Topic 1.4
What natural factors limit the growth of ecosystems?

Specific Expectations

- **B2.3** compile and graph qualitative and quantitative data on organisms within an undisturbed or disturbed ecosystem (terrestrial or aquatic)
- **B3.2** describe the interdependence of the components within a terrestrial and an aquatic ecosystem, and explain how the components of both systems work together to ensure the sustainability of a larger ecosystem
- **B3.4** identify the major limiting factors of ecosystems, and explain how these factors are related to the carrying capacity of an ecosystem

Skills

- communicate in a variety of formats
- formulate hypotheses
- conduct inquires to collect data
- draw conclusions

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-38 for a summary of the materials required in this topic.

Overview

In this topic, students will determine what biotic and abiotic factors limit the growth of an ecosystem as well as the role that resource availability plays in ecosystem growth. Students will conduct an experiment to explore how fertilizer affects the growth of an algae population.

Common Misconceptions

- **Students may believe that varying the population size of a species may not affect an ecosystem because some organisms are unimportant.** All organisms are important to the sustainability of their ecosystem. Have students choose any organism in an ecosystem they are familiar with and consider extreme situations such as the effects of removing the species from the ecosystem or multiplying its population by 100.
- **Students may believe that varying the population size of a species may not affect the others in an ecosystem unless they are directly connected through a food chain.** Remind students that any change in population size has a direct impact on all species in the food chain, because the change in population could affect the amount of space, shared food, or water available. Remind students that food chains are also connected to one another in a web, so organisms that do not seem closely connected are connected somehow.
- **Students may believe that forest fires are harmful to ecosystems and should not be allowed to burn.** However, fires can rejuvenate ecosystems by clearing old, dead wood and may actually be beneficial in letting new plants grow. Some plant populations depend on occasional forest fires to thrive. Of course, students should always practise forest fire prevention when camping or having a bonfire.

Background Knowledge

Species interactions include competition, predation, mutualism, commensalism, and parasitism. As the size of a population increases, the demands placed upon resources such as food, water, shelter, and space increase as well. Consequences of this overcrowding can include disease and greater predation as the sick and weak organisms form easy prey. The maximum population size that an ecosystem can sustain in good health is termed the carrying capacity. As resources are added and removed from an ecosystem, the carrying capacity changes; this can occur because of either natural disasters or human activities. The Three Gorges Dam in China is an extreme example of how a human activity totally altered an entire ecosystem: by flooding the valley, all flora and fauna were eliminated. Various combinations of abiotic and biotic components can cause increases and decreases in population size. Overpopulation is prevented by limiting factors such as competition, predation, disease, parasitism, human activities, and natural disasters. A forest fire in the interior of British Columbia or a drought in Southwestern Ontario would severely limit the population of any index species. To sustain any ecosystem, carrying capacity must not be exceeded; as long as the biotic and abiotic components are in balance, the ecosystem can be maintained. A healthy population can usually recover from natural disasters given enough time but we must ensure that any changes humans make to the environment do not prevent that ecosystem from maintaining balance.

Literacy Strategies

Before Reading

- Have students use a Predict-Read-Verify strategy as they read the text. Students should combine background knowledge with the headings, visuals, and captions to predict what information each spread will contain. Break text into manageable chunks for students to synthesize and have them verify their predictions as they read.
- ELL Prior to assigning a passage of text, record the critical statements from that passage and make copies for English language learners. Ask them to predict whether each statement is true or false. Have them read the passage and use the information from the text to verify the response.

During Reading

- Have students create a T-chart to summarize the factors that limit population growth and how each factor does that. For example, Availability of resources: without enough food, individuals will die and new ones will not be born.
- Have students perform a Think-Pair-Share activity. Ask them to think about why carrying capacity is important to an ecosystem, then discuss answers with a partner.
- ELL Have English language learners use **BLM G-35 Main Idea Web** during reading. As they read a passage, have them stop and think about what the main idea is. Record the main idea in the centre of the web. Then record the details from the text that support this main idea around it. English language learners could work with a partner.

