

Climate Change and Agriculture: Causes and Effects

*How should decisions about environmental
and agricultural sustainability be balanced?*



A Teaching
and Learning
Resource for
Grade 7 Science

Climate Change & Agriculture: Cause & Effect

2nd Edition

The roots of most Canadian rural communities are in agriculture. Today, Canada is no longer an agrarian nation. And in this change, we are losing the connection to the food we eat – where it comes from, what is required to provide our 'daily bread,' and the independence that our forefathers knew came with being able to grow enough to feed one's self.

But more importantly, we are losing the resources that allow Canada to produce its food, and the citizenship that values regional cuisine made from foods that are produced in the areas where they live.

These resources are meant to 'reconnect' a population pulled to the city with the industrial revolution, with an appreciation for the resources that agriculture needs, if 'made in Canada' food is to continue to be a reality.

May this resource be helpful to you and your students.

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INTRODUCTION AND OVERVIEW

The world can be classified into major biomes. A biome is a large geographical area that is characterized by species of plants and animals that are adapted to their environment. Biomes are also characterized by geographic factors that include climate, altitude and topography. This resource encourages students to explore how human activity has had, and continues to have, a significant impact on biomes. It develops and builds on key concepts that include climatic factors, patterns and change. Students also explore the relationship and potential impact of human activity – through the lens of agriculture – on climate patterns and the environment.

A Critical Issues Approach

Issues that are relevant and meaningful to students support a constructivist, inquiry-based approach to learning. Critical issues frame learning around key questions that pose problems that intrigue and interest students, and set a focus for motivated learning. Posed effectively, critical issues ask students to develop and apply critical thinking skills and look at multiple perspectives, consider alternatives and recognize that challenges can often involve many different solutions.

This teaching and learning resource is developed around a critical issues approach and promotes inquiry-based learning and critical thinking. The exploration of issues is framed around inquiry questions that are relevant and meaningful to students, engage them in deliberative research and promote social participation skills.

Curriculum Support

This resource supports Alberta's **Grade 10 Science** program of studies. Unit D: Energy Flow in Global Systems encourages an exploration of the impact of human activities on global energy flow. This resource develops concepts focused on the relationship between climate change and human activities. It also develops skills and attitudes that emphasize problem solving and stewardship. A curriculum correlation chart follows. Specific charts are provided with each of the three lesson sequences in this resource, indicating curricular outcomes for each lesson sequence. These lesson sequences include activities that may take two to five 50-minute class periods, depending on activities selected.

Climate Change & Agriculture: Cause & Effect

Grade 10 Science Curriculum Connections Summary

Critical Issues and Inquiries

How should effects of human activities on the environment be balanced with human needs?

Biomes & Global Agriculture

What do biomes have to do with human agricultural activities? (Lesson Sequence One)

Climate Patterns & Change

What evidence suggests that climatic patterns are changing? (Lesson Sequence Two)

Climate & Agriculture

What impact does climate change have on agriculture? (Lesson Sequence Three)

Knowledge Outcomes

Unit D: Energy Flow in Global Systems Focusing Questions

- Are there relationships between solar energy, global energy transfer processes, climate and biomes?
 - What evidence suggests our climate may be changing more rapidly than living species can adapt?
 - Is human activity causing climate change?
 - How can we reduce our impact on the biosphere and on global climate, while still meeting human needs?
3. Relate climate to the characteristics of the world's major biomes, and compare biomes in different regions of the world
- Relate the characteristics of two major biomes (*i.e., grassland, desert, tundra, taiga, deciduous and rain forest*) to *net radiant energy, climatic factors (temperature, moisture, sunlight and wind) and topography (mountain ranges, large bodies of water)*
 - Analyze the climatographs of two major biomes (*i.e., grasslands, desert, tundra, taiga, deciduous and rain forest*) and explain why biomes with similar characteristics can exist in different geographical locations, latitudes and altitudes
4. Investigate and interpret the role of environmental factors on global energy transfer and climate change
- Investigate and identify human actions affecting biomes that have a potential to change climate (*e.g., emission of greenhouse gases, draining of wetlands, forest fires, deforestation*) and *critically examine the evidence that these factors play a role in climate change (e.g., global warming, rising sea level(s))*
 - Describe and evaluate the role of science in furthering the understanding of climate and climate change through international programs

Skills Outcomes

Initiating and Planning

- Identify science-related issues
- Identify questions to investigate arising from science- and technology-related issues
- Assess and develop appropriate procedures and instruments for collecting relevant data and information

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Apply given criteria for evaluating evidence and sources of information
- Apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments
- Identify new questions and problems that arise from what was learned identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives

Communication and Teamwork

- Work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- Assess potential decisions; and recommend the best decision, based on findings
- Make clear and logical arguments to defend a given decision on an issue, based on findings
- Evaluate individual and group processes used in investigating an issue and in assessing alternative decisions

- Describe the role of technology in measuring, modeling and interpreting climate and climate change (e.g., *computer models, devices to take measurements of greenhouse gases, satellite imaging technology*)
- Describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., *predicting the direct and indirect impacts on Canada's agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns*)
- Assess, from a variety of perspectives, the risks and benefits of human activity, and its impact on the biosphere and the climate (e.g., *compare the Gaia hypothesis with traditional Aboriginal perspectives on the natural world; identify and analyze various perspectives on reducing the impact of human activity on the global climate*)

Attitude Outcomes

Scientific Inquiry

- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (e.g., *view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation*)

Collaboration

- Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., *choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)

Stewardship

- Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., *recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment*)

THE CRITICAL ISSUE & INQUIRY PROCESS

How should effects of human activities on the environment be balanced with human needs?

Related Inquiries

**What do biomes have to do with human agricultural activities?
(Lesson Sequence One)**

In Lesson Sequence One, students review and reinforce their understandings of the characteristics (net radiant energy, climatic factors and topography) of the major biomes of the world. Students examine climatographs of two biomes – grasslands and boreal forests – that are part of the landscape of western Canada. They analyze why biomes with similar characteristics can exist in different geographical locations and consider how human activities, such as agriculture, can affect biomes.

**What evidence suggests that climatic patterns are changing?
(Lesson Sequence Two)**

In Lesson Sequence Two, students examine evidence of climate change, including different points of view on causes and effects of changing climatic patterns. Students start to explore connections between climate and human activity and the resulting affects on biomes.

**What impact does climate change have on agriculture?
(Lesson Sequence Three)**

In Lesson Sequence Three, students explore the impact of agricultural innovations, including selective breeding and genetic engineering, on crop production and the environment. Students consider the intentional and unintentional impact of genetic technology on food crops like canola. Students think critically about how decisions between increasing use of crop production technologies and economic and environmental sustainability are balanced.

**How do agricultural decisions and practices promote sustainability?
(Lesson Sequence Four)**

In Lesson Sequence Three, students explore the impact of climate change on agriculture, and assess the potential effects of agricultural activities on changing climatic patterns. Students use examples from agricultural practices to analyze differing perspectives on climate change.

In their inquiry into this critical issue, students explore the impact of human activities and decisions on biomes. They collect and analyze evidence of the connection between agricultural practices on climate patterns and change.

The Process

This resource is structured around inquiry questions that form the basis for exploring the critical issue. Each inquiry question provides a focus for a lesson sequence and for deliberative research. Each lesson sequence also contains “I can...” statements that set a context for research and inquiry, provide criteria for assessment and help students focus their learning. These statements can be shared with students at the beginning of each lesson sequence.

