pine and red oak are often planted with a cover or nurse crop to help them establish.

Literacy Support

Using the Text

Preview vocabulary with English language learners. Use an analogy to compare ecosystem communities to human communities with which students are familiar, such as their school. The Sense of Value feature on page 96, explaining what a keystone is, can help students understand and remember the term *keystone species.*

Before Reading

- Have students scan the section and create a list in their notebook of Key Terms, as well as other words that they find in headings or definitions that seem important. Tell them that as they read, they will be looking for relationships among these ideas to create a concept map. Students can create their lists on their own or in pairs. Have students list approximately 20 terms.

- ELL English language learners can work with a fluent English speaker. Have them also identify words that they do not understand, and use the Glossary or ask their partner for clarification.

- Refer students to the concept map in Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook.

During Reading

- As students read through the section, they should reflect on how they will link each of the terms in their lists in their concept map. Students may want to record some ideas in a rough draft.

After Reading

- To help students differentiate between concepts and linking words, have students brainstorm some of each as a class. Create two lists on the chalkboard and ask students to describe the differences they see between concepts and linking words.
- Have students create a concept map. Students may want to attach two pieces of notebook paper to make a larger piece of paper, or work in a group and use chart paper, for this activity. It is useful to have some coloured pencils or markers on hand.

Using the Images

- Have students examine the two illustrations in Figure 3.7, on page 96, and list as many differences as they can in their notebooks. Have students state in their notebooks whether they think the sea urchin population affects the otter population or the otter population affects the sea urchins, and explain how. Ask students how a change in the sea otter population might affect populations of other organisms in this ecosystem. For example, fewer sea otters and less kelp could cause a decline in the populations of small fish, and cause predatory birds, such as eagles, to eat more seabirds.
- How many phases of succession can students observe in Figure 3.10, on page 98? Students can write about how the beaver pond has facilitated or changed each of these phases. Students could also use a flowchart or a cause-and-effect diagram.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Selected Response Learning Check questions, page 97	Students explain the importance of captive breeding and define keystone species.	• Provide an illustration of a keystone in an arch. Ask, "If the keystone of the arch is removed, what happens?" Ask students why scientists choose this analogy to describe why some species are crucial to the health of their ecosystem.
Selected Response Section 3.2 Review questions, page 99	Students identify a keystone species and describe its role in an ecosystem.	• Direct students to Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 567 of the student textbook, for directions to construct a Venn diagram. • Direct students to answer question 3 using a cause-and-effect diagram. Refer them to Study Toolkit 4 on pages 566 and 567. • Direct students to illustrate the situation described in question 4 using a flowchart or a concept map to help them answer. Refer to Study Toolkit 4, on pages 566 and 567. • For question 5, have students rank each of the species from least charismatic to most charismatic.

Instructional Strategies

- DI Any video about one of the keystone species mentioned in this section would be an effective way to introduce or conclude the section, especially for spatial learners and for students who are not familiar with the species.
- Have students research on the Internet the Toronto Zoo's captive breeding programs. Assign an animal from this program to a pair of students, and each pair will design a poster outlining the captive breeding program for their animal. Include information such as where the animal's native habitat is, and what other organizations are involved. This activity will appeal to spatial learners, as well as naturalistic and interpersonal learners.
- Students can construct a model of the succession facilitated by beavers. Leave the choice of materials to the students, but you may wish to put a price limit on the project.
- As an alternative to building a model, students can create a comic or graphic novel describing the succession facilitated by beavers. There are many software programs available to schools for making comics and movies. Students can also add music to their comic or graphic novel using computer movie-making software.
- DI ELL Have linguistic and intrapersonal learners research other ecosystem engineers and prepare a brief written report, or a creative oral or multimedia presentation. If English language learners have information about ecosystem engineers in their country of birth, ask them to share it with the class.

Learning Check Answers (Student textbook page 97)

1. It is important to preserve the biodiversity of communities in order to protect the species in that community because species depend on the relationships among organisms that exist within the community.
2. A keystone species greatly affects the population numbers and health of an ecosystem. Sea otters are a keystone species because they control the number of sea urchins, which allows kelp to survive.
3. A captive breeding program re-introduces a species that is in danger of becoming extinct into its natural environment to increase its population.
4. Black-footed ferrets use the burrow system made by the prairie dogs, so when prairie dog populations suffered, so did the ferret population.

Section 3.2 Review Answers (Student textbook page 99)

Please see also **BLM 3-4 Section 3.2 Review (Alternative Format).**

1. A community includes all the populations of different species that interact in a specific area or ecosystem.
2. Students' Venn diagrams should show the following similarities and differences: The removal of both dominant species and keystone species results in decreased biodiversity within the ecosystem. However, dominant species are very abundant and have a large biomass, and they are always primary producers. Keystone species are generally not abundant, and they can be plants or animals.
3. Students may say that removing a rare species would not change the ecosystem much because if there is only a small number of this species, other species probably do not depend on it for survival. A dominant species, however, is very abundant and has a large biomass, so more species would depend on it.
4. The beetle would be classified as an ecosystem engineer because it causes a dramatic change to the landscape and creates a new ecosystem.

5. Students' answers will vary, but may include the following ideas:

- **a.** The polar bear could be considered a charismatic species because it is cute and can interact with people.
- **b.** A fern probably would not be considered a charismatic species because it is not personified.
- **c.** A blue whale could be considered a charismatic species because it is huge and strong.
- **d.** An earthworm would not be considered a charismatic species because it does not capture most people's attention and is not usually cared for as a pet.

Students may feel that charismatic species should not receive more attention than other species at risk because all species at risk deserve equal attention.

6. Succession refers to the changes that occur over time after a disruption in an ecosystem.

7. Beaverpond basket-tail dragonflies and wolves both benefit from the changes that beavers make to their environment when they build dams. The dragonflies live in beaver ponds and the wolves live in the meadows that form after the ponds have dried up.

8. An ecosystem engineer is like an urban planner who develops housing communities in formerly rural or untouched areas.

Section 3.3 Threats to Biodiversity

(Student textbook pages 100 to 109)

Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed*
- **B2.5** analyze the effect of human activity on the populations of terrestrial and aquatic ecosystems by interpreting data and generating graphs
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

In this section, students will learn that threats to biodiversity include habitat loss, the introduction of alien species, overexploitation, and breaking the connectivity among ecosystems. Students will understand that draining wetlands can result in habitat loss. Students will be able to explain that extinction is a natural event that has occurred throughout Earth's history, and that current extinction rates may be accelerated due to human activities.

Common Misconceptions

- **Students might believe that all invasive species enter the ecosystem by accident.** Zebra mussels did enter the ecosystem by accident, but many other species, such as dandelion, were introduced intentionally. Noxious weeds, for example, were introduced by settlers to remind them of the wildflowers from home.
- **Students may not be aware that the most significant rates of extinction are probably occurring in our oceans.** We tend to think only of terrestrial animals that evoke an emotional response, such as polar bears. However, overfishing is the leading cause of the decline in populations of large predatory fish, including tuna, marlin, and swordfish. Some estimates report that populations have declined as much as 90 percent over the last 20 years.

Background Knowledge

Wetlands are often drained for agriculture. The Holland Marsh in Ontario now supplies food for a large portion of Canada, not just Southern Ontario. Agriculture in this area dates back to the 1920s, and the drainage system was completed in the 1930s. What was gained in agricultural productivity was lost in watershed management. The natural floodwater protection provided by marshes and wetlands was not in place when Hurricane Hazel struck in 1954, and many people on the marsh lost their homes.