After Reading

- Have students work in pairs to reflect on the Topic. They should share their understandings of carrying capacity. Encourage them to use diagrams such as a graph of population growth up to the carrying capacity to demonstrate their understanding. Alternatively, students could record their work as a graffiti activity, in which each group is given a large sheet of paper, and individuals in the group record their understandings on it, in whatever form they choose. Provide students with an opportunity to circulate to view other groups' graffiti.
- Have students prepare their own summary sheet to explain what natural factors limit the growth of ecosystems. They can record on **BLM G-32 Cause and Effect Map**.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check, page 43 Activity 1.11, page 45 Learning Check, page 45	Students identify the major limiting factors of ecosystems and relate them to the carrying capacity.	• Ensure that students understand the Key Terms, as well as parasite/parasitism, competition, predators, and prey. • Have students categorize limiting factors as abiotic and biotic, or as internal or external to the species. • Refer students to the notes they made in a T-chart during reading. • Ask students how adding or removing a limiting factor would affect the carrying capacity for a species.
Investigation 1B, pages 46–47	Students compile data on organisms within an undisturbed ecosystem.	• Work through the fourth and fifth points of Step 1 together to make sure students can define the independent, dependent, and controlled variables before they construct a table. • Have students continue to adjust their procedure plan until it is sufficient to give useable results for the Investigation. • Have students rank their samples in order of size of algae population, then ask them to look for a pattern or relationship between the amount of fertilizer and the algae population. • Provide **BLM G-25 Constructing a Line Graph** and **BLM G-17 Variables in Science** for students to refer to.

Topic 1.4 (Student textbook pages 40–49)

Using the Topic Opener (Student textbook pages 40–41)

- Review graph interpretation skills by discussing the graph on page 41. Have students find the years 1955 and 1985 and the human population in these years. Ask students what the numbers on the *y*-axis represent (billions of people). Have students consider whether the years 1955 and 1985 were typical. Can they tell from the graph in what year the world's population passed 5 billion people?
- The scale on the horizontal axis of the graph on page 41 is not consistent. Ask students why the graph is shown this way; use the significance of the values for 1927 and 1999 (when the population reached 2 billion and 6 billion, respectively) to guide them to the solution.
- ELL English language learners may not know who James Dean, Rosa Parks, and Rick Hansen are and be confused as to their significance. Be sure to discuss and state simply that the purpose of this opener is to focus on what changes have occurred to the world population over the past century.
- Enrichment—Have students identify other significant historical events since 1900 and determine the approximate world population at that time.
- Have students explain the role that projected data might play in human decision making at all levels of government.
- In order to prepare students for the concept of carrying capacity, have them imagine what would happen if the population of a plant or animal species increased indefinitely. You could use the example of humans from the textbook. Ask what problems the species would encounter and how the population growth would affect other species in the same ecosystem.
- Have students identify activities that are affecting the populations in a local ecosystem. Ask in what circumstances human intervention such as a deer cull or a sterilization project might be considered useful for an ecosystem.

Starting Points Activity

Pedagogical Purpose

Students will consider what factors might limit human population growth and if there is an upper limit to human population growth.

Planning	
Materials	**BLM 1-16 Topic 1.4 Starting Point Activity**
Time	10 min in class

Activity Notes and Troubleshooting

- Students should work independently for this activity. Distribute **BLM 1-16 Topic 1.4 Starting Point Activity** so each student has a worksheet to complete the questions. These questions form an excellent starting point for discussion. Once they have answered the Starting Point Activity questions, discuss their answers and the ramifications that humans have on their ecosystem. This post-discussion is essential to English language learners. Record key words on the board as you are talking with the class. Direct students to add these words to a glossary.
- After students have completed this topic, consider returning to the questions on **BLM 1-16** and discussing what new ideas students have about them.

Additional Support

- DI Students with logical-mathematical aptitude may want to investigate the shape of the line graph on page 41 if the scale on the horizontal axis is consistent. They may be able to recognize that not only is the world population increasing, but it is increasing faster as time goes on.
- ELL If assigning this as an independent task, be sure to circulate when students are working to check with English language learners that they understand the questions. Alternately, have them work with a partner who could read and restate the questions. For example question 2 could be restated: With the number of people on Earth getting bigger and bigger, will there be enough resources (things they need to stay alive) for them? Why could this be a problem?