Each of the lesson sequences in this resource is structured around the following features:

- Each lesson sequence provides activities that introduce and explore topics in **two to five 50-minute** class periods, depending on activities selected. Choices can be made by both the teacher and students about the scope and extent of research and assignments associated with the lesson sequence. Depending on the time available, modify the number of class periods for the lesson sequence.
- Additional activity suggestions provide opportunities to extend the lesson sequence and further develop research and inquiry skills.
- An overview of instructional strategies is provided with each activity.
- Rubrics can be used to assess many of the products that students create in the lesson sequences. Sample rubrics and criteria statements are provided at the end of this section of the resource, as well as a template for creating customized rubrics.
- Student products may be displayed and shared with other classrooms and students, the school, parents and the community. If appropriate, discuss ways that projects may be completed in cross-curricular contexts with other subject area teachers.

Each of the lesson sequences is self-contained and provides the instructional process, activity ideas, Briefing Notes and other handouts. **Therefore, teachers should select those activities in the lesson sequences that they believe will be most effective in supporting their students’ learning in the Grade 10 Science program.**

Briefing Notes

Each of the lesson sequences centres on a topic introduced through Briefing Notes. Each Briefing Notes handout opens with *Predict* questions that emphasize critical thinking and connect to students’ prior knowledge, understandings, attitudes and assumptions.

The Briefing Notes also provide questions, activities and Internet website links that encourage research and the exploration of multiple viewpoints and opinions on issues relating to global systems, such as biomes, and the impact of human activities, such as agriculture, on climate and climate change.

The Briefing Notes format provides an opportunity for students to take on a variety of research roles. Each lesson sequence contributes to research that students gather to explore the critical issue. Students should be encouraged to revisit, discuss and reflect on the critical issue when the lesson sequences have been completed.

At a Glance

The following chart provides an overview of each lesson sequence, inquiry focus, instructional strategies, curriculum connections and assessment focus in this resource.

Lesson Sequence One

Biomes & Global Agriculture

In Lesson Sequence One, students review and reinforce their understandings of the characteristics (net radiant energy, climatic factors and topography) of the major biomes of the world. Students examine climatographs of two biomes – grasslands and boreal forests – that are part of the landscape of western Canada. They analyze why biomes with similar characteristics can exist in different geographical locations and consider how human activities, such as agriculture, can affect biomes.

Inquiry Focus and Key Concepts

What do biomes have to do with human agricultural activities?

- Biome
- Radiant energy
- Steppes
- Taiga
- Climate
- Climatograph

Instructional Strategies

- Map Exploration
- Venn Diagram
- KWHL Chart
- Evidence Analysis

Curriculum Connections

Knowledge

Focusing Question

- Are there relationships between solar energy, global energy transfer processes, climate and biomes?

3. Relate climate to the characteristics of the world's major biomes, and compare biomes in different regions of the world

- Relate the characteristics of two major biomes (*i.e.*, *grassland*, *desert*, *tundra*, *taiga*, *deciduous and rain forest*) to *net radiant energy*, *climatic factors* (*temperature*, *moisture*, *sunlight and wind*) and *topography* (*mountain ranges*, *large bodies of water*)
- Analyze the climatographs of two major biomes (*i.e.*, *grasslands*, *desert*, *tundra*, *taiga*, *deciduous and rain forest*) and explain why biomes with similar characteristics can exist in different geographical locations, latitudes and altitudes

Skills

Initiating and Planning

- Identify science-related issues
- Identify questions to investigate arising from science- and technology-related issues

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Identify new questions and problems that arise from what was learned identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives

Communication and Teamwork

- Work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise

Attitudes

- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (e.g., view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation)
- Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions)

Assessment Focus (I Can... Statements)

- **I can** describe and assess the extent of the relationship between the characteristics of biomes and human activities.
- **I can** analyze the effect of human activities on the characteristics of two biomes.

Students should understand how characteristics of major biomes affect the types of agricultural activities found in each.

Lesson Sequence Two

Climate Patterns & Change

In Lesson Sequence Two, students examine evidence of climate change, including different points of view on causes and effects of changing climatic patterns. Students start to explore connections between climate and human activity and the resulting affects on biomes.

Inquiry Focus and Key Concepts

What evidence suggests that climatic patterns are changing?

- Climate change
- Greenhouse gas
- Greenhouse effect
- Agriculture
- Ecosystems

Instructional Strategies

- Brainstorm Research
- Carousel
- Visual Comparisons

Curriculum Connections

Knowledge

Focusing Question

- What evidence suggests our climate may be changing more rapidly than living species can adapt?

4. Investigate and interpret the role of environmental factors on global energy transfer and climate change

- Investigate and identify human actions affecting biomes that have a potential to change climate (*e.g., emission of greenhouse gases, draining of wetlands, forest fires, deforestation*) and critically examine the evidence that these factors play a role in climate change (*e.g., global warming, rising sea level(s)*)
- Describe and evaluate the role of science in furthering the understanding of climate and climate change through international programs
- Describe the role of technology in measuring, modeling and interpreting climate and climate change (*e.g., computer models, devices to take measurements of greenhouse gases, satellite imaging technology*)

Skills

Initiating and Planning

- Identify science-related issues
- Identify questions to investigate arising from science- and technology-related issues
- Assess and develop appropriate procedures and instruments for collecting relevant data and information

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Identify new questions and problems that arise from what was learned identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives

Communication and Teamwork

- Work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- Make clear and logical arguments to defend a given decision on an issue, based on findings

Assessment Focus (I Can... Statements)

- **I can** identify and assess evidence that shows the extent to which human activities are connected to climate patterns and change.
- use evidence to support positions relating to climate change.

Students build and strengthen understandings of climate change and its consequences and effects.

Attitudes

- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (e.g., *view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation*)
- Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., *choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)
- Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., *recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment*)

Lesson Sequence Three

Climate Change & Agriculture

In Lesson Sequence Three, students explore the impact of climate change on agriculture, and assess the potential effects of agricultural activities on changing climatic patterns. Students use examples from agricultural practices to analyze differing perspectives on climate change.

Inquiry Focus and Key Concepts

What impact does climate change have on agriculture?

- Agriculture
- Global warming
- Climate change
- Biodiesel

Instructional Strategies

- Map Analysis
- Cause and Effect Chart & Jigsaw
- Benefits-Challenges Wheel
- Horseshoe Debate

Curriculum Connections

Knowledge

Focusing Question

- Is human activity causing climate change?
- How can we reduce our impact on the biosphere and on global climate, while still meeting human needs?

4. Investigate and interpret the role of environmental factors on global energy transfer and climate change

- Describe the role of technology in measuring, modeling and interpreting climate and climate change (e.g., *computer models, devices to take measurements of greenhouse gases, satellite imaging technology*)
- Describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., *predicting the direct and indirect impacts on Canada's agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns*)
- Assess, from a variety of perspectives, the risks and benefits of human activity, and its impact on the biosphere and the climate (e.g., *compare the Gaia hypothesis with traditional Aboriginal perspectives on the natural world; identify and analyze various perspectives on reducing the impact of human activity on the global climate*)

Skills (Lesson Sequence Three)

Initiating and Planning

- Identify science-related issues

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Apply given criteria for evaluating evidence and sources of information
- Apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments

Communication and Teamwork

- Assess potential decisions; and recommend the best decision, based on findings
- Make clear and logical arguments to defend a given decision on an issue, based on findings
- Evaluate individual and group processes used in investigating an issue and in assessing alternative decisions

Attitudes

- Work collaboratively in carrying out investigations and in generating and evaluating ideas (*e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)
- Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (*e.g., recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment*)

Assessment Focus (I Can... Statements)

- **I can** describe the relationship between agricultural activities and climate change, including the effect that climate change has on agriculture; and the effect that agriculture has on climate change.
- **I can** assess and discuss the risks and benefits of human activities, such as agriculture, on the world's biomes.