Extinction occurs when a species is no longer able to survive in changing conditions or against superior competition. The apparent acceleration of extinction rates has been called the biodiversity crisis. Not too long ago, our attitude toward extinction was much more cavalier than it is today. In the late 1800s and early 1900s, leading museums often hunted down a species on the verge of extinction to the very last specimen. They did this so they could say that they had the last known member of a species.

The debate on the seemingly imminent extinction of the popular yellow banana is ongoing. On one hand, the banana is a primitive plant and may have been naturally on its way out. On the other hand, as a result of human activity, the bananas we consume are most often from large monocultures and therefore lack genetic diversity. The jury is still out on whether commercial propagation has doomed the banana into early extinction or bought us a few more years to enjoy this fruit.

Literacy Support

Using the Text

Before Reading

- Make connections to prior knowledge. Talk with students about the meaning of each Key Term and record their ideas on the chalkboard. Encourage others to question or refine the ideas. If students need help, they can refer to the definitions in the textbook.
- Once you have recorded a definition for each term, have students list examples of each term. Record these under the definitions on the chalkboard. Students will find some definitions in the textbook, including the images.

During Reading

- Have students work in groups of four. Each group member identifies the causes and effects that are associated with one of the threats, and then explains these to the group. Refer students to Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook. Students can record on **BLM G-33 Cause-and-Effect Map.**
  - ELL English language learners may benefit from working in pairs for one threat.

After Reading

- Have each student summarize the causes and effects associated with all four threats using a format of their choice. Some may wish to record point-form study notes. Others may want to create a concept web.
- Alternatively, students could summarize in their groups by creating a concept web for the section as a placemat activity on a large sheet of paper. The placemats could be displayed in the classroom for all students to refer to.

Using the Images

- Ask students to compare the cut areas in Figure 3.11, on page 100, with the forest on the distant slope to the right. Ask, "How has the forest regrown just above the clear-cut area compared with the slope on the right?" What other effects of deforestation can students notice in the picture? (for example, soil erosion) The observations can be recorded on the chalkboard during class discussion.
- For Figure 3.12, on page 101, ask students how the forest loss compares between Africa, and Central and South America. Ask, "Why are so many more countries listed for one region?" Do students notice that any countries are missing from the list? Ask, "What other information might be needed in order to compare one region with another, and where can you find this information?" (For example, areas of deforestation could be found in an atlas or on the Internet.) The answers can be recorded on the chalkboard as a brainstorm session, or students can record the answers in their notebooks.
- As students examine Figure 3.16, on page 104, ask why they think the cod catch went up in the 1960s: "Was it a natural increase or human-induced?" Students should verbally describe what they think happened. Ask, "In what ways can this pattern be compared to a predator-prey relationship?"
- For Figure 3.17, on page 105, have students make the last connection. What benefits do the trees provide for the salmon? (They reduce run-off, clear shaded streams, and provide oxygen to the ecosystem.) Have students copy the diagram into their notebooks and include the last connection, or distribute **BLM 3-5 Ecosystem Connections,** for them to complete.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Selected Response Learning Check questions, page 103	Students explain the significance of habitat loss and the possible effects of introducing an alien species.	• Suggest that students think about a concrete example as they answer questions 1 and 3. • Have students do an Internet search to find more information on the significance of wetlands. Suggested search queries include Ontario wetlands and Ontario wetland habitat.
Selected Response Section 3.3 Review questions, page 109	Students explain the human impacts that cause habitat loss. Students also explain the significant impact of invasive species and what can be done to control invasive species. Students consider different perspectives as they make environmental decisions.	• For question 2, refer students to Science Skills Toolkit 1, Analyzing Issues–Science, Technology, Society, and the Environment, on page 529 of the student textbook. They can also use **BLM G-16 Tips for Investigating Many-Sided Issues; BLM G-17 Worksheet for Investigating Issues; and/or BLM G-18 Decision-Making Organizer,** to help them consider differing viewpoints fairly. • In groups of four, have students brainstorm and answer questions 3 and 5 on chart paper. Display the answers to share with the rest of the class. Encourage students to use real examples in their T-charts and slogans, for which Internet access may be helpful. • Students can use **BLM A-13 Venn Diagram Assessment Checklist,** to guide their work in question 6. • For questions 7 and 8, have students do some brief research on the Internet to learn more about the concepts.
Activity 3-3, Alien Invasions, page 104	Students extract the necessary information from a table and decide on the appropriate application for a given scenario.	• Refer students to the Interpreting Tables strategy in the Study Toolkit on page 88. • Ask students to identify and locate specific information that they need for the activity. You might ask the following questions: "How large is the infestation? (Locate that information on the left side of table.)" "What is the density of the infestation? (Locate that information across the top of the table.)" "Where do the columns and rows intersect?"
Activity 3-4, Plants at Risk, page 108	Students estimate numerical values from the bar graph. Students calculate percent and write persuasively about species at risk.	• Refer students to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs, on page 557 of the student textbook. • Allow students to use computers to design their flyers. • Allow English language learners and others to present most material visually, with little text. • Provide students with a template for a persuasive argument. See **BLM 3-6 Writing a Persuasive Argument,** or **BLM 3-7 Writing a Persuasive Argument (Alternative Version).**

Instructional Strategies

- Book a computer lab and have students find information about recent extinctions. Using an LCD projector, share some of the websites that students have found with the rest of the class.

- Have a "Town-Hall Meeting" role-play about the draining of a local wetland for development. The interested parties include the mayor and town council, the developers, the citizens concerned about West Nile virus, the Federation of Ontario Naturalists, and the Ontario Federation of Agriculture. Allow students to select their own groups as much as possible. Each group will present their side to the town council in order to persuade them to allow, or dissuade them from allowing, the development of the wetland. Students may need a little time to prepare, and they may want to do some Internet research overnight. Although this is not strictly a debate, students may want to prepare their arguments and anticipate others' arguments using **BLM G-15 Debate Organizer.**
- Read *The Lorax,* by Dr. Suess, aloud to students, which will be beneficial to auditory learners and English language learners. Alternatively, watch *The Lorax* DVD with the subtitles on. Afterward, have students create their own poem, rap, song, or picture book about the environment.
- Real World Investigation 3-A, on page 117 of the student textbook, allows students to apply what they have learned about threats to an ecosystem to consider the effects of introducing zebra mussels into Lake Ontario.
- Making a Difference, on page 101 of the student textbook, introduces students to the role that commitment can play in creating environmental change and asks students to consider what they have learned and make their own commitments.
- In the Case Study, on pages 106 and 107 of the student textbook, students explain the role that traditional ecological knowledge can play in determining sustainable use of natural resources.

Activity 3-3 Alien Invasions (Student textbook page 104)

Pedagogical Purpose

This activity allows students an opportunity to practise interpreting graphic text and applying the information. Students also consider the roles of some common methods of controlling alien species.

Planning	
Materials	Paper (any size, including chart paper) Coloured pencils and markers Computer lab and internet access (optional) LCD projector (optional)
Time	45–55 min plus an additional 40–90 min if students create Web pages

Background

Purple loosestrife may have been introduced accidentally in ship ballast. It has also been used as a horticultural plant. The horticultural variety was once thought to be sterile, but it often is not.

Activity Notes and Troubleshooting

- If time is limited, make sure that students understand that they have to complete only an outline of a poster.
- Provide these guidelines for making a poster:
  - Divide a paper into six equal sections:
  - One section is for the title, and one is for the location and directions.
  - Two sections are for illustrations or graphics.
  - Two sections are for information, with no more than seven bullet points each.
- Students should be able to complete this activity individually.

Additional Support

- Complete this activity in groups of four, and have each group present their poster to the class.
- Allow students the option to use a computer to create a Web page instead of a poster. They may want to use publishing software or web-design software.