Answers

1. Answer may vary. For example: Humans need food, places to live, and water to survive.
2. There could be more competition for the resources.
3. As our population grows, other organisms that depend upon the same resources as we do could become endangered and/or extinct.
4. Any population size is limited by the availability of resources such as food and space.

Instructional Strategies

Ecosystem growth is limited by the availability of resources.

(Student textbook pages 42–43)

- Have students construct a Picture Glossary using key terms as they are introduced. Recommendations for creating a Picture Glossary can be found in the Unit 1 Review, question 4 on page 84.
- DI A fun way for students to act out the introduction to this spread is by designating ¼ of the classroom as the Earth. Ask students seated there how they feel about the amount of space and the desks and chairs available to them. Then have students from another quarter of the room to move to the designated quarter. Ask again about adequate space and resources. Finally, double the population again by asking all remaining students to join them. Discuss the changes when the population increased. Clearly relate this activity to what they will be learning about ecosystems.
- To check comprehension, name a well-known species and have students come up with concrete examples of limiting factors that relate to it.
- Ask students how adding or removing a limiting factor would affect the carrying capacity for a species. Use a concrete example.
- Remind student that Figure 1.9 is representative, and that the limiting factors do not take turns reducing the population.

Abiotic and biotic factors limit populations in ecosystems.

(Student textbook pages 44–45)

- ELL Ensure English language learners understand the terms parasitism, predator, prey, and competition. Develop a concept map on the chalkboard for each term, or have students complete **BLM G-31 English Word Study**.
- Have volunteers read the callouts in Figure 1.10 aloud.
- For each caption, invite students to suggest other examples.
- In preparation for Topic 1.5, ask students to consider how human activities might change limiting factors and carrying capacity for all other species. Examples may include changes to the amount or quality of water available, space availability, loss of shelter due to deforestation, and the introduction of new species or disease.

Activity 1.10 Up for the Count (Student textbook page 42)

Pedagogical Purpose

Students make predictions about the growth of a bacteria population.

Planning	
Materials	Graph paper **BLM 1-17 Up for the Count** (optional)
Time	10 min in class 5 min preparation (have graph paper available or have a large-scale graph of the data available)

Background Knowledge

There are a wide variety of bacterial pathogens behind human illnesses from minor food poisoning and diarrhea to strep throat, tuberculosis, leprosy, and possibly the bubonic plague. There are vaccines against most of these bacteria and most are treatable with antibiotics. A typical bacterial pathogen is 1-5 μm long (0.000 001 m).

Skills Focus

- formulate hypotheses

Activity Notes and Troubleshooting

- Introduce the idea of bacteria germs. Ask students to name a bacterial illness they know or have had. Point out that if someone had an illness such as strep throat, then they have recovered and the bacteria population must have been killed.
- ELL You may need to simplify this further for English language learners and suggest that some bacteria germs can make you sick. Taking an antibiotic can make you better. Make the connection of the term antibiotic with what the students have already learned about the term biotic.
- Have students present their predictions to the class after they have recorded them. Make a list of all possible reasons that the bacteria population cannot continue to grow. Students may predict different results. Point out that we do not know the answer for certain, and discuss what it might depend on (availability of food, presence of antibiotics, and so on).
- Point out that, bacteria is a plural word. The singular is bacterium. Like datum and data, bacterium and bacteria come to English from Latin, and form their plurals as in Latin. Be sure to note that this is an exception to the rule for plurals.
- This activity is useful background for the Strange Tales of Science on page 48.

Additional Support

- DI Spatial learners can start out by creating a data table and graphing the bacteria population growth on **BLM 1-17 Up for the Count**. They can connect the points as a smooth line and use it to predict trends.
- ELL English language learners may also benefit from **BLM 1-17 Up for the Count**. Demonstrate how to use this BLM to aid in making predictions. Provide sentence starters to show how to write a prediction such as: I think that this will happen because …
- Enrichment—Provide students with a second scenario with a different speed of reproduction and ask them to make another prediction.