Students should understand the effect that climate change has had on agriculture; and that agricultural activities can also contribute to climate change. Students should appreciate the work that agricultural practitioners and researchers are doing to reduce negative effects on the environment.

ASSESSMENT TOOLS

The assessment criteria statements that follow can be developed into rubrics and applied to many of the products that students develop in the activities in this resource. The criteria statements should be discussed, adapted and developed with students. A template is provided for the creation of customized rubrics.

VISUAL ORGANIZERS

Excellent 4	<ul style="list-style-type: none">• Demonstrates a thorough understanding of the topic, its relationships and related concepts and ideas• Provides descriptive labels and organizers; provides information that reflects the topic• Makes appropriate links• Uses the visual organizer to make connections and draw relationships
Proficient 3	<ul style="list-style-type: none">• Demonstrates an adequate understanding of the topic and concepts• Provides appropriate labels and organizers• Provides information that relates to the topic• Attempts to make links• Uses the visual organizer appropriately for topic and concepts
Acceptable 2	<ul style="list-style-type: none">• Identifies concepts and ideas that relate to the topic• Provides labels and organizers• Includes information that relates to the topic• Uses the format of the visual organizer
Limited 1	<ul style="list-style-type: none">• Provides limited information related to the topic• Uses parts of the visual organizer to present information

GROUP ACTIVITIES

Excellent 4	<ul style="list-style-type: none">• Demonstrates clear understanding of the group task and their individual contribution to the group• Listens to group members• Expresses original opinions and ideas• Contributes meaningful information and research• Works with the group to fulfill group responsibilities
Proficient 3	<ul style="list-style-type: none">• Articulates understanding of the group task and the role they play within the group• Listens to group members• Contributes ideas and information• Fulfills individual responsibilities for the group
Acceptable 2	<ul style="list-style-type: none">• Describes the group task• Describes individual role within the group setting• Listens to group members• Contributes information to group task
Limited 1	<ul style="list-style-type: none">• Describes individual role within the group setting• Listens to others in the group• Contributes limited ideas

RESEARCH

Excellent 4	<ul style="list-style-type: none">• Develops a strategy for conducting research• Develops and identifies research and inquiry questions• Analyzes and assesses sources of information selected for the research task• Records information using an appropriate format• Applies research to inquiry question• Makes effective use of research time
Proficient 3	<ul style="list-style-type: none">• Identifies a strategy for conducting research• Identifies research and inquiry questions• Selects and assesses sources of information• Records information using an appropriate format• Identifies links between research collected and inquiry question• Makes effective use of research time
Acceptable 2	<ul style="list-style-type: none">• Uses a previously identified strategy for conducting research• Records research and inquiry questions• Selects and reads sources of information• Records information using an appropriate format• Uses information from sources to answer inquiry questions
Limited 1	<ul style="list-style-type: none">• Selects and reads sources of information• Records identified research and inquiry questions• Records information using an identified format• Identifies information from sources that relates to inquiry questions

SOURCE ANALYSIS

Excellent 4	<ul style="list-style-type: none"> Identifies key points from the source Identifies and considers biases inherent in points of view reflected by the creator of the source Draws supported conclusions about the relevance and perspectives of information presented in the source Makes comparisons between factual information and opinions Assesses evidence from multiple sources to verify information in the original source Distinguishes between different types of sources and the information each presents
Proficient 3	<ul style="list-style-type: none"> Identifies key points from the source Identifies points of view and the presence of bias in the source Draws supported conclusions about the overall perspectives presented in the source Consults multiple sources of information to compare the information presented in the original source Identifies different sources of information on similar topics Identifies and compares factual information and opinion in the source
Acceptable 2	<ul style="list-style-type: none"> Identifies relevant information from the source Identifies and summarizes the points of view of the creator of the source Relates the perspective of the source to own opinion Identifies other sources of information on similar topics Differentiates between factual information and opinion in the source
Limited 1	<ul style="list-style-type: none"> Lists information drawn directly from the source Identifies the creator of the source and why the source was created

PROJECTS

Excellent 4	<ul style="list-style-type: none"> Develops a project planning strategy and process Identifies goals and purpose of project Demonstrates understanding of topics and concepts represented in the project Selects an appropriate method of constructing and creating project Uses research and information gathered appropriately and effectively in the project Demonstrates ability to summarize and synthesize information within the project Displays learning with pride in final presentation of project
Proficient 3	<ul style="list-style-type: none"> Identifies a project planning strategy and process Identifies purpose of project Selects information relating to topics and concepts under study for the project Selects an appropriate method of constructing and creating the project Uses research and information gathered appropriately and effectively in the project Demonstrates ability to summarize information within the project Displays learning appropriately in final presentation of project
Acceptable 2	<ul style="list-style-type: none"> Uses a previously identified project planning strategy and process Selects information relating to topics and concepts under study for the project Selects a method for constructing and creating the project Uses research and information gathered throughout the project Displays learning adequately in final presentation of project
Limited 1	<ul style="list-style-type: none"> Selects information relating to topics and concepts under study for the project Constructs and creates the project using an identified approach Uses information gathered for the project

RUBRIC

Excellent 4	
Proficient 3	
Acceptable 2	
Limited 1	
No work completed 0	

LESSON SEQUENCE ONE: BIOMES & GLOBAL AGRICULTURE

Overview

In Lesson Sequence One, students review and reinforce their understandings of the characteristics (net radiant energy, climatic factors and topography) of the major biomes of the world. Students examine climatographs of two biomes – grasslands and boreal forests – that are part of the landscape of western Canada. They analyze why biomes with similar characteristics can exist in different geographical locations and consider how human activities, such as agriculture, can affect biomes.

Rationale

Students should understand how characteristics of major biomes affect the types of agricultural activities found in each.

Presenting students with “I can...” statements can help focus their learning and provide a context for assessment with this lesson sequence’s activities.

Inquiry

What do biomes have to do with human agricultural activities?

Key Concepts

Biome **Radiant energy** **Steppes** **Taiga** **Climate** **Climatograph**

Preparation

Suggested Time: 3 to 4 50-minute class periods

This lesson assumes that students have developed understandings of the world’s major biomes. It provides a brief review of the requirements for determining the existence of a biome.

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
 - Briefing Notes 1A: Biomes & Global Agriculture
 - Student Resource 1B: KWHL Chart
- Map of world biomes
- Atlases or Internet sources with world maps
- Internet, library, classroom and textbook resources, with information on biomes and their characteristics
- Internet access and interactive whiteboard to display and share website links

“I CAN”

Lesson Sequence One encourages students to demonstrate their learning by developing understandings such as the following:

- **I can** describe and assess the extent of the relationship between the characteristics of biomes and human activities.
- **I can** analyze the effect of human activities on the characteristics of two biomes.

Lesson Sequence One

Grade 10 Science Curriculum Connections

Inquiry

Biomes & Global Agriculture

What do biomes have to do with human agricultural activities? (Lesson Sequence One)

Knowledge

Focusing Question

- Are there relationships between solar energy, global energy transfer processes, climate and biomes?
- 3. Relate climate to the characteristics of the world's major biomes, and compare biomes in different regions of the world**
- Relate the characteristics of two major biomes (i.e., grassland, desert, tundra, taiga, deciduous and rain forest) to net radiant energy, climatic factors (temperature, moisture, sunlight and wind) and topography (mountain ranges, large bodies of water)
- Analyze the climatographs of two major biomes (i.e., grasslands, desert, tundra, taiga, deciduous and rain forest) and explain why biomes with similar characteristics can exist in different geographical locations, latitudes and altitudes

Skills

Initiating and Planning

- Identify science-related issues
- Identify questions to investigate arising from science- and technology-related issues

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Identify new questions and problems that arise from what was learned identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives

Communication and Teamwork

- Work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise

Attitudes

- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (*e.g., view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation*)
- Work collaboratively in carrying out investigations and in generating and evaluating ideas (*e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)



Lesson Sequence One Teaching and Learning Strategies

What do biomes have to do with human agricultural activities?