Answers

1. Different methods of controlling purple loosestrife include digging and pulling, chemical control, cutting, and biological control.
2. The conservation officer should choose digging and chemical control.
3. For larger infestations you would not want the control methods to damage native plants and animals; therefore, a variety of methods would be necessary to remove purple loosestrife from different situations.
4. Students' poster designs will vary. Tasks should include digging and pulling, chemical control, and cutting. Students should mention that controlling purple loosestrife is important to keep the plants from forcing out native wetland species and changing the wetlands ecosystem.

Activity 3-4 Plants at Risk (Student textbook page 108)

Pedagogical Purpose

This activity allows students an opportunity to practise interpreting graphic text and applying the information. At the same time, students internalize the meanings of the subcategories by applying their knowledge to effect environmental change.

Planning	
Materials	Calculator **BLM 3-6 Writing a Persuasive Argument** (optional) **BLM 3-7 Writing a Persuasive Argument (Alternative Version)** (optional) Letter- or legal-sized paper Coloured pencils or markers Canadian dictionary
Time	50–55 min

Background

Species at Risk is Canada's system of categorizing the degree to which a species is in danger of becoming extinct. Other countries use only one or two categories—such as endangered or threatened. In general,

- extinct means not existing anywhere on Earth
- extirpated means no longer existing in a particular area
- endangered means a severe reduction in numbers over the past 10 years
- threatened means a significant reduction in numbers over the past 10 years
- of special concern means susceptible to a known threat, for example, an animal that feeds primarily on an organism that is significantly declining in numbers

For more specific definitions, see **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- Students may not be able to find the definitions in the dictionary, as they pertain to wildlife and plants. You may have to use the Internet to access Environment Canada's definitions of these terms.
- Have students use a ruler to help estimate the number of endangered and threatened species from the graph.

- Guidelines for making a flyer:
  - Divide a paper into six equal sections.
  - One section is for the title, and one is for the location and directions.
  - Two sections are for illustrations or graphics.
  - Two sections are for information, with no more than seven bullet points each.
- Provide students with a template for making a persuasive argument, such as **BLM 3-6 Writing a Persuasive Argument.**

Additional Support

- Allow students to complete their flyer on a computer using publishing software. If you do so, provide an electronic copy of the template for students to use.
- Practise making a persuasive argument with the class. For example, ask students to form a persuasive argument convincing their parents to allow them to stay out later with their friends this Friday.
- Some students may benefit from the additional support of **BLM 3-7 Writing a Persuasive Argument (Alternative Version).**
- ELL Together, make a list of words that can be useful in a persuasive argument in general, and in this persuasive argument in particular. These can be words associated with cause and effect, such as if…then, so, because, therefore, result, as well as the Key Terms of this unit. English language learners may want to create a cause-and-effect map first, and possibly develop the ideas they include into a written argument later.

Answers

1. The endangered category contains the most plant species, and the extinct category contains the least plant species.
2. Approximately 2 percent of the plant species are endangered, and 0.9 percent are threatened.
3. Students' flyers will vary. Main points should include what deerberry shrubs look like, how they contribute to their ecosystem (they are an important food source for deer and other animals), why they are at risk, and how they can be protected by hikers staying on the paths. Students might also include images of deerberry plants and the park trail routes.
4. Students' answers will vary. Answers could be that the endangered plant should be saved because it is more at risk of becoming extinct or that the threatened plant should be saved because there is a better chance of bringing back the population so it is no longer at risk. Students might argue that the solution is to find funding to save both plants.

Learning Check Answers (Student textbook page 103)

1. Habitat loss is when an ecosystem is altered by events due to natural disasters or human activities to the point where many species can no longer live there.
2. Wetlands are drained for farming or for building homes and other buildings, and sometimes for mosquito control.
3. Alien species often do well when they are released in a new part of the world because they often have no natural predators to control their population, they can out-compete native species for food, and they can take over native environments.
4. Round gobies might function effectively as predators and competitors in the Great Lakes because within 10 years of their arrival, they were found in all five Great Lakes, and their population in the western Lake Erie region is estimated to be in the billions.

Section 3.3 Review Answers (Student textbook pages 109)

Please see also **BLM 3-8 Section 3.3 Review (Alternative Format).**

1. Human activities that destroy habitats include deforestation, draining wetlands, and damming rivers.
2. Students' answers will vary. They may feel that the creation of jobs is not worth the habitat destruction that will result from draining the wetland, and perhaps they could develop a plan to create jobs by starting an environmentally-friendly project.
3. Students' answers may vary.

Eliminating a Naturally Invasive Species

Advantages	Disadvantages
Invasive species upset the equilibrium of an ecosystem, causing problems for the native species. Invasive species can out-compete native mussels and other native organisms in the lakes. Will protect native species and their ecosystem. Will ensure the ecosystem stays in balance.	Complete elimination might not be possible if species is wide spread. Elimination methods might cause more harm than good (such as using cane toads to control rabbit populations in Australia). Very expensive. Money might be better spent on an environmental project that can be successful.

4. Overexploitation, such as overhunting and overfishing, can threaten biodiversity because the population of species can become very low, or the species could even disappear.
5. Students' slogans will vary. Ensure that they include three human activities that have a negative effect on biodiversity, such as overhunting, overfishing, deforestation, and pollution. A possible slogan might be "If we overhunt, overfish, or overcut, we'll overdo it!"
6. Students' Venn diagrams should include the following ideas: In both background extinction and mass extinction, species become extinct. In background extinction, some species become extinct over a long period of time, but some new species appear through evolution. In mass extinction, a sudden change makes Earth's ecosystems unsustainable, leading to the extinction of many or all species.
7. It is believed that mass extinctions are caused by sudden changes to Earth's ecosystems, such as an asteroid hitting Earth or an extended period of massive volcanic activity.
8. The biodiversity crisis refers to the current rate of extinction being 100 to 1000 times higher than a normal background extinction rate. Scientists believe that the crisis is caused by human activity.

Section 3.4 Restoration Ecology (Student textbook pages 110 to 116)

In this section, students will learn that restoration ecology includes reforestation and wetland restoration, the control of alien species, bioremediation, and bioaugmentation. Students will learn that the flow of nutrients through ecosystems can be interrupted by human activities, and restoration techniques can offset those interruptions.

Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Common Misconceptions

- **Students might confuse *restoration ecology* and *conservation ecology.*** *Conservation ecology* is the predecessor; the focus is on rare and endangered species, mainly animals. *Restoration ecology* attempts to address extinction, food supply, timber supply, the maintenance of clean air and water, and climate regulation. Restoration ecologists consider many of the holistic benefits provided by a healthy and diverse ecosystem.
- **Some students may believe that reforestation projects restore a forest to its original state.** However, diverse mixed forests are replaced with monocultures, mostly because it is more economical and practical to do so. Many species of trees found in mixed old-growth forests are not easily cultivated and must seed themselves on their own. Hemlock would be one such species.
- **Students may not consider that there are any drawbacks to restoration ecology.** However, there are some. In bioremediation, plants are often used to soak up contaminants in the soil. The plants are harvested and then incinerated. The problem with this technique is that the toxins are now concentrated in the ash from the incinerated plants. How should we dispose of it?

Background Knowledge

Environmental stewardship is defined as the co-operative planning and management of a resource to meet the needs of a community. The original pine, maple, and oak trees in York Region were cleared in the late 1800s for farming. In 1924, a tree-planting program was established to reduce wind. The distinctive red pine plantations of York Region were originally intended to promote the establishment of oak through succession. To do this, the forest required manual thinning at 30 and 60 years. Unfortunately, this part of the plan was forgotten over the generations, and the first thinning did not occur. Now that the pine has sufficiently grown, we are starting to see some natural thinning from blowdowns, and oak trees have started to re-establish themselves in the gaps.