Activity 1.10 Answers

Prediction: The germ population will continue to grow in size until available resources diminish, the immune system attacks it, or an antibiotic is taken; at that point, either food and space will become limiting or a predator will start killing the bacteria.

Learning Check Answers (Student textbook page 43)

1. Answers may vary. Carrying capacity is the largest population size that an ecosystem can sustain.
2. Limiting factors can include oxygen supply, food supply, disease, predators, and space.
3. The limiting factors of an aquatic ecosystem are the forces that determine many organisms the ecosystem can sustain. If the limiting factors change, the carrying capacity will change.
4. Answers may vary. Limiting factors affect humans, but we have developed the ability to change the limiting factors, for example, killing our predators and developing vaccines for diseases.

Activity 1.11 What's the Link? (Student textbook page 45)

Pedagogical Purpose

Students think critically or research about questions relating to carry capacity.

Planning	
Materials	None required
Time	20 min in class 0 min preparation

Skills Focus

- formulate hypotheses

Activity Notes and Troubleshooting

- Students will analyze these ideas to determine how both abiotic and biotic factors limit populations in ecosystems.
- ELL English language learners may not be familiar with many terms in this activity. Read questions aloud to the students and have class members illustrate using simple sketches or words to explain these terms.
- Have students work in pairs to come up with at least one solution for each question. Then, take up the solutions with the class. Write the solutions for each question and have students copy them.
- Allow for multiple right answers: There are numerous factors that affect carrying capacity.

Additional Support

- Select two possible answers for one of the questions and have students discuss which is the more complete answer.
- ELL English language learners benefit from analogies and real examples. Bring in a balance/scale to reinforce the concepts of carrying capacity and limiting factors. Place a few objects (weights) on one arm to represent factors such as parasites, limited space, predators, and food supply. The population can grow to a certain point, but when it passes the tipping point, the limiting factors reduce the population. This visual can also tie into the idea of equilibrium in Topic 1.6.
- Enrichment—Ask students what some limiting factors are in a local ecosystem. Have them investigate an endangered ecosystem in the local community.
- This activity can be used to develop student responsibility. Have students complete some research for this activity and provide proof of their work. Students should be able to summarize their research and not copy it word for word.

Activity 1.11 Answers

1. Palm trees grow in Florida but not in Ontario because they require warmer winters.
2. Since rabbits are the prey of foxes, too many foxes would rapidly decrease the size of the rabbit population; too few foxes and the rabbit population would increase due to lack of predation.
3. A severe drought would reduce the size of the pond so that fewer organisms could live there.
4. Nitrogen is a nutrient. Not enough nitrogen means species who rely on it must compete to survive. Too much nitrogen in a lake ecosystem causes too much algae growth, which limits oxygen availability for fish and other aquatic animals.

Learning Check Answers (Student textbook page 45)

1. Answers may vary. For example, water, living space, shelter, sunlight, and nutrients.
2. Answers may vary. For example, if there is not enough food, some individuals will starve; if there is not enough rain, plants will die, if there is not enough space, predators will not be able to establish territories and find enough prey to survive; if there are not enough places to hide, more prey will be killed.
3. Answers may vary. For example: Sunlight, water, living space, nutrients.

Investigation 1B Investigating Limiting Factors for Algae Growth

Pedagogical Purpose

Students will plan and conduct an experiment that explores how fertilizer affects the size of an algae population. They then analyze and interpret their results and communicate them using graphs and written explanations.

Planning	
Materials	5 Erlenmeyer flasks fertilizer solutions (5 different concentrations) eye dropper pond water (contains algae) graph paper growth lights or well-lit space **BLM 1-18 Investigation 1B** **BLM G-17 Variables in Science** **BLM G-25 Constructing a Line Graph** (optional) **BLM G-26 Interpreting Line Graphs** (optional)
Time	40 min initially and then time during 6 subsequent classes 10 min in preparation (prepare fertilizer concentrations; start at recommended strength and dilute accordingly)
Safety	Handle fertilizer solutions with care. Dispose of algae populations properly.