Introductory Activity

Students review and revisit the characteristics of world biomes.

Instructional Strategy: Map Exploration

Maps and other visual sources present evidence of global systems and patterns in a visual format and encourage students to look for connections and relationships, draw conclusions and make predictions that can form the basis of research questions.

PROCESS

1. Challenge students to share examples of classification systems that are used to “make sense” of the world by grouping and “clustering” it into areas. (*Students can be prompted with concepts they have learned about in previous grades, including regions, ecosystems and environments.*) Review the concept of biomes.
2. Provide students with a map of world biomes or use one provided in a textbook or classroom resource. Have students work with a partner to brainstorm the characteristics that they think make each biome distinct. Remind them to consider vegetation, landforms and climate.
3. Have the class share what they already know and understand about biomes, using examples from their initial exploration of the maps. Ask them to respond to questions such as:
 - What is a biome?
 - What characteristics are used to identify biomes? Why do you think vegetation is important in classifying areas as biomes?
 - What changes do you think biomes are experiencing?
 - How do you think climate could be a significant influence on the types of human activities you would find in different biomes?



Briefing Notes Activity

Students use the Briefing Notes to explore characteristics of biomes that support agricultural activities and production. They create a Venn diagram to look for relationships between characteristics of biomes and these activities.

Instructional Strategy: Venn Diagram

Reading for meaning and summarizing main points requires students to synthesize information, critically evaluate relationships and make connections to their prior knowledge and understandings. Organizing information by using a visual organizer, such as the Venn diagram used in this activity, asks students to find related ideas and examples, make comparisons and expand their ideas and understandings.



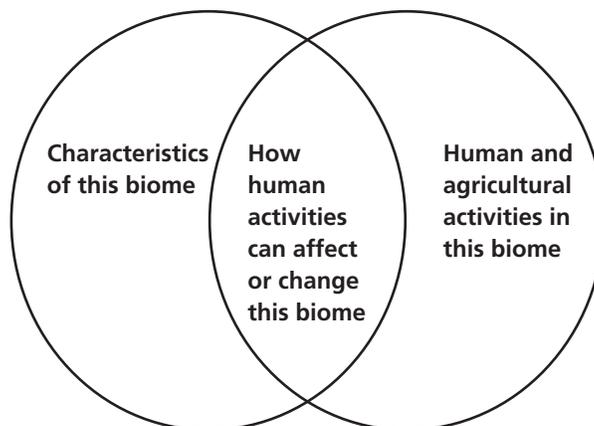
DIFFERENTIATE

Structure the Briefing Notes discussion and questions as a class activity or by organizing students to work with a small group or partner.

If students need additional support with the concept of biomes and their characteristics, create a poster for each biome. Have students contribute examples and descriptions of the biome to each poster. Research and add sketches, illustrations or photographs to provide visual reinforcement of the differences between each biome.

PROCESS

1. Provide each student with a copy of the **Briefing Notes 1A: Biomes & Global Agriculture**. Ask students to discuss or respond in writing to the Predict questions at the beginning of the handout.
2. Have students individually read the Briefing Notes and then, as a class, discuss the characteristics of major global biomes.
3. Continue with the activities in the Briefing Notes to compare two biomes prevalent in western Canada: the grasslands and the boreal forest. Students compare the variety of physical factors that determine the climate of each biome and construct a climatograph of each. Students then compare the climatic factors and forms of life that each biome supports.
4. Have each pair of students combine with another pair to form a small group. Ask each group to consider the impact of human activities, including agriculture, on each biome.
5. Have groups synthesize their research using a Venn diagram. Have each group summarize the characteristics of each biome in one circle and describe human and agricultural activities in each biome in the other circle.
6. Have students use the intersection between the two circles to record ways they think human activities affect or change physical and climatic conditions in each biome.
7. **Extend:** This activity could be extended by having students explore characteristics of different biomes.





Closing Activity

Students complete a KWHL chart that introduces and focuses on the effect of human activities on biomes.

Instructional Strategy: KWHL Chart

Group discussion, analysis and synthesis of information encourage students to draw conclusions and ask questions that lead to further research. Using a visual organizer, such as a KWHL chart, students link their prior knowledge and understandings to ideas for further research.

PROCESS

1. Introduce the critical issue to students by writing the issue question on the board: How should effects of human activities on the environment be balanced with human needs?
2. Have each student complete **Student Resource 1B: KWHL Chart**. Trade the chart with another student and discuss ideas that are similar and different.
3. Have students work in small groups to discuss and record their responses to the question.
4. Ask small groups to share their perspectives, responses and ideas with the whole class.



Extension Activity

Students work with a small group to analyze different classifications of biomes.

Instructional Strategy: Evidence Analysis

Encouraging students to explore different interpretations of scientific investigation and evidence develops critical and analytical thinking skills as well as the ability to consider multiple perspectives in scientific inquiries.

PROCESS

1. Agreement on the names and types of biomes is not universal. Have students use Internet and classroom sources of information to research different interpretations associated with classifications of biomes.
2. Ask them to outline each set of biomes and compare them for characteristics, location and terminology used.
3. Ask students to consider why they think there are different interpretations.

The World's Biomes from the University of California Museum Of Paleontology, at www.ucmp.berkeley.edu/glossary/gloss5/biome/ provides a detailed discussion of the world's biomes and identifies issues associated with human interaction with each biome.

World Biomes: Rationale for Hierarchical Organization of the World's Environments, at <http://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/world-biomes/>, provides an overview of the importance of climate in determining the natural and human environments of the world.

Biomes & Global Agriculture

Predict

Why do you think an understanding of biomes is significant to the decisions people make about activities like agriculture?



DID YOU KNOW?

Canadian farms are found in different regions ranging from the Atlantic, the St. Lawrence valley and Great Lakes, through the prairies and parkland and in the lowlands and coastal valleys of British Columbia. There are four main types of agricultural activity in Canada – grain, livestock, combination grain and livestock and special crops. The type of agricultural activity depends largely on soil type, precipitation and length of the growing season.

Stock Photo of Farm

Global biomes

A **biome** is an area that has similar temperature and precipitation (climate) as well as a similar range of vegetation (flora) and animal life (fauna). Because vegetation is more stable than animal life, the vegetation dictates the types of animals that can exist in a biome. There are six major biomes: grassland, desert, tundra, taiga, temperate deciduous, and rain forest. The same biome type can be found in many different parts of the world.

Taiga or Boreal Forest

The Taiga biome is found where there are shorter, warm summers and long winters. It is the largest of the land biomes and is found in Europe, Asia, Siberia, and North America. Evergreens and other resilient vegetation are typical of this region.

Temperate Deciduous

Temperate deciduous biome is similar to the Taiga biome and is found in areas with a milder, shorter winter season. The vegetation consists of a variety of deciduous trees as well as evergreens. The soil is rich; therefore, this biome features a larger assortment of forest floor plant life.

Rainforest

The rainforest biome is usually found around the equator, where there is little temperature variation (warm temperatures prevail, as there is no winter season). The rainforest is the most ecologically rich of the world's biomes. It has thousands of different species of trees, plants, flowers, mammals, birds, reptiles, amphibians, insects, invertebrates and microorganisms. The best-known part of the rainforest is found in Brazil.