When preserving or restoring an ecosystem, we have to be careful not to lock ourselves into a historical ideal of what the ecosystem once was and neglect the process of succession. Algonquin Park was originally intended to preserve the headwaters of five major rivers that were important to the transportation of timber. The park has been selectively logged since that time. Since the park is also heavily used by campers, and it is surrounded by several communities, it is beneficial that Algonquin has not stayed "frozen in time," because its current state makes nature safe and accessible.

Unfortunately, restoration ecology is much more easily practised by regions with stable governments and economies. It is mostly found in more developed countries in the northern hemisphere. Restoration ecology is not often practised in the tropical regions where there are more environmental hotspots at risk.

Literacy Support

Using the Text

Before Reading

- Preview text features. Have students create a three-column table in their notebooks. Have students preview the section and list all the bolded words and headings in the left column, leaving plenty of room below each one.

During Reading

- Monitor comprehension. While students are reading the text, they will locate and copy two or three sentences that describe or define each term or heading into the middle column of their table.

After Reading

- Make study notes. Using the context of how each term was used in the text, students will come up with their own definitions and record them in the right column of their table. Students can share some of their definitions with the class afterward.
- ELL Encourage students to ask about any terms they do not understand.

Using the Images

- For Figure 3.22, on page 112, ask students to describe the diversity in each of the four photographs. Students can divide their notebook paper into four sections, and record their observations for each photograph in the corresponding section on their paper.
- For Figure 3.27, on page 115, have students use the person and pickup truck to estimate how deep the tar sands are at the location where the photograph was taken. Students should describe the steps they think will be necessary before trees can be planted again. Ask students where most of the soil nutrients lie in these northern boreal forests. Ask, "After mining is completed, where have the nutrients gone? How can they be replaced?" Students should make a sketch of this photograph in their notebooks and answer the questions above or below their sketch.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Selected Response Learning Check questions, page 111	Students explain the meaning of *stewardship* and *restoration ecology* including listing similarities and differences.	• To help students understand *stewardship,* use the example of a family pet. Although not all students have pets, many will be able to share their experience with the class. Ask students who in their home is responsible for taking care of the pet, feeding it, and cleaning up after it. Ask students what other needs the pet has. Is the student a good steward for the pet? • Research and point out where restoration ecology projects are occurring in your area. Describe what is happening. Ask students how this is different from stewardship. • Provide examples and non-examples of restoration ecology, and have students work in pairs to categorize them.
Selected Response Section 3.4 Review questions, page 116	Students explain the steps involved in the process of restoration ecology, including its costs and benefits to the environment.	• In addition to activities they take part in now, ask students to list five things they could do on a daily or weekly basis that would contribute to environmental stewardship. • Have students answer questions 3 and 4 using a cost/benefit/risk table. Remind students that the costs are not necessarily financial. Students can work in groups and post their answers on chart paper to share with the class.
Game Strategy Activity 3-5, The Common Good, page 113	Students connect the lesson they learned from the game to ecosystems and overexploitation of resources.	• Appoint one member of the group to record the number of chips and points after each round, and then graph the data. What was the trend observed by each group?

Instructional Strategies

- Contact your local conservation authority or chapter of the Federation of Ontario Naturalists, and find out if there are any tree plantings or other restoration projects with which students can get involved. Encourage students to participate in these events; they may even be able to pick up community service hours.
- Plan a trip to a local bog or wetland. Your school board's outdoor education centre may be able to assist with this field trip. This field trip may bring the content to life for spatial, bodily-kinesthetic, and naturalistic learners.
- Have students research a local restoration project and prepare a brief report or presentation.
- What if a portion of the schoolyard or local playground was set aside for bioremediation to return it to a natural state? In small groups of three or four, have students design a plan and outline the steps to follow for such a project. As an extension, students could write proposals to the principal or town council and present them.
- Enrichment—Have students apply what they have learned in this chapter as they carry out the research outlined on **BLM 3-9 Biodiversity in Ontario.**

Activity 3-5 The Common Good (Student textbook page 113)

Pedagogical Purpose

This activity models what happens when a limited resource is shared without regulation, which can result in overexploitation.

Planning	
Materials	Bingo chips or similar small items (100 per group) Watch or clock Paper to track points Large cardboard (to go outside)
Time	15 min (maximum)

Background

There are many variations of this game; it is based on the ecological article "The Tragedy of the Commons" written by Garrett Hardin.

Activity Notes and Troubleshooting

- The number of people in each group is not as important as making sure all the groups have the same number of people. Any students who are not in groups can be assigned the tasks of keeping score and replenishing chips.
- Bingo chips are preferable to other materials because they are smooth and flat and difficult to pick up. It may be necessary to provide a smooth, sturdy surface, such as cardboard or Bristol board.
- If there is not enough room in the classroom, find another location such as the library or gym, or go outside.
- It might be interesting to try the activity a second time with uneven numbers in the groups. What do students notice? What does that tell us about overexploitation and sustainable use?

Additional Support

- DI In order to appeal to students who do not understand the point of the game, collect and graph the data. Doing so will help the logical-mathematical students and students whose background does not involve game strategy as part of their learning. Discussing the answers with the class will also help to debrief the activity and help students recognize what they can learn from it.
- Plot the data for number of chips collected in round 1 and the number of points for each round. Ask, "Is there a trend to the data?" You may have to complete more than three harvests.
- Enrichment—Ask, "Is there a point in the game when there will be no more chips to harvest?" Students can extrapolate their graph to predict this.

Answers

Answers will vary depending on the behaviour of students and the results of the game. Some students realize right away that they should never allow the remaining chips to go below 50 and co-operate from the start.

1. The strategies that led to the greatest decline in a team's resources were not cooperating, taking too many chips, and not ensuring students had chips in sets of 10.
2. The strategies that led to the highest number of points for a team were co-operating, only taking chips in sets of 10, and never letting the pool go below 50 chips.
3. The strategies that provided the maximum points for an individual and a group are different. An individual will get the maximum points if he or she gathers as many chips as possible. A group will get the maximum points if they leave most of the chips in the pool.
4. Resources might include trees, fish, or other renewable natural resources that need to be sustainably harvested.

Learning Check Answers (Student textbook page 111)

1. Stewardship is the belief that all humans are responsible for the welfare of the environment.
2. Daylighting is a restoration technique used by restoration ecologists to uncover buried streams and rivers.
3. A series of ponds can improve water quality by capturing sediment, filtering water, and providing habitat for wildlife. They are also an interesting feature for visitors.
4. Restoration ecology is a practical extension of stewardship where degraded or destroyed ecosystems are restored to their natural state.

Section 3.4 Review Answers (Student textbook page 116)

Please see also **BLM 3-10 Section 3.4 Review (Alternative Format).**

1. Students' answers may vary, but they might include planting trees; getting involved in projects to restore wetlands, shorelines, and species at risk; controlling alien species; and bioremediation and bioaugmentation.
2. Human activities that create the need for restoration ecology include overhunting, overfishing, deforestation, habitat destruction, and air and water pollution.
3. Nearly a century of brick making and mining had left the environment around the Don Valley Brick Works very badly damaged. Rather leaving it as a wasteland, the site was sold and restored. Now it is a cultural heritage park with three filtration ponds, wetlands, a wildflower meadow, and other features. The Brick Works shows that ecological restoration is possible and desirable in cities.
4. Students' paragraphs will vary, but they may include the following idea: Petroleum should not be extracted by deforestation and removal of soils because forests and soils are important to sustain an ecosystem. Instead, people should rely less on fossil fuels and instead use alternative sources of energy.
5. Some methods that can be used to eliminate alien species include introducing another species to the environment that will kill the alien species (biocontrol) and using chemicals such as poisons or herbicides.
6. A poisoning campaign would not be successful. The islands are too large to poison all the rats at once so they would continue to breed. The poison would also harm native and farm animals. Even if all the rats were killed, it would be very difficult to prevent them from being reintroduced.
7. Students will most likely find that the campaign was successful; however, the number of wildlife cases of rabies was beginning to rise again after 1998.
8. Bacteria have been used in restoration ecology to break down the oil from oil spills that damage coastline ecosystems.

