Section 7.3 Indicators and Effects of Climate Change

Specific Expectations

- **D1.1** analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems
- **D1.2** assess, on the basis of research, the effectiveness of some current individual, regional, national, or international initiatives that address the issue of climate change, and propose a further course of action related to one of these initiatives
- **D2.4** investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change, using simulations and/or time-trend data that model climate profiles
- **D3.8** identify and describe indicators of global climate change

In this section, students will learn about indicators that show Earth's climate is changing. The most significant of these is global warming, which in turn affects many other features such as polar ice caps and atmospheric temperatures. Students will learn about the impacts of these changes will be introduced to programs designed to address climate change.

Common Misconceptions

- Students may confuse the terms *global warming* and *climate change*. Global warming is, in fact, an indicator of the long-lasting changes to climate that are occurring on a global scale.
- Students may think that effects such as global warming and rising sea levels occur in isolation. In fact they strongly influence each other. Students will learn about such feedback loops in Chapter 8.
- Students may believe that global warming is irreversible and that humankind has gone beyond the point of no return. Students need to be aware that the fight is not over and there is still (and will always be) time to change.
- Students may feel that the melting of the polar ice caps is not a big deal to them because the ice caps are far away and Ontario is not a coastal province. Emphasize the interrelatedness of global changes.
- Students may feel that global warming is good, considering how cold Canada is in winter. While there will be opportunities for Canada (for example, in agriculture) to take advantage of warmer weather, the global scale of the changes means that everything will change (e.g., water levels, immigration, etc.), not just winters.

Background Knowledge

The globally averaged surface air temperature is estimated to increase between 1.4°C and 5.8°C by 2100 from 1990 averages. The challenges of determining a "global" average, coupled with the inherent uncertainty of models (because of assumptions and representations of complex processes), makes it difficult for more precise forecasts. However, the magnitude of this increase over this short span of time is unprecedented during the last 10 000 years. Most models agree on the following predictions:

- more hot days and higher daily maximum temperatures in all land areas,
- higher minimum temperatures and fewer frost days in all land areas,
- more frequent intense precipitation events over the Northern Hemisphere, and
- increased continental drying and likelihood of drought.

The melting of large ice sheets is not the only cause of sea-level rise. In fact, a significant amount of sea-level rise is caused by the thermal expansion of ocean water as the temperature increases. Huge floating ice sheets will not cause any change in sea levels as they melt, because floating ice displaces the same volume of water as it does when it melts. One of the key concerns is about large pieces of ice breaking off the land-based Greenland and Antarctic ice shelves.

The rising acidity of the world's oceans is having a significant effect on ocean biodiversity. Tiny, shelled amoeba-like animals called foraminifera play a major role in trapping carbon dioxide, which is a component of their shells. They transport the carbon dioxide in their shells to the ocean depths when they die and sink to the bottom. The carbon dioxide gets locked away for decades, centuries, or even longer. Scientists have compared the shell weights of today's foraminifera to data from 50 000-year old specimens and have shown a 30 to 35 percent reduction in shell weight, meaning less carbon dioxide is being captured to make their shells.

Models show a consistent pattern of increased precipitation in the tropics, Northern Africa, and South Asia. The risk of flooding will increase, as will the risk of water-borne and mosquito-borne disease (e.g., malaria, dysentery, and cholera). A consistent pattern of decline in rainfall is seen in subtropical regions of sub-Saharan Africa, Central Asia, and Australia. These are areas already suffering from water shortages.

The sub-Saharan region of Africa is known as the Sahel. This region has suffered persistent reductions in precipitation during the last 100 years, with severe droughts in the 1910s, 1940s, and 1970s and 1980s. The Ethiopian famine in 1984 was brought about by drought, and an estimated 1 million people died. This started international actions to slow the desertification of the region. Deserts do not advance (or retreat) at a steady rate along a front. Advances begin in patches, which then grow and meet. Estimates are that 20 million hectares of once-arable land are being transformed into unproductive desert land every year. This translates to a desert "front" moving southwards in Africa at a rate of 50 km per year. These statistics led to a United Nations response similar to the Intergovernmental Panel on Climate Change (IPCC). Ultimately, the group negotiated the Framework Convention to Combat Desertification.

Earth's biodiversity has steadily increased over the last 600 million years, even though it has been interrupted by mass extinctions. Current biodiversity is threatened by the scale and rate of climate change. Typically, climate changes slowly, allowing biodiversity to adapt. In addition to causing outright extinction, many organisms will suffer from the lack of season changes they rely on to trigger life cycle events (e.g., reproduction, hibernation, etc.) Changes in these organisms can be used to gauge the effects of changes in global temperature and seasonal variation.