Grasslands

Grasslands include prairies, steppes, and savannas. Prairie biomes are covered in tall grass, with few trees due to insufficient water supply to support the growth of trees to maturity. Most trees that do exist are found on hills. Because of the rich soil, plants grow abundantly, making this biome well suited for farming. The steppe grassland biomes have a dry climate and plant life has to be adaptable as they have access to little moisture. Grass is generally shorter than that found in prairie grasslands. Savannah biomes are found in warm, dry climates characterized by drought. Plants have to survive in this hot and dry climate without water for long periods. One variation of the savannah is found in Africa.

Deserts

There are four types of deserts. Arid deserts are found in North America, South America, Africa, and Southern Asia. These areas are at low altitude and are hot and very dry. The soil is usually either sand or coarse and rocky. Semi-arid deserts have somewhat more moisture and are found in North America, Europe, Russia, and Northern Asia. Other deserts are the coastal deserts found in areas that are moderately warm to cool, and cold deserts, with snow and rain in the winter but poor growing conditions for plants.

EXPLORE

- 1. Summarize the major characteristics of each type of biome in the retrieval chart that follows.**
- 2. Then, analyze the suitability of each biome to agriculture. What type of agricultural activities do you think you would be most likely to find in each? Record your predictions in the last column of the chart.**

Source:

World Biomes:
worldbiomes.com
website. www.worldbiomes.com

Briefing Notes 1A

Major Biome	Where Found	Climate	Vegetation	Agricultural Activities
Boreal forest or Taiga				
Temperate deciduous				
Rainforest				
Grassland				
Desert				
Tundra				

Agricultural activity across Canada

Agricultural activities across Canada are influenced by both climate and soils. The most important factors that affect agricultural production include:

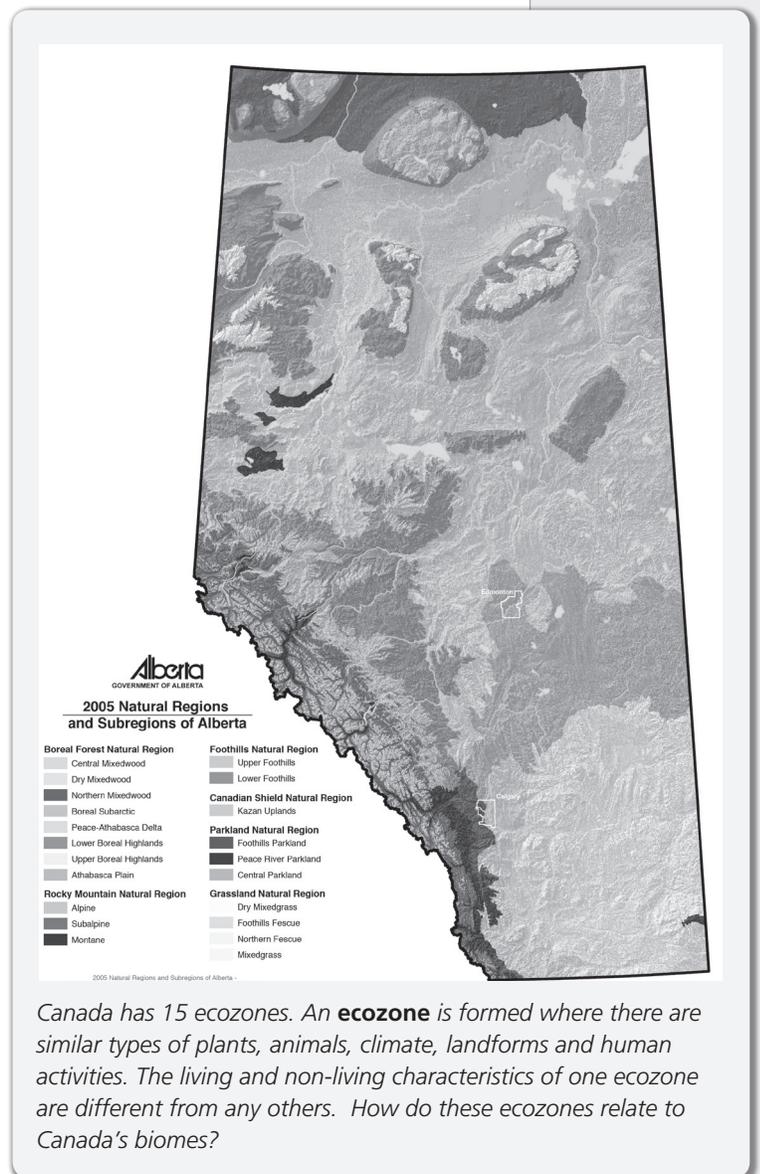
- Temperature
- Soil moisture
- The length of the growing season
- Winter conditions.

Growing seasons are affected by the levels of **radiant energy** received in each biome. As the earth rotates, different areas receive higher or lower levels, resulting in seasons. Growing seasons refer to the number of days when climatic conditions are favourable for plant growth.

Temperature can affect crops such as corn and soybean, as those crops need more heat during the growing season. Growing days affect crops that need a longer growing season, such as spring wheat and potatoes. The length of the winter season can affect crops that require seeding over the winter months, such as winter wheat, clover, and alfalfa. Extreme cold temperatures, combined with low levels of insulating snow cover, also affect these crops negatively, and are referred to as winterkill.

Tree fruits and horticultural crops require mild winter temperatures and longer and warmer growing seasons. Precipitation affects crop production and yields. Too much moisture in the spring can delay planting, decrease growing days and increase the risk of fungal or bacterial disease in seedlings. Too much moisture in the fall can delay harvesting, exposing it to increased risk of frost damage and reducing the overall quality of crops.

What types of crops are grown in different areas of Canada? Canada's climate is greatly influenced by the Pacific and Atlantic oceans, as well as the Great Lakes. These bodies of water provide more temperate areas with high percentages of atmospheric humidity, compared to the rest of Canada that experience generally extreme temperature ranges and relatively low precipitation levels.



Briefing Notes 1A

Only a small area of Canada is suitable for growing fruits and crops such as corn, soybeans and sugar beets. These crops are more dependent on a moderate winter temperature than the length of the growing season.

On the west coast, the climate provides a long growing season that allows for the production of horticultural crops such as fruits and vegetables. The best soils are found in the Fraser Valley and southeastern Vancouver Island. In these areas, horticulture and mixed farming is found. In the interior regions of British Columbia, horticulture and livestock production are the main agricultural activities, due to the greater variation between the seasons. The Peace River region of the Mackenzie Basin supports oilseed and grain production.

The prairies have short hot summers and cold winters. The major crops in these areas are grains and oil seeds.

The St. Lawrence and Great Lakes experience high precipitation and moisture content throughout the year. Fruit and vegetable crops do well in this area. Most of Ontario and Quebec's productive land and agricultural activity is found in the mixed-wood plains ecozone.

The colder climate and less productive soils in the southern boreal shield and Atlantic maritime ecozones limit most agricultural activity to livestock and forage. The Atlantic provinces have more storms than any other region in Canada. This area has short, cool growing seasons and acidic soils. Agriculture in the Atlantic region is mixed with livestock and potato, cereal and hay crop production.

EXPLORE

1. What relationships do you think exist between climate and agricultural production?

2. What types of agricultural activities exist in different biomes in Canada? Compare the information on agricultural activities in different areas of Canada with a map of Canada's biomes. What do you observe?

Case Study One: Temperate Grassland Biome

Climate

Grasslands, sometimes called steppes, have warm to hot summers and cool to very cold winters. The prairie biomes have temperatures that can be very cold and very hot. They are found between forests and deserts temperate biomes. Winds can be strong and snowfall varies from high in the northern parts to very little in the south.

Vegetation

Grassland biomes are dominated by grass. The height of the grasses is dependent on the amount of rainfall. Short to medium grasses are found on the prairie grassland as a result of low levels of precipitation.