Real World Investigation 3-A Zebra Mussels in Lake Ontario

(Student textbook page 117)

Pedagogical Purpose

Students will analyze data and use the information to write an argument for a specific purpose in the form of an editorial. Many students may assume that writing and communication skills apply only to English class. Science is pervasive in the news, literature, entertainment, and sports. Professional scientists must be able to communicate their ideas and results clearly, and are expected to write well.

Planning	
Materials	Graph paper Coloured pencils Access to the Internet **BLM 3-11 Writing an Editorial** (optional) **BLM 3-12 Real World Investigation 3-A Zebra Mussels in Lake Ontario** (optional) **BLM 3-13 Peer Editing Template** (optional)
Time	1 h 45 min–2 h 15 min Some work could be done out of class.

Background

Zebra mussels originated in the Caspian sea. They arrived in the Great Lakes in the 1980s, probably when ships cleared their ballast. Zebra mussels do provide some benefits: they help to clean and filter the water they live in; however, this benefit does not seem to outweigh the nuisance they cause by disrupting food webs and outcompeting native species.

Activity Notes and Troubleshooting

- Students may not understand the importance of writing in the science profession. Clear and concise communication can be the difference between having a research grant renewed or not. The people renewing the grant may not be scientists. Scientific research may also influence public opinion and the creation of legislation. Those who are writing the legislation may not be scientists, so the experts must be able to make the writers understand the importance of an issue. Take the time to extend this activity beyond what is on page 117.
  - Talk about the importance of scientific writing and communication.
  - Deconstruct a few editorials as a class.
  - Encourage students to take time to do extra research.
  - Show some news clips.
  - Provide an opportunity to do some peer editing. Use some of the techniques from Think Literacy, such as a pass-around.
- Make this assignment count toward a summative mark.
- Parents and students may see this activity as trivial. Point out that it is an opportunity to stress the importance of, and encourage, good scientific communication. It is a misconception that science is just about facts.

Additional Support

- Make sure students understand the difference between an editorial and a letter to the editor. Bring in some newspapers and have students critique the editorials.
- Have students use **BLM 3-13 Peer-editing Template,** to edit each other's work before the final draft is completed.

Answers

Analyze and Interpret

1. The chlorophyll a seemed to decrease as the zebra mussels increased.
2. The zebra mussels are filter feeders and most likely consume phytoplankton. Less phytoplankton will result in less oxygenated water and a decrease in the fish population.
3. Populations of lake floor plants and food supplies could increase due to the zebra mussels.

Conclude and Communicate

4. Students' articles will vary. Points should include that zebra mussels are released into the Great Lakes in ballast water from ships; that they crowd out native species of mussels; that they eat food other species rely on; and that they change the environment of the lake which kills fish and other aquatic species.

Extend Your Inquiry and Research

5. Students should include some of this information: The Ballast Water Control and Management Regulations are Canada's rules about how ballast water can be used and disposed of by ships so that the spread of invasive aquatic species can be controlled. The regulations, and similar regulations in other countries, were written to meet a requirement of The International Convention for the Control and Management of Ships' Ballast Water and Sediments adopted by the International Maritime Organization in 2004. The convention was later ratified by 30 countries, including Canada, representing 35 percent of the world's shipping tonnage.

Inquiry Investigation 3-B Balancing Populations and the Environment (Student textbook pages 118 to 120)

Pedagogical Purpose

Students will investigate the factors that affect the equilibrium of a population using a game as a simulation of the system. Students will then interpret the data that they have collected and interpret the meaning.

Planning	
Materials	2 sheets of white poster paper (32 cm × 32 cm each) Ruler Sharp pencil 32 squares of green sticky notes (4 cm × 4 cm each) Bag of 100 checkers or similar objects (50 black and 50 red) Calculator Graph paper **BLM 3-14 Inquiry Investigation 3-B Balancing Populations and the Environment** (optional)
Time	TOTAL: 75 min
Safety	Students should use caution when working with sharp pencils.

Background

There are many variations of this game. It is based on the ecological article "Tragedy of the Commons" written by Garrett Hardin.

Activity Notes and Troubleshooting

- Students can conduct this investigation in groups of two or more. Some discussion about wildlife management policies should occur.
- Students can complete a formal lab write-up of this activity; if they do not follow up in this way or in a similar way, the significance of the learning may be lost.
- If there is time to spare at the end of class, ask students how they might simulate the introduction of wolves and then play a game for that scenario.

Additional Support

- You may have to run a trial year that does not count to make sure everyone understands the instructions.
- Save some "parks" and "hunting screens" from a previous class as spares, in case a group has trouble making them.
- Use the word *simulation* instead of *game* to help impart the seriousness of the activity.
- ELL Place English language learners in groups with fluent English speakers to help interpret the instructions.

Answers

Analyze and Interpret

1-3. The answers will vary depending on students' results.

4. The population size is dependent on the resources available. Humans are different than deer because we can import resources if there are not enough to meet the needs of the population.

5. Possible answers include the following:
   a. Deforestation would decrease the food supply and then the deer population.
   b. Reforestation would replenish the food supply and the population would increase.
   c. Removing wolves might cause the deer to exceed the carrying capacity of their environment. The population would increase and then crash.
   d. Restricted hunting might keep the population stabilized enough that the deer would not exceed the carrying capacity.

Conclude and Communicate

6. Answers will vary depending on students' results. Those groups with very low deer populations would not want to introduce wolves.