Many plants and animals become isolated geographically in areas called refugia, which lack areas to migrate to if needed. Refugia are often created by a climate event. For example, on Mount Olympus in Greece there are 20 species of plant found nowhere else in the world. They were isolated to that refugia during the last ice age. Organisms in refugia are extremely vulnerable to climate change because their ability to relocate to a more favourable climate is limited.

Literacy Support

Using the Text

- Encourage students to make a concept web to help organize their understanding. They can begin with headings in the section, and develop the content as they progress through the material.

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.

During Reading

- As students progress through the section, have them write down a question and an answer at the end of each subsection. The questions can be shared with the class and answered during a class discussion.
- As students approach the end of the section, have them complete **BLM 7-13 Put Yourself in the Future.** This will challenge them to consider the effects of climate change and visualize themselves living in a world changed by climate change.

After Reading

- Ask each student to write a two-sentence summary of the main points of the section. You can then have students work in groups to compare their summaries and agree on one. These summaries can be shared with the class and recorded so they can be used for review.

Using the Images

- Before reading, have students make connections to visuals. In particular, have them identify if any of the photographs or illustrations describes a situation they have first-hand knowledge of. For example, some may have experienced walking through wetlands, or may be from farming families.
- After reading, have students form groups and look through the photographs and illustrations in the section. Students can come up with a summary of the section based on what is presented in the visuals. Each student can record their group's summary and use it as a study tool later.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check questions, page 296	Rising temperatures are linked to spread of disease into formerly inhospitable (e.g., too cold) regions. Flowcharts show multiple interactions among factors.	Have students complete **BLM 7-13 Put Yourself in the Future** to explore effects of the anthropogenic greenhouse effect, the depletion of stratospheric and tropospheric ozone, and the formation of ground-level ozone and smog.
Section 7.3 Review, page 299	Students link multiple data represented in the graph. Short-term weather events are excluded from definitions of climate.	Refer students to the Reading Graphic Text section of the Study Toolkit Overview on page 560 of the student textbook.

Instructional Strategies

- DI Establish interest centres based on the topics in the section where intrapersonal learners perform the activities based on their own interests and at their own pace.
- DI Provide the opportunity for intrapersonal learners to work independently on a topic of particular interest.
- DI Develop key visuals such as a flow chart that can be used during class discussion. Develop these on your own, or have the class assist with the development.
- ELL Simplify the vocabulary whenever possible for English language learners. If you have already created a word wall with first language translations, continue to add to it. This will reinforce section and chapter-specific vocabulary.
- Encourage students to make graphic organizers to help them organize the information into chunks as they read.
- Pre-assess what students know about climate change indicators and effects by having a class discussion. Ensure that all students participate, even if just minimally with a show of hands, to determine understanding.
- Have students prepare and carry out their own survey using **BLM 7-11 Public Perception of Climate Change Risks** and have students perform the survey. This can lead to a class discussion about the indicators and effects of climate change, and how students themselves perceive the risks.

Activity 7-4 Acidity and Coral Reefs (Student textbook page 293)

Pedagogical Purpose

This activity highlights the importance of pH on calcium carbonate. Students see first-hand, how acid affects calcium carbonate and infer the effect on shell-forming marine organisms.

Planning		
Materials	3 glass jars or 50 mL beakers 20 mL vinegar 3 pieces of chalk or eggshell Tongs	20 mL water 20 mL soft drink Graduated cylinder **BLM 7-12 Acidity and Coral Reefs** (optional)
	One or two days before, ask students to collect eggshells from home.	
Time	30–45 min 5 min to observe observe over next two days	
Safety	Have students wash their hands well after handling the materials. Remind students never to eat in the science classroom. Have liquid and glass clean-up kits available.	

Background

Calcium carbonate is a compound with the chemical formula $CaCO_3$. It makes up most of the shells of snails, eggs, and marine organisms such as corals. Eggshells, for example, consist of about 94 to 97 percent calcium carbonate. It is a very common chemical compound and can be found as rock all over the world. It is the active chemical in agricultural lime and can be used to neutralize acid, as explored in Chapter 6.

The unstated link between acidity, shells, and climate change is a sort of feedback loop. Shells store carbon, greenhouse gases (GHGs) cause acid rain that breaks down the shells. Carbon that used to be stored in the shells is now in the system, contributing carbon to global warming.