Variety of Plants and Animals

The open landscape of grassland biomes results in less variety of plants and animals. There are usually no more than two or three species of large grazing mammals and birds along rivers and in wetlands in the temperate grasslands.

Plants

The natural grasses in this biome provide good groundcover. These grasses are resistant to grazing and fire. Most plants add new leaves at the top; natural grasses grow from the base of the plant, which allows new growth. Some grasses are very wind resistant. Grasses also have the added advantage of being wind pollinated, making them very well adapted to growing in open spaces.

Human Activities

Agriculture is suited to this biome. Grain crops are themselves grasses, and naturally thrive. Grasses can also be grown for grazing, so livestock is also found in grassland biomes.



Photographs and maps of the temperate grassland biome can be found in *Biomes of the World: Temperate Grasslands*, provided by Radford University at https://php.radford.edu/~swoodwar/biomes/?page_id=173.

Agricultural Ecozones in Alberta

In Alberta, a number of ecozones in the grasslands biome have extensive agricultural land uses.

The Aspen Parkland ecozone extends west from the foothills, north of Edmonton and across to Saskatchewan. It covers about 9 percent of the total area in the province. This ecosystem has short warm summers with an average temperature of 15°C, snow cover in the winter and annual precipitation averaging 400 to 500 mm.

Together, grasslands ecozones cover over 14 percent of the total land area of Alberta and can be grouped into three main grassland subregions – mixedgrass, dry mixedgrass and fescue. The mixedgrass subregion has warm summers with an average temperature of 15.5°C, as well as low precipitation, averaging 350 to 400 mm yearly.

Summer and winter temperatures in the dry mixedgrass subregion are higher than other areas of the province. This ecozone experiences precipitation that averages 250 to 350 mm yearly, with high evaporation and transpiration rates.

The fescue subregion experiences Chinook conditions, milder winters and annual precipitation averaging 400 to 450 mm yearly.

Case Study Two: Taiga or Boreal Forest

Climate

This high-latitude biome experiences cool summers and very cold winters, often with heavy snow. It is also found near warmer coastal water, such as in Norway and the Pacific Northwest of North America. Precipitation tends to be even throughout the year.

Vegetation

The **taiga** biome is also known as the boreal forest and is characterized by coniferous trees. The Pacific Northwest has some of the largest trees in the world. At higher elevations, the size of trees decreases as climatic conditions prevent any tree growth.

Variety of Plants and Animals

There is a limited diversity in the trees found throughout much of this biome, with dominant trees being fir, spruce, pine and larch. There is some diversity of both animals and migratory birds.

Plants

Evergreens have needles that are adaptable to the winter climate and remain on the trees.

Human Activities

Much of the human activity that occurs in this biome is dominated by the forestry industry – logging is a major activity and has resulted in decrease in forested areas. The climate in this biome is more extreme and soils do not always support a variety of agricultural activities.



Photographs and maps of the taiga or boreal forest biome can be found in *Biomes of the World: Boreal Forest (Taiga)*, provided by Radford University at https://php.radford.edu/~swoodwar/biomes/?page_id=92.

Agricultural Ecozones in Alberta

In northern Alberta, the boreal transition subregion is located in the southern edge of the boreal forest biome. This region is located to the north of Edmonton and extends east to Saskatchewan. The most extensive land use is arable agriculture. It covers nearly 4 million hectares or about 6 percent of the total area of the province.

The summer temperatures are warm – the mean average is 14°C and precipitation averages about 450 mm yearly. There are a number of small lakes, ponds and sloughs. The main drainage system is the North Saskatchewan River.

A Case in Point: Canola

Agricultural activities across Canada are influenced by both climate and soils. The most important factors that affect agricultural production include:

- Temperature
- Soil moisture
- The length of the growing season
- Winter conditions.

Growing seasons are affected by the levels of **radiant energy** received in each biome. As the earth rotates, different areas receive higher or lower levels, resulting in seasons. Growing seasons refer to the number of days when climatic conditions are favourable for plant growth.

Temperature can affect crops such as corn and soybean, as those crops need more heat during the growing season. Growing days affect crops that need a longer growing season, such as spring wheat and potatoes. The length of the winter season can affect crops that require seeding over the winter months, such as winter wheat, clover, and alfalfa. Extreme cold temperatures, combined with low levels of insulating snow cover, also affect these crops negatively, and are referred to as winterkill.



DID YOU KNOW?

The highest concentration of canola acreage is in the black and grey soil zones of Western Canada.

EXPLORE

Use the information in these Briefing Notes and other sources to compare two biomes in Alberta – the boreal forest and temperate grasslands.

	Grasslands	Boreal Forest
Radiant energy (seasons, growing season)		
Climatic factors (temperature, moisture, sunlight, wind)		
Topography (mountain ranges, large bodies of water)		
Animal and plant life		
Human activities (including agriculture)		

Find Information

Explore these websites to find additional information and research sources.

Find information on biomes at *Biomes of the World* on The Wild Classroom at www.thewildclassroom.com/biomes/index.htm and World Biomes on worldbiomes.com at www.worldbiomes.com/default.htm.

The *Agricultural Land Resource Atlas of Alberta*, found at [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex10300](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10300), contains a number of maps that provide information on agriculture linked to various characteristics of the ecozones in which agricultural activities take place.

The *Agroclimatic Atlas of Alberta: Agricultural Climate Elements*, found at [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/sag6301](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6301), provides information on precipitation, temperature, heat units, frost-free periods, growing season length and wind.

Population Change

Physical conditions, particularly climate, determine the biome of an area. **Climate** is primarily based on the amount of annual rainfall and average seasonal temperatures that a region experiences. To understand why a particular biome exists in a given area, investigation of the influence of its climate factors is essential.

Prince George British Columbia

BIOME: BOREAL FOREST												
Monthly Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (°C)	-8	-3.9	0.9	6.1	11	14.4	16.5	16	11.3	5.7	-1.6	-6.5
Precipitation (mm)	53.4	32.4	25.9	30.3	44.9	62.5	55.7	48.7	50.5	54.5	43.7	51.8

Lethbridge Alberta

BIOME: GRASSLAND												
Monthly Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (°C)	-7.8	-4.1	-0.3	6.1	11.4	15.6	18.2	17.7	12.3	7.2	-1.2	-5.9
Precipitation (mm)	20.1	12.2	27.5	32.5	48.3	53	37.2	47.4	38.3	15.1	14.8	18.6