Extend Your Inquiry and Research Skills

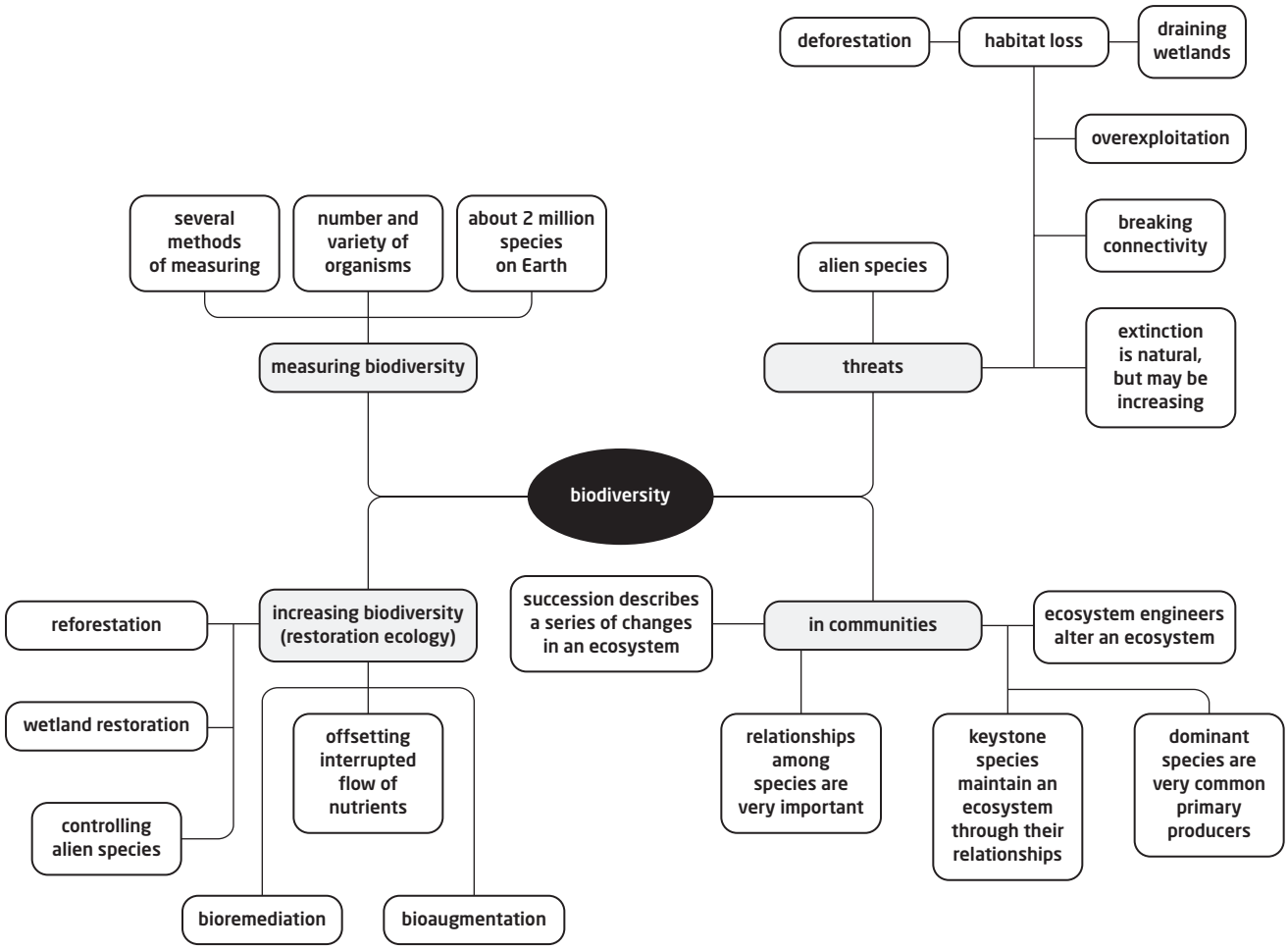
7. Students' answers will vary. One commonly used method is to do a helicopter survey in midwinter when the deer are not as mobile in deep snow, and there is less forest cover to obscure the count.
8. Answers will vary depending on students' research. Ontario is a world leader in using computer simulations for forest-fire prediction models.

Chapter Review Answers (Student textbook pages 122 and 123)

Please see also **BLM 3-15 Chapter 3 Review (Alternative Format).**

Make Your Own Summary

Students' graphic organizers should include the following key concepts. An example is provided below.



Reviewing Key Terms

1. the biodiversity crisis
2. restoration ecology
3. biocontrol
4. succession
5. Bioremediation
6. captive breeding
7. biodiversity

Knowledge and Understanding

8. Maintaining biodiversity on Earth is important because nutrients and energy cycle through ecosystems, and what happens in one ecosystem can affect cycles in other ecosystems. Organisms depend on each other and their environment to survive.
9. Methods to measure biodiversity include canopy fogging (spraying a low dose of insecticide up into the top of a tree, and collecting the insects for observation), quadrat sampling (counting species in a marked area), transect sampling (recording the type and number of species along a transect line at set intervals), and netting (capturing, identifying, measuring, and tagging birds and bats in ecosystems).
10. A biodiversity hotspot is a relatively small area with a very large number of species. Most hotspots are found in tropical areas.
11. When the death rate of a species remains higher than the birth rate for a long period of time, extinction occurs.
12. The most recent mass extinction was the death of the dinosaurs, when an asteroid is believed to have hit Earth 65 million years ago.

13. The greatest mass extinction of all time is believed to have occurred a massive volcano in Asia was active for an extended period of time.

14. No, because all species are connected and what happens in one ecosystem can affect cycles in other ecosystems.

15. Langara Island was originally predator-free. The populations of nesting sea birds declined when two alien species of rats, which were accidentally introduced by ship, ate the birds' eggs and nestlings.

16. Deforestation is a threat to biodiversity because forests are cleared and never replanted, which affects other organisms that depend on the forests for survival.

Thinking and Investigation

17. fish

18. a. Since wolves eat elk, the elk population would increase if wolves were eliminated. Therefore, since elk eat aspen trees, the aspen tree population would decrease. The new aspen trees likely would not have a chance to mature before they were eaten by the elk, so natural succession would not occur.

b. Students' answers will vary, but they might say that if wolves were re-introduced, the elk population would begin to decrease, and the aspen tree population would begin to increase.

19. If the wolves were re-introduced, the number of beavers would increase because the wolves would eat the elk that were eating all the aspen trees. There would then be some aspen trees for the beavers to eat.

20. No, because native species are important to an ecosystem.

21. Wildfires can regenerate growth and create a new ecosystem.

Communication

22. The alien species might adapt to their surroundings and become native species over a long period of time.

23. Students' answers will vary. Examples might include restoration methods such as reforestation, wetlands restoration, and controlling alien species.

24. First, it is efficient and cost effective to have one provincial agency that manages information about Ontario's biodiversity. Second, the centre's database provides a valuable and necessary resource for studying and understanding Ontario's biodiversity. Third, the centre ensures scientists have the information they need to manage our natural resources and protect species at risk.

25. Humans have a responsibility to look after the biosphere for other human beings and for other organisms.

26. Humans have a responsibility to look after the biosphere because if species are lost, the ecosystem will not be able to sustain the remaining species, including humans.

27. Dominant species have to be primary producers because they are extremely abundant and are in the first trophic level of the food chain, which means that all other organisms depend on them for survival.

28. Students' analogies will vary. A possible example is many people waiting in five check-out lines at a busy grocery store. One cashier going on a break will have little effect on the customers. However, if all five cashiers went on a break, customers would not be able to purchase their groceries.

Application

29. Students' answers will vary. Some students might feel that captive breeding programs are worth it because they help to restore an ecosystem. Re-introducing one species can help many other species to survive.

30. A; Keystone species generally do not have a large biomass, but they greatly affect ecosystem health.

31. Chemicals cannot be used because the chemicals will kill other species and destroy the ecosystem. Also, digging up or cutting the plants would be too time-consuming and expensive.

32. Students' answers will vary. The solution that is in place now internationally is to sanitize ballast water before it is dumped.

Unit 1 Projects

Inquiry Project
Pollutants and Aquatic Ecosystems (Student textbook page 126)

Pedagogical Purpose

This investigation allows students to study the impact that humans can have on the sustainability of an ecosystem. The pollutants in this investigation are common substances resulting from the choices average people make for their homes and lifestyles.

This project is an opportunity for students to demonstrate the understandings and skills they have developed in this unit.

Planning	
Materials	Salt 100 mL beef or chicken broth 50 mL plant food Seven 2 L soft drink bottles, or large jars, per group Aquatic plants and organisms for each ecojar 100 mL vinegar 50 mL dish detergent 50 mL paint thinner **BLM 3-15 Inquiry Project: Pollutants and Aquatic Ecosystems** (optional) **BLM G-23 Data Table** (optional) • Purchase the aquatic supplies ahead of time. • Ask students to bring in 2 L soft drink bottles for several days berforehand, until you have enough.
Time	• 15–20 min to create the plan and data table • 5–10 min to prepare each ecojar • 10 min to apply the treatments to each jar • 3–5 days to record the effects on each jar • 1 period to prepare the presentation, and 1 period for all students to present their findings.
Safety	Students should wear goggles.