Background

Algae refers to a large family of aquatic producers that includes single-celled organisms and seaweed. Most commercial fertilizers provide instructions for their recommended use and these can be used to produce the five different concentrations.

Skills Focus

- communicate using a variety of formats
- conduct inquiries to collect data
- draw conclusions

Activity Notes and Troubleshooting

- This Investigation will be challenging for most students at the applied level; proceed slowly. Outline the expectations for the Investigation and monitor each stage of their progress closely, encouraging and redirecting as necessary.
- Students are to plan and conduct an experiment with teacher approval. They will record data over a 7 day period and produce and interpret graphs to further analyze their data and to make reasonable conclusions.
- Distribute **BLM 1-18 Investigation 1B** to students.
- Use **BLM G-17 Variables in Science** to help with monitoring the amount of light, temperature, and water volume in each sample.
- Break up the steps in the investigation so that students can assimilate each step. Have students complete one step at a time and get your approval before proceeding.
- Be prepared to suggest a design, or parts of a design, to students having difficulty creating their own or so they can make improvements to their design.
- Begin your own investigation at the same time as students, to provide data for those students who might not obtain adequate results.
- Have students share graphical results with the class.
- Relate question 6 on algal blooms to Figure 1.8 on page 35.

Additional Support

- DI A variety of skills are required in this investigation. Ensure that each group includes several types of learner and that roles are shared.
- ELL Some English language learners will just need clarification support with this task. Read the introduction to the student and assign a peer coach they can ask for support from as the Investigation continues. If possible, provide a write-up template containing subtitles of the important sections that should be included.
- It may be useful to review graphing techniques before students organize their results. Use Numeracy Skills Toolkit 4: Organizing and Communicating Scientific Results with Graphs, on page 370 of the student textbook, **BLM G-25 Constructing a Line Graph**, and **BLM G-26 Interpreting Line Graphs**.
- To save on space and materials, this Investigation can be performed as a class project. Or, if time is limited, have data from a completed investigation available for students to analyze and draw conclusions from.
- Ask students what difficulties they encountered in this investigation and brainstorm how these difficulties can be handled in future activities.

Answers

1. The limiting factor was the concentration of the fertilizer. The factor was abiotic.
2. The independent variable was the concentration of the fertilizer. The dependent variable was the algae growth. Other variables that were kept the same for all samples were the amount of light, the temperature, and the amount of pond water.
3. Answers may vary. Students should identify flaws and suggest improvements.
4. Answers may vary. Students should identify which concentration resulted in the most algae growth. Answers depend on the initial concentrations and the dilution factors.
5. The population will continue to grow until the carrying capacity is reached. Population growth could also be controlled by the amount of light, temperature, pH, the amount of dissolved oxygen, and available space.
6. An algal bloom will block sunlight from getting to deepwater plants, killing them. All the dead plants will cause an increase in the number of decomposers which use up the available oxygen in the water, killing all the aquatic organisms that need that oxygen.
7. Answers may vary. Students should find that all fertilizers contain nitrogen, which can cause algal blooms. They may find references stating that organic fertilizers release the nitrogen more slowly. For useful Web sites about synthetic versus organic fertilizers, go to **www.scienceontario.ca**.

Using Strange Tales

Literacy Support

Before reading

- Have students refer to the in Activity 1.10 on page 42 which features a similar growing bacteria population, but only at its beginning.
- ELL English language learners benefit from revisiting the text. Have them refer to their tables from **BLM 1-17 Up for the Count** to recall the similar growing bacteria population.
- Ask students what they know about E. coli bacteria. E. coli are commonly found in the intestines of mammals. Some students may remember hearing about a community suffering from food poisoning due to E. coli, which can occur if there is fecal contamination of their water supply.
- Watch a video featuring time-lapse photography of a growing E. coli colony before looking at the cartoon image. Visit **www.scienceontario.ca** for more information.
- Ask students to predict what the text is about based on the picture. The colour of the cartoon bacterium matching the colour of the growing mass should convey the idea of a rapidly spreading population.