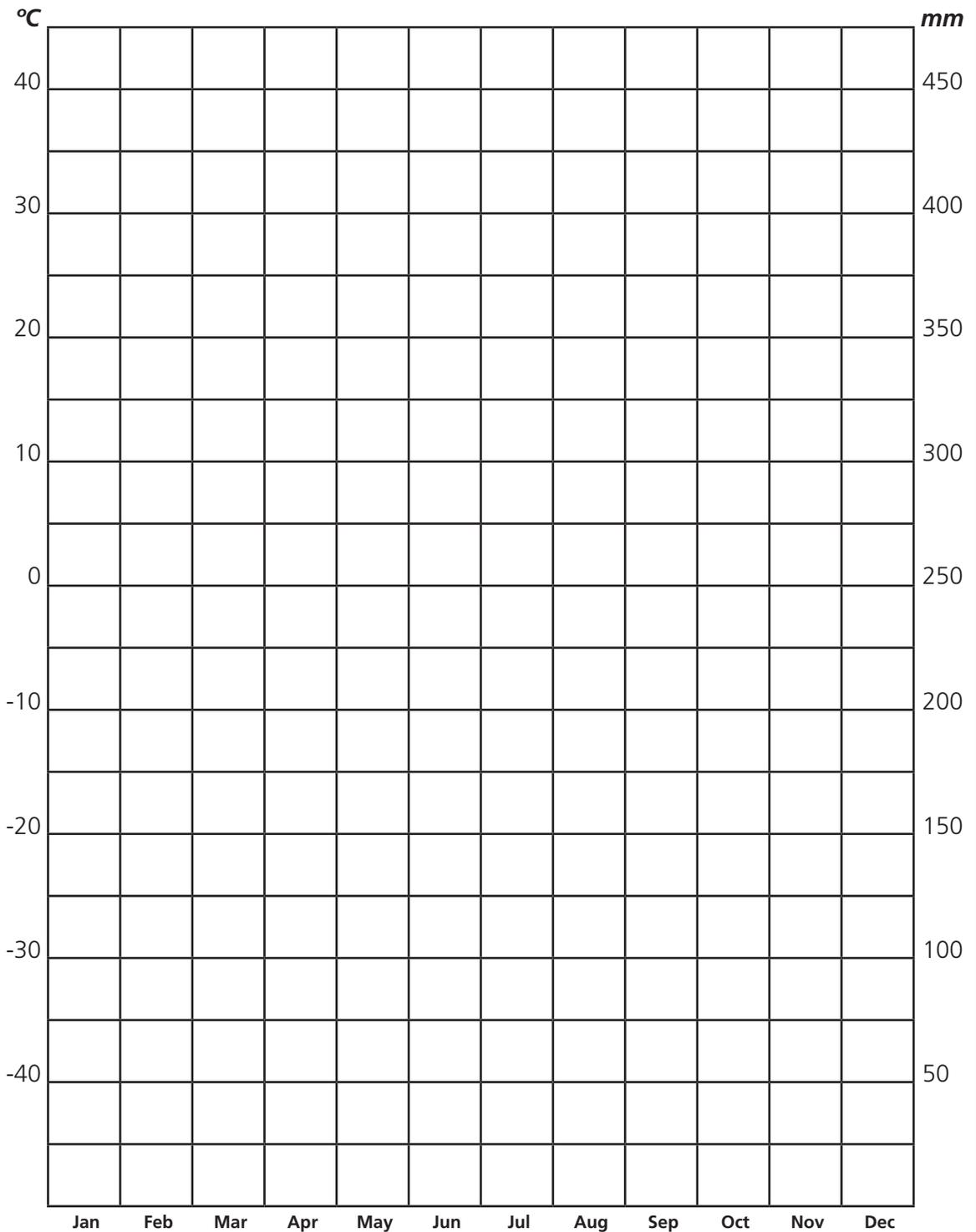
EXPLORE

1. Create a climatograph for each city. What comparisons can you make? Why do you think similarities in climatic patterns exist between these two biomes?

2. What effect do you think the climate of each biome has on agricultural activities?

Climatograph

Station: _____



Annual Average Temperature: _____ °C

Total Annual Precipitation: _____ mm

Annual Range of Temperature: _____ °C

Find Information

Use the search terms, "How to make a climatograph."

Explore these websites to find additional information and research sources.

Environment Canada provides climate data and normals in *National Climate Data and Information Archive* at http://climate.weatheroffice.gc.ca/Welcome_e.html.

Find out more about world climate zones in *World Climate Zones* at www.blueplanetbiomes.org/climate.htm.

Student Resource 1B

What do biomes have to do with human agricultural activities?

Global biomes are classified using characteristics such as climate, topography, vegetation, plant and animal life. Human activity, including agricultural production, is affected by, and can affect, these characteristics.

DEFINING TERMS

Write your definition for each term:

Global systems

Biomes

Climate change

What I Know	What I Want to Know More About	How I Will Find This Out	What I Learned

LESSON SEQUENCE TWO: MANAGING ENVIRONMENTS

Overview

In Lesson Sequence Two, students examine evidence of climate change, including different points of view on causes and effects of changing climatic patterns. Students start to explore connections between climate and human activity and the resulting affects on biomes.

Rationale

Students build and strengthen understandings of climate change and its consequences and effects.

Presenting students with “I can...” statements can help focus their learning and provide a context for assessment with this lesson sequence’s activities.

Inquiry

What evidence suggests that climatic patterns are changing?

Key Concepts

Climate change **Greenhouse gas** **Carbon dioxide**
Methane **Greenhouse effect** **Agriculture** **Ecosystems**
Atmosphere **Hydrosphere** **Cryosphere** **Biosphere**

Preparation

Suggested Time: 3 to 5 50-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
 - Briefing Notes 2A: Changing Climatic Patterns
 - Student Resource 2B: Research Sources Chart
- Map of biomes in Canada
- Population density maps of Canada and the world
- Poster paper
- File folders
- Transparent paper
- Internet, media sources, library, classroom and textbook resources, with information on climate change
- Internet access and interactive whiteboard to display and share website links

“I CAN”

Lesson Sequence Two encourages students to demonstrate their learning by developing understandings such as the following:

- **I can** identify and assess evidence that shows the extent to which human activities are connected to climate patterns and change.
- **I can** use evidence to support positions relating to climate change.

Lesson Sequence Two

Grade 7 Science Curriculum Connections

Inquiry

Climate Patterns & Change

What evidence suggests that climatic patterns are changing? (Lesson Sequence Two)

Knowledge

Focusing Question

- What evidence suggests our climate may be changing more rapidly than living species can adapt?
- 4. Investigate and interpret the role of environmental factors on global energy transfer and climate change
- Investigate and identify human actions affecting biomes that have a potential to change climate (e.g., *emission of greenhouse gases, draining of wetlands, forest fires, deforestation*) and critically examine the evidence that these factors play a role in climate change (e.g., *global warming, rising sea level(s)*)
- Describe and evaluate the role of science in furthering the understanding of climate and climate change through international programs
- Describe the role of technology in measuring, modeling and interpreting climate and climate change (e.g., *computer models, devices to take measurements of greenhouse gases, satellite imaging technology*)

Skills

Initiating and Planning

- Identify science-related issues
- Identify questions to investigate arising from science- and technology-related issues
- Assess and develop appropriate procedures and instruments for collecting relevant data and information

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Identify new questions and problems that arise from what was learned identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives

Communication and Teamwork

- Work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- Make clear and logical arguments to defend a given decision on an issue, based on findings

Attitudes

- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (e.g., *view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation*)
- Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., *choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)
- Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., *recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment*)

Lesson Sequence Two Teaching and Learning Strategies

What evidence suggests that climatic patterns are changing?



Introductory Activity

Students begin by considering the relationship between biomes and population distribution. They brainstorm questions about the impact of human population patterns and climate change on biomes.

Instructional Strategy: Brainstorm

Brainstorming questions provides an opportunity for students to consider what they already know and understand, and what they would like to know more about. This allows students to re-examine prior understandings and revise opinions once they have completed their research.

PROCESS

1. Ask students to discuss the question: What is the relationship between human activities and biomes? Use examples and evidence from students' work in Lesson Sequence One. *(Remind students to consider the effect of climate, landforms, natural vegetation and soil on agricultural activities. Ask them to consider how they think population distribution would be affected by the characteristics of different biomes.)*
2. Organize students to work in small groups. Use a population density map and a map that shows biomes in Canada to identify the population distribution in different biomes in Canada. Each group can be asked to examine the population density in one biome. What patterns are evident in each biome? Have groups contribute their observations in a class discussion.
3. As a class, brainstorm research questions that explore the relationship between population distribution and biomes, and the effects that these populations might have on the biome. *(Students can be prompted to ask questions about correlations between characteristics in biomes and population density. For example, How does population density affect the levels of human activities?)*
4. **Extend:** Have students find and use a population density map of the world to compare population distribution to global biomes. Make comparisons to Canadian population patterns.

A population density map of Canada, based on 2011 Census data, can be accessed on the ArcGIS website at www.arcgis.com/home/item.html?id=694d16de0a70473da12ceba8d14f4f6e.