Background

The choices we make every day to maintain our lifestyle can have direct impacts on the environment. We salt roads and driveways in the winter, and the salt collects in storm-water retention ponds. Car exhaust and coal-burning power plants contribute to acid rain. Fertilizer and animal waste from our lawns as well as from farmland produce run-off. Many household chemicals are intentionally and accidentally poured down the drain, or washed down the driveway. When we think of pollution, we often consider industry before we think of our own actions and choices.

Activity Notes and Troubleshooting

- Students should plan out the investigation several days before starting. They should also come up with their own list of materials so you know what to acquire for them.
- You may want students to conduct this investigation on their own and purchase their own supplies. To be equitable, supply some of the basic materials to get each ecojar started, such as plants and other organisms.
- Often, students want to put fish or tadpoles in their ecojars. This activity is discouraged, and may contravene local board policy, as the investigation will harm and probably kill the animals, and will be extremely upsetting to some students.

- Decide on the type of audience to which students will present their findings, and let them know. For example, will students be presenting to members of their community, or to members of their class? Students' presentations should be tailored to their audience.
- The assessment criteria are printed in the student textbook. Make sure students understand what is required of them, are aware of the assessment criteria, and refer to the list as they conduct their investigation and plan their presentation.

Additional Support

- DI Bodily-kinesthetic and spatial learners may prefer to use chart paper or to draw their own overheads, as opposed to preparing a computer presentation.
- DI Intrapersonal learners and English language learners may feel uncomfortable presenting their findings to the class. Provide the option of presenting to a smaller group, or allow them to submit their presentation electronically by recording it at home.
- Another option is to have students who are uncomfortable presenting in front of a large group come in after school or at lunch to present.

Rubric

ACHIEVEMENT CHART CATEGORY	Level 1	Level 2	Level 3	Level 4
Knowledge & Understanding	Abiotic and biotic components of the ecosystem are described in limited detail.	Abiotic and biotic components of the ecosystem are described in some detail.	Abiotic and biotic components of the ecosystem are described in considerable detail.	Abiotic and biotic components of the ecosystem are described in thorough detail.
Thinking & Investigation	Designed and executed a procedure controlling appropriate variables and using equipment and materials safely, accurately, with limited effectiveness. Analyzed and interpreted qualitative and quantitative data to determine whether evidence supports predictions with limited accuracy. Identified sources of error and suggested improvements in limited detail.	Designed and executed a procedure controlling appropriate variables and using equipment and materials safely, accurately, with some effectiveness. Analyzed and interpreted qualitative and quantitative data to determine whether evidence supports predictions with some accuracy. Identified sources of error and suggested improvements in some detail.	Designed and executed a procedure controlling appropriate variables and using equipment and materials safely, accurately, with considerable effectiveness. Analyzed and interpreted qualitative and quantitative data to determine whether evidence supports predictions with considerable accuracy. Identified sources of error and suggested improvements in considerable detail.	Designed and executed a procedure controlling appropriate variables and using equipment and materials safely, accurately, with a high degree of effectiveness. Analyzed and interpreted qualitative and quantitative data to determine whether evidence supports predictions with a high degree of accuracy. Identified sources of error and suggested improvements in thorough detail.
Communication	Data is recorded and organized with limited effectiveness.	Data is recorded and organized with some effectiveness.	Data is recorded and organized with considerable effectiveness.	Data is recorded and organized with a high degree of effectiveness.

Please also see **BLM A-44 Unit 1 Inquiry Project Rubric.**

An Issue to Analyze
Protecting Ecosystems (Student textbook page 127)

Pedagogical Purpose

In the process of becoming scientifically literate, students are asked to draw on their scientific knowledge and skills to assist them in making personal choices. Scientifically literate students are able to actively participate in and contribute to their neighbourhoods and communities. Being scientifically literate is part of being a good citizen. For this issue, students are asked, "What could you do, as a member of this community?"

This analysis is an opportunity for students to demonstrate the understandings and skills that they have developed in this unit.

Planning	
Materials	Local newspapers and maps **BLM 3-16 An Issue to Analyze: Protecting Ecosystems** (optional)
Time	• 2 weeks (in and out of class) for research • 1 or 2 periods for presentations

- Book a computer lab.
- Book a library period.
- Contact a local environmental group to see if they have resources that students might use.

Background

Over 30 years ago, a small group of concerned citizens started a campaign that resulted in the creation of one of the largest urban wilderness parks in North America. The creation of Rouge Park by the Ontario government in 1995 was the result of many years of public campaigning. Concerned citizens established the Save the Rouge Valley Society (SRVS) in 1975, and they tirelessly campaigned for the creation of Rouge Park. Thousands of citizens wrote letters and attended public meetings. Members of the SRVS went even further to demonstrate their dedication to the park by establishing a volunteer organization in 1989 called 10 000 Trees for the Rouge, which co-ordinates community tree planting events every spring to help maintain and rehabilitate park habitats and ecosystems. Rouge Park now connects the Oak Ridges Moraine greenbelt to Lake Ontario. Rouge Park is an example of how citizens' involvement can have positive and lasting results.

Activity Notes and Troubleshooting

- Students may not be aware of their local natural ecosystems. Local maps and news articles may help them identify a local ecosystem to investigate.
- Approve students' ecosystem choices to be sure they are appropriate before students begin significant research. In some cases, you may have to assist students in identifying these areas. Sources of information might include the local public library and local environmental groups.
- Consider planning a trip to a local conservation area or outdoor education centre.
- With students, decide on the audience they are targeting before they create the vehicle to communicate their findings.
- Provide students with a rubric for the assessment criteria at the beginning of the assignment.

Additional Support

- By using a generic rubric, you allow students to choose the medium that best suits their particular ecosystem, audience, and preferred learning style.
- Be flexible in allowing students to speak about areas they are most familiar with. For example, a student may want to address an area near his cottage or his grandparents' home. You may decide to specify that the ecosystem must be from within Ontario, or within Canada.
- ELL English language learners may find an activity that is so locally targeted problematic. They should be allowed some flexibility. If they are very familiar with an ecosystem within their country of origin, they may wish to address this area.