Activity Notes and Troubleshooting

- This activity requires that the eggshell or chalk be allowed to sit in solution overnight. Alternatively, you may wish to start a demonstration set of experimental conditions and time them so they have already sat overnight on the day of the activity. Students could then complete the initial stages themselves and be shown what would occur if the eggshell or chalk were left overnight.
- Time this activity so that students will be able to record observations over the two following days.
- Actual coral or sea shells could be substituted for the eggshell.
- To protect against spills while the samples sit for days, use cups with lids or place the cups in a drip tray to collect any spills or leaks.
- When calcium carbonate is added to an acid, it will fizz, producing carbon dioxide and water. The stronger the acid, the fizzier the reaction will be. Students may benefit from a quick review of their notes from the chemistry unit. In particular, notes relating to Investigation 4-B Keep That Toothy Grin.
- Have students work in groups for this activity. Ensure that there is enough room for everyone to observe all the test conditions.
- Go through the design of the data table in advance. Have students show you their tables before they start in order to ensure they will be able to record the correct data.
- Analyze the elements in calcium carbonate (Ca and C) to help students recognize the carbon trapped within it. Encourage students to recognize reefs and shells for their role as carbon sinks. If less carbon can be trapped in these places because of water acidity, the effectiveness of these carbon sinks is reduced.

Additional Support

- DI This activity is well-suited for visual, spatial, and bodily-kinesthetic learners.
- Have group members take on specific roles (e.g., recorder, set-up, etc). Depending on the individual, assign them a role that they will be comfortable doing (e.g., recording masses in a table, removing shell/chalk with tongs, etc.).
- Enrichment—Encourage students to research the impact of ocean acidity on shelled organisms. They can report how their research results compare with their activity results.
- Extension—Have students compare the mass of the samples before and after to either confirm that mass was lost (if the jars are not seale) or conservation of mass.
- You may wish to hand out **BLM 7-12 Acidity and Coral Reefs** which scaffolds the procedure and observations.

Answers

1. The surface became pocked and bumpy.
2. vinegar, since that eggshell sample was the most bumpy
3. Rising acidity would case the shells of marine organisms to be thinner and softer because they would contain less carbon.

Learning Check Answers (Student textbook page 297)

1. Global warming has shifted warm winds toward the poles. These winds cause compression of snow to form ice, and then push sea ice south toward warmer waters, where the ice melts.
2. Desertification may lead to crop failure as a result of lack of water. When crops fail, food supplies may dwindle, which may lead to famines.
3. Precipitation rates in most of Ontario have increased by 10 to 20 percent since 1948. In a small part of Ontario southwest of James Bay, precipitation rates have not changed.
4. Flowcharts should show that rising global temperature can increase precipitation and flooding, which can lead to increased runoff and sewage systems overflowing, contaminating drinking water.

Section 7.3 Review Answers (Student textbook page 299)

Please also see **BLM 7-14 Section 7.3 Review (Alternative Format).**

1. The most important indicator of global climate change in recent years is global warming, or an increase in the average temperature of the atmosphere and oceans.
2. Rising temperatures have caused polar ice to melt, which has added large volumes of water to the oceans and raised sea level. In addition, as water becomes warmer, it expands. This expansion also causes sea level to rise.
3. As climate becomes warmer, insects and micro-organisms that carry or cause diseases are better able to survive the winter. In addition, changes in precipitation may lead to flooding, which may cause outbreaks of waterborne diseases. Climate change may also increase allergens and asthma triggers in the air, which may cause more people to stay inside or seek medical attention.
4. The number of skin diseases reported appears to have increased and peaked following increases in temperature and humidity during the summer months. The number of skin diseases reported was lowest when temperature and humidity were lowest during the late winter months between January and June.
5. High temperatures increase the rate of evaporation. As moist air cools, precipitation falls as rain or snow. Therefore, higher temperatures may lead to more rain in some areas.
6. Crops can be replanted or replaced every year. Forests can take decades or centuries to establish themselves and are not easily moved or replaced.
7. No. Data from many years are needed to identify a trend in storm intensity and frequency. It would be more reasonable to chart the average numbers and strengths over many years to identify an increase.
8. As climate changes, organisms that are adapted to a certain climate may not be able to cope with different conditions. Some species will become extinct, while others may migrate to other regions to compete for food and other resources. As a result, global biodiversity will decline.