During reading

- Discuss the times shown on the 24 h clocks. Ask students how much time has passed between each map.
- ELL Read the text aloud to the class.

After reading

- ELL Partner English language learners with a proficient English speaking peer to work together on the questions.
- Take up the questions as a class to discuss the activity and determine to what extent students comprehended the text.

Instructional Strategies

- This activity relates to the growing bacteria population in Activity 1.10 on page 42. Have students use their knowledge of carrying capacity and limiting factors to answer the questions.
- Point out that the 20 minute doubling time is only under ideal conditions. Talk about what factors might cause slower growth rates.

Answers

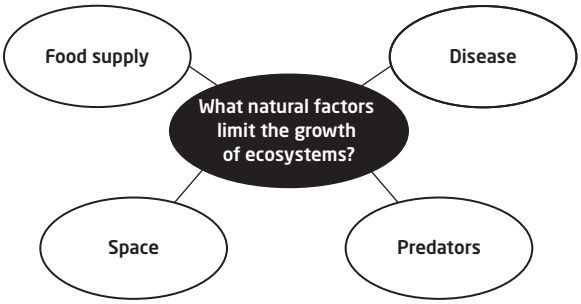
1. E. Coli could not create a super colony with the same mass as Earth in 24 hours because food and space would be too limited to allow unchecked growth of the bacterium.
2. Food, space, nutrients, pH, and temperature are limiting factors that keep bacteria from taking over the planet; as well too much waste would be produced by the dividing bacteria.
3. If there were no bacteria, then the amount of decomposition would decrease and the ecosystem would lose nutrients.

Topic 1.4 Review (Student textbook page 49)

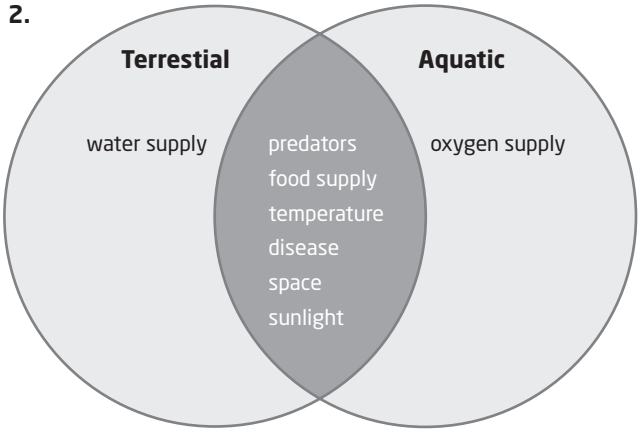
Please also see **BLM 1-19 Topic 1.4 Review (Alternative Format)**.

Answers

1. Answers may vary. For example:



2.



3. a) In the graph to the left, the population for bacteria is increasing at a rapid pace. The graph to the right had rapid initial growth and has slowed to a plateau.

b) The graph on the right has reached its carrying capacity because the population has stopped growing.

4. a) Answers may vary. For example: There may not be enough space in urban environments or limited resources like food and water.

b) Answers may vary. For example:
Yes, the government should be allowed to pass laws if it is for the long term benefit of the majority.

No, the size of a family and where the family wants to live is a freedom the government has no right to take away.

c) Answers may vary. For example:

Pros	Cons
• High concentration areas like subways will not be overcrowded.	• We will be losing freedoms.
	• Many couples may have to leave the urban environment and either leave their jobs or take on a longer commute, both which could negatively impact productivity.

d) Answers may vary. The solution should summarize parts a) to c).

5. It would probably lower the carrying capacity due to the fact that squirrels can use dead timber as shelter and protection from predators.

6. Answers may vary. For example: Biotic factors include food supply, predation, and disease. Abiotic factors include water supply, living space, and temperature.

7. Until around 80 days, the carrying capacity was not met because the population kept growing. This suggests the population had an absence of limiting factors until around the 80 day mark.