Rubric

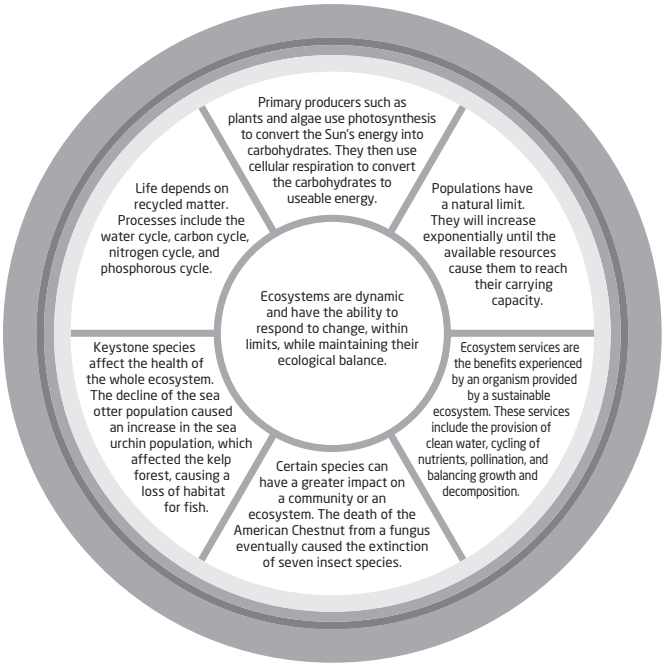
ACHIEVEMENT CHART CATEGORY	Level 1	Level 2	Level 3	Level 4
Knowledge & Understanding	Human factors impacting the ecosystem are described in limited detail.	Human factors impacting the ecosystem are described in some detail.	Human factors impacting the ecosystem are described in considerable detail.	Human factors impacting the ecosystem are described in thorough detail.
Communication	Includes information from a variety of sources using an accepted form of academic documentation with limited effectiveness. Communicates using scientific vocabulary with limited effectiveness. Communicates for the chosen audience and purpose with limited effectiveness.	Includes information from a variety of sources using an accepted form of academic documentation with some effectiveness. Communicates using scientific vocabulary with some effectiveness. Communicates for the chosen audience and purpose with some effectiveness.	Includes information from a variety of sources using an accepted form of academic documentation with considerable effectiveness. Communicates using scientific vocabulary with considerable effectiveness. Communicates for the chosen audience and purpose with considerable effectiveness.	Includes information from a variety of sources using an accepted form of academic documentation with a high degree of effectiveness. Communicates using scientific vocabulary with a high degree of effectiveness. Communicates for the chosen audience and purpose with a high degree of effectiveness.
Application	Analyzes information for bias and accuracy with limited effectiveness. Analyzes information to identify protection strategies and obstacles with limited effectiveness. Proposes courses of action of limited effectiveness.	Analyzes information for bias and accuracy with some effectiveness. Analyzes information to identify protection strategies and obstacles with some effectiveness. Proposes courses of action of some effectiveness.	Analyzes information for bias and accuracy with considerable effectiveness. Analyzes information to identify protection strategies and obstacles with considerable effectiveness. Proposes courses of action of considerable effectiveness.	Analyzes information for bias and accuracy with a high degree of effectiveness. Analyzes information to identify protection strategies and obstacles with a high degree of effectiveness. Proposes highly effective courses of action.

Please also see **BLM A-45 Unit 1 An Issue to Analyze Rubric.**

Unit 1 Review Answers (Student textbook pages 128 to 131)

Connect to the Big Ideas

Connect to the Big Ideas answers are also available as a Blackline master on the accompanying CD.



Knowledge and Understanding

1. d.

2. d.

3. a.

4. c.

5. a.

6. phosphorus

7. Carbon dioxide has been increasing in the atmosphere because we have been burning fossil fuels that release carbon dioxide.

8. This example might be considered predation (bird preying on insect parasite) or mutualism (bird benefits by getting food, and large animal benefits by being rid of parasites).

9. Urban sprawl is a form of development where houses and business are built outside the core of the city, expanding the city. These areas often have few services available, making them car-centric.

10. Organisms can be very small; they can be located in places that we cannot access easily (for example, the ocean floor); they can have different life stages; they can look similar but actually be different.

11. any three of the following: Carolinian Canada of southern Ontario, Leitrim Wetlands near Ottawa, Long Point in Lake Erie, the Georgian Bay Biosphere Reserve

12. In the water cycle, water continually cycles through the hydrosphere, atmosphere, lithosphere, and biosphere through the process of evaporation, condensation, and precipitation. In the phosphorus cycle, phosphorus moves through the hydrosphere, biosphere, and lithosphere. It is carried from the lithosphere (soil) to the hydrosphere (lakes and rivers) by water run-off.

13. Plants are sometimes grown at a contaminated site to accumulate the poisons in their tissues, which cleans many of the poisons out of the soil.

14. Burning fossil fuels, such as gasoline in a car, increases the amount of carbon dioxide in the atmosphere, which travels with weather systems, and has a negative impact on ecosystems far away.

15. Some energy in tertiary consumers is transferred to a decomposer. Most is moved back to the abiotic components of the ecosystem.

Thinking and Investigation

16. The ruby-throated hummingbird and the monarch butterfly migrate long distances every year, so they are dependent on many ecosystems along their migratory routes for food and shelter. Since these organisms rely on many ecosystems, maintaining connectivity among ecosystems allows them to survive, and also allows the organisms that depend on them to survive.

17. a. In the first graph, the number of bacteria is increasing. In the second graph, the number of bacteria increased and then levelled off.

b. first graph

c. second graph

d. yes, second graph

18. The carrying capacity is approximately 1.6 million. In real life, populations can exceed the carrying capacity, but then they will run out of food. Once they number less than the carrying capacity, their predators will run out of food and begin to die, allowing the population to grow to exceed the carrying capacity again.

19. They harvest and hide seeds, some of which grow into new trees; stored seeds are a food source for other seed-eaters; squirrels are prey for larger predators like owls; squirrels make nests that are later used by other small mammals; squirrels scold predators, warning other animals.

20. Acid precipitation causes forest soils to lose nutrients, and it also increases the amount of aluminum in soil, which interferes with the uptake of nutrients by trees. Some species cannot survive these changes. Acid precipitation also affects aquatic ecosystems because it can lower the pH of water, causing problems for fish, amphibians, and other organisms that live in the water. Some aquatic organisms are very sensitive to a drop in pH.

21. Canadians use more electricity; consume more oil; and have more highways, which probably indicates more vehicle use.

22. Answers will vary, but should include questions about chemicals and alien species that the ship may be carrying, and possibly also questions about where the ship has been.

Communication

23. The greenhouse effect is the process in which greenhouse gases in the atmosphere—such as water vapour, carbon dioxide, and methane—prevent heat from leaving the atmosphere, therefore increasing the temperature of the atmosphere. Without greenhouse gases, Earth's temperatures would be much colder than they are.

24. Answers may include symbols for biodiversity, communities, environmental groups, traditional ecological knowledge, and stewardship. Alternatively, symbols may represent five different rich ecosystems, for example, aquatic, tundra, prairie, forest, and wetland.

25. Flowcharts should show many of these connections:

- Prairie dogs → "dog towns" (burrow system) → poisoned, trapped, shot → soil poor, drier, plant diversity drops
- prairie dogs → "dog towns" → prairie rattlesnake, black-footed ferrets use the burrows and eat the prairie dogs → population reduced
- captive breeding in zoos → trained for wild → re-introduced → population rescued

Application

26. Questions might include the kinds and quantities of chemicals that were used; the likelihood of run-off; where and how the pesticide will be used and disposed of, what animals might come into contact with it, and how quickly it will decompose.

27. Answers should include an appreciation of the importance and difficulties of sustaining several ecosystems far apart and in different countries.

28. Students should include a rationale for their course of action, including risks and benefits; for example, using birds of prey to control the gull population does not introduce poisons into the environment, but birds of prey may eradicate other populations, and upset the balance in the ecosystem.

29. Answers will vary, but sustainable activities use resources more efficiently by using only what can be regrown. Unsustainable activities will eventually use up the resource.

30. property in public ownership, proximity of industry that might imperil the restored wetland, proximity of residential development, size, links to other wild areas, suitable topography

31. It might cause you to spend more funding on foxsnakes because we have a greater responsibility for the global population, and they have a smaller range overall.

Literacy Test Prep

Multiple Choice

32. b.

33. b.

34. d.

35. b.

Written Answer

36. CO_2: Burning fossil fuels releases carbon dioxide into the atmosphere. It is believed that increased carbon dioxide is causing global warming.

vehicles driven: Vehicle emissions contribute to acid precipitation.

paper used: Cutting down trees to produce paper leads to erosion, a loss of habitat, and less photosynthesis.

gasoline used: Gasoline is a fossil fuel that when burned, releases carbon dioxide into the atmosphere.

fresh water used: Water sources can dry out during long, hot periods with no rain. Chemicals from industries can contaminate water.

Sustainable practices may vary, but should address the issues listed above.