Inquiry Investigation 7-A Specific Heat Capacity of Earth's Materials (Student textbook pages 300 to 301)

Pedagogical Purpose

Students investigate how the amount of electromagnetic radiation absorbed or reflected by a material is related to the material's specific heat capacity.

Planning		
Materials	Three 600 mL beakers 100 mL dark-coloured soil 100 mL cold water Lamp or light bulb socket with clamp 4 ring stands (optional) Clock, watch, or stopwatch Coloured pens or pencils (optional)	Scoop 100 mL light-coloured sand 100 W light bulb 3 thermometers or temperature probes 3 thermometer clamps (optional) Graph paper **BLM 7-6 Specific Heat Capacity of Earth's Materials.**
	One week before the investigation, obtain dark-coloured soil and light-coloured sand. Make sure that the sand and soil are dry. Gather the materials. Check that the light bulbs are working. One day before the investigation, photocopy BLM.	
Time	40–60 min	
Safety	Students should use caution when handling the lamp because the light bulb will become very hot. Have glass clean-up kits available.	

Background

The albedo of an object is a measure of the extent to which the object reflects light from the Sun. A highly reflective material, such as fresh snow, will have an albedo of 96 percent. An object like black charcoal will have an albedo of 5 percent because it absorbs nearly all of the light. The approximate albedos of the materials in the investigation are as follows: dry sand 35 to 45 percent; dry soil 20 to 33 percent; and water 5 to 8 percent. If sand and soil are wet, their albedos are 20 percent less. The temperature of the sand should increase and decrease slowest. The water temperature should increase and decrease most rapidly.

Activity Notes and Troubleshooting

- This activity should be done in groups of two or three students.
- Remind students to copy both tables into their notebooks. Alternatively, they can use **BLM 7-6 Specific Heat Capacity of Earth's Materials** to record their data.
- Encourage students to read the procedure completely before starting.
- Ask students to write down which material they think will heat up fastest and which will cool the fastest.
- The lamp should be the same distance from each of the beakers. As well, the thermometer bulbs should be covered by the material, and the sand, soil, and water should all be at the same temperature before they are heated. This will ensure a fair test.
- When students have plotted their results, compare and discuss graphs and the previous predictions.

Additional Support

- ELL Encourage English language learners to describe the apparatus to their partners or to you.
- DI This is a good hands-on activity for bodily-kinesthetic and spatial learners.
- Enrichment—Consider having the students perform either of the Extend Your Inquiry and Research Skills questions. Make sure to ask the students what results they would predict and have them support their predictions with their reasoning.

Answers

1. water; dark-coloured soil
2. Example: errors in reading thermometer, imprecise thermometer, light moved, water content in samples changed
3. **a.** water
   b. water
4. The atmosphere above darker material will stay warmer longer because the heat is absorbed and released over time.
5. The water decreases the amount of time to warm up and increases the amount of time to cool down. The material with the lowest specific heat capacity will increase the temperature of the atmosphere above it most rapidly.
6. Experimental designs might use a set-up similar to this investigation, substituting the four materials, and measuring the temperature 2 cm above the material to measure the air temperature.

Data Analysis Investigation 7-B Comparing Ecoregions of Canada (Student textbook pages 302 to 303)

Pedagogical Purpose

Students identify the ecoregion and ecozone in which they live and then compare it to other areas of Ontario and Canada.

Planning	
Materials	Maps of Canadian ecozones and Ontario ecoregions
Time	30–40 min

Background

The Hudson Plains consists of many small wetlands and swampy forests, together making one of the world's largest wetlands. Animals found in this ecozone include polar bears and arctic foxes, snow geese and willow ptarmigan. The Boreal Shield covers 60 percent of Ontario's landmass. Large mammals, such as the eastern timber wolf, woodland caribou, moose, and lynx, are found in this region, as well as birds such as the common loon. The Mixedwood Plains is located south of the Precambrian Shield and supports species such as white-tailed deer, flying squirrels, and wild turkeys.

The Great Lakes are an aquatic ecozone in Ontario that supports thousands of organisms (in the water and along the shore), including the map turtle and the Lake Erie watersnake.

Activity Notes and Troubleshooting

- Students can work independently or in pairs. Provide enough maps for everyone to have one.
- You may wish to have students compare the ecoregions as well.
- Some students may have trouble interpreting maps. You may wish to have a class discussion about interpreting the ecozones and ecoregions on the maps before beginning the Investigation.

Additional Support

- DI This is an excellent activity for spatial learners. You may wish to pair them with students who are having trouble interpreting the maps.
- ELL Students will benefit from the structure of using a table to summarize the differences between ecozones.
- Encourage students to look at the ecozones and ecoregions from other parts of the country, particularly if they have personal experience with the areas.
- Allow students to use a computer to research more details about each ecozone, such as the wildlife that lives there. They also can create their tables with a computer program.

Answers

1. Hudson Plains, Boreal Shield, Mixedwood Plains
2. Example: Boreal Shield
3. There are 10 ecoregions of Boreal Shield in Ontario, as well as the Hudson Plains and Mixedwood Plains ecozones.
4. Example: Algonquin-Lake Nipissing

5. The Hudson Plains and the Boreal Shield are both flat ecozones with clay plains drained by rivers. Winters in both ecozones are very cold. The summer high in the Hudson Plains is +15°C or below. The summer high in the Boreal Shield is below +20°C. The Hudson Plains ecozone has scrub above the tree line and bushes, flowers, and aquatic vegetation below the tree line, whereas Boreal Shield is primarily forest, with mostly coniferous trees. The Hudson Plains ecozone has mostly swamps and bogs, with some rocks. The Boreal Shield is hilly with many lakes and rivers. While the Hudson Plains region is only very lightly settled by humans, the Boreal Shield has settlements along highways, on rivers, or at mines.
6. Venn diagrams should show that the mixed-wood ecozone and the Boreal forest ecozone are different because the mixed-wood ecozone has warmer temperatures. It should also show that the ecozones have different vegetation. The Boreal forest is mostly coniferous trees and shrubs and grasses, whereas the mixed-wood ecozone has both coniferous and deciduous trees. The diagram should also indicate that the soils, land and settlement in the two ecozones differ.
7. Conditions in some of the ecozones are not suitable for agriculture, easy transportation, or building structures. All these factors are important for human habitation.
8. All of the ecozone boundaries may move north, so more land area will become suitable for human habitation or industry (forestry, agriculture, etc.). More settlements will be possible, allowing a larger population to live in the (current) extreme environments.
9. Understanding ecozones and ecoregions allows strategic decision making, such as conservation plans, development plans, and decisions about how humans can use the features of the areas in which they live (resource management).
10. On average, the ecozone boundaries will shift north. Encourage students to provide sources when they provide their answers. There is variation in what experts are predicting, so there may not be consensus amongst students' maps.
11. Example: People may start to leave Ontario's bigger cities (located around the great lakes) in search of reliable water supplies. Or, the cities may expand, following the receding shoreline.

Data Analysis Investigation 7-C Comparing The Effects of Climate Change on Vegetation in Canada

(Student textbook pages 48 and 49)

Pedagogical Purpose

Students will evaluate the change in land cover that could occur in Ontario as a result of climatic and ecological changes.

Planning	
Time	30–40 min

Background

Ontario grasslands are one of the most endangered ecosystems in the world, because of development and an invasive species. Originally, grasslands could be found in Ontario from the southernmost regions up to Georgian Bay. Less than 3 percent of the original tall grass prairies are left. Climate change is expected to increase the area of grassland in Ontario significantly, which will result in expansion of habitat for some endangered species such as the Eastern fox snake and the American badger.

Activity Notes and Troubleshooting

- Students can work independently, or in pairs. Have a class discussion about interpreting the land cover on the maps before beginning.

Additional Support

- DI You may wish to pair spatial learners with students who are having trouble interpreting the maps.
- ELL Students can be encouraged to choose an alternative way to present their findings, such as verbally or in illustrations.
- Enrichment—Have students explore the National-Scale Ontario Land Cover project. This site includes detailed satellite imagery of land cover in Ontario. Students can develop a presentation based on this information.

Answers

1. **a.** Grassland, Boreal forest, Temperate forest.
   b. Boreal forest.
2. **a.** Grassland, Boreal forest, Temperate forest.
   b. Temperate forest.
1. The boreal forest did not move northward because of the constraints of soil quality.
2. Logging the temperate forest will clear land that may result in an expansion of grasslands in western Canada.
3. The forestry industry will need to adapt to a different mix of trees in their communities. If they are not able to change, the industry may be reduced and the communities may face severe economic hardship.
4. The permanent ice biome would disappear because it is highly temperature dependent. As the temperature increases and the other biomes shift northward, these biomes would displace earlier biomes suited to colder conditions. There would be no colder place for the permanent ice to go.
5. Example: The Niagara fruit belt will probably expand to cover a larger part of Ontario. This would shift the economy towards a heavier dependence on these products.