DIFFERENTIATE

Work as a class to discuss and compare population densities and the characteristics of biomes in one area of Canada. Model and guide students through this comparison.

If students need additional support, identify one characteristic and ask students to examine and compare how population distribution is affected.



Briefing Notes Activity

Students read and discuss the Briefing Notes with a small group. They focus on information and issues associated with climate change, and contribute to a group research task.

Instructional Strategy: File Folder Research

Group research strategies provide the opportunity for students to practice research skills in a group setting. Provide each group with a file folder to hold their research. As students collect and record information, use the file folders to hold research as well as to record group discussion and reflection on the research.

PROCESS

1. Discuss the following questions as a class:
 - How does climate affect where people choose to live?
 - What impact do you think people's activities have on biomes?
 - To what extent do you think higher population density in an area might be related to climatic characteristics and change?
 - How might people living in an area be affected if the climate started to change?
 - What research questions would help you explore this relationship?
2. Provide each student with a copy of the **Briefing Notes 2A: Changing Climatic Patterns**. Ask students to discuss or respond in writing to the Predict questions at the beginning of the handout.
3. Have students work in research groups and provide each group with a file folder and **Student Resource 2B: Research Sources Chart**. Have groups explore the information and respond to the questions in the Briefing Notes.
4. Then, have each group select one of the questions at the end of the Briefing Notes, or select a research question they brainstormed. Provide time for each group to research their question, consulting three different sources and organizing their information on the Research Sources Chart.
5. Each group may also record or cut and paste additional research, excerpts and examples from media sources, and visuals that support perspectives and evidence on climate change directly on the inside and outside covers of their file folders.
6. Have each group discuss and identify one or two current issues that are associated with their research. Students may identify issues such as those connected with the causes of climate change, different opinions and scientific evidence relating to changing climatic patterns, and the sources of evidence.



DIFFERENTIATE

Assign a different question to each research group or select one or two research questions on which the whole class will focus.



Closing Activity

Students share their research evidence with others in the class in a carousel.

Instructional Strategy: Carousel

A carousel allows students to share research and learning with other students or groups in the class. Each group organizes a display of their research results on their group table. Place a comment sheet on each group table. Groups rotate through the displays at timed intervals. One group member can remain with their displays to present group research and ask visiting groups to record questions or comments. Alternatively, groups can stay together and be asked to record their comments or questions on the comment sheet on each table. The carousel strategy encourages students to develop presentation and communication skills in a small group setting instead of in front of the entire class.

PROCESS

1. Have each group share their file folder research with other groups through a carousel sharing strategy.
2. Discuss the effectiveness and processes used to complete the research in a group setting. Ask each group to reflect on the group processes they used to work together.



Extension Activity

Students focus on climate change in a local context by comparing the average climate of an urban area to that of a rural area. They complete climatographs and compare conclusions.

Instructional Strategy: Visual Comparisons

Creating visual overlays to compare data can address different learning needs and encourage students to identify patterns, similarities, and differences.

Environment Canada's National Climate Archive contains numerous statistics related to weather patterns in communities across Canada. Climate data can be accessed by community at www.climate.weatheroffice.gc.ca/climateData/canada_e.html?StationID=5097&Month=10&Day=2&Year=2012&timeframe=2.

Students may need some support in selecting a community and specifying a data range. Data can be displayed as a temperature graph and downloaded and saved.

PROCESS

1. Have each student choose two communities in Canada: one urban and one more rural. A rural community may include the area around a smaller urban centre. Have students use Environment Canada's website to collect data about climatic patterns, temperature and precipitation.
2. Construct a climatograph on each community using sheets of transparent paper, or constructing the graphs digitally. Overlay one climatograph on top of the other. Ask students to make comparisons. What similarities and differences do they notice? What explanations can they develop for these similarities and differences?
3. Pose the following final discussion question to students:
 - Are there differences in the effects that changing climatic patterns can have on urban and rural communities? Why or why not?

Changing Climatic Patterns

Predict

What does climate change mean to you?

What impact do you think climate change has on agriculture?

Global climate change

Most people agree that the earth has become warmer over the last century. Organizations such as the Intergovernmental Panel on Climate Change (IPCC), a group established by the World Meteorological Organization (WMO), and the United Nations Environment Programme (UNEP), have found that the average surface temperature of the earth has increased during the twentieth century by about 0.6°. This may seem like a small change, but what impact can it have?

The average temperatures in biomes and short-term temperatures can fluctuate over a wide range. However, global temperature averages are generally stable. **Climate change** refers to a long-term change in average and extreme weather conditions and is measured by indicators such as temperature, precipitation and wind.

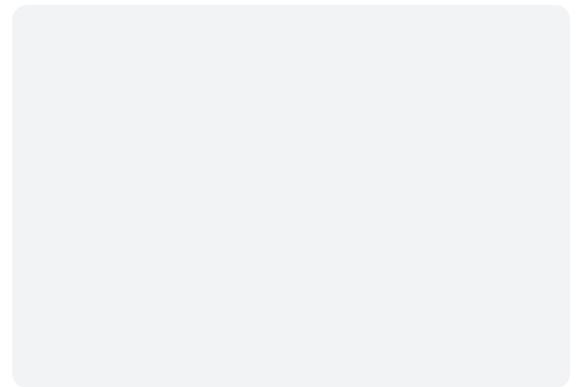
Many agree that human activities have had a significant effect on the earth's atmosphere. The burning of fossil fuels has increased greenhouse gas content in the earth's atmosphere. Greenhouse gases trap heat near the earth's surface. **Carbon dioxide** is one of the most important greenhouse gases, as is methane. **Methane** is a by-product of the process of waste material decomposition.

Canada's Action on Climate Change is an initiative of the federal government that seeks to protect the environment by taking action on climate change. The government describes evidence and effects of climate change.



DID YOU KNOW?

Did you know that the difference between today's average global temperature and the average global temperature during the last Ice Age is only about 50C? The warmest years in the last hundred years have occurred in the last ten years. It is warmer today than it has been at any time over the last thousand years.



There is a very strong body of evidence, based on a wide range of indicators, that climate change is occurring, and the climate system is warming. The evidence includes observed increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level (in response to the addition of water from melting snow and ice and the expansion of water when warmed). Plants and animals are responding to climate change in ways that are consistent with the observed warming with repercussions throughout natural and managed environments.

Source:

Information on Climate Change: Canada's Action on Climate Change.
www.climatechange.gc.ca/default.asp?lang=En&n=F2DB1FBE-1

Although climate change can be caused by both natural processes and human activities, the recent warming has been largely attributed to human activity, primarily the release of carbon dioxide and other greenhouse gases to the atmosphere. These gases enhance the insulating properties of the atmosphere, reducing heat loss, thereby warming the planet. Continued emission of these gases is the primary cause for concern about climate change now and into the immediate future. Particularly important is the emission of carbon dioxide, which is released through the combustion of carbon-based fossil fuels. In Canada, over 80 % of total national greenhouse gas emissions are associated with the production or consumption of fossil fuels for energy purposes.

Climate change and the greenhouse effect

A natural system known as the "**greenhouse effect**" regulates the temperature on earth. Sunlight passes through the earth's atmosphere and heats its surface. Some of this heat is trapped by gases in the atmosphere. The greenhouse effect is a natural effect of the molecular structure of these gases.

Without the greenhouse effect, the earth's average temperature would be somewhere around -18°C . Human activities, including the use of fossil fuels, add to the concentration of greenhouse gases. This traps more heat near the surface and leads to an increase in global temperatures. These warmer climatic patterns have potentially serious effects on the environment.

What is some of the evidence?

- The 1980s and 1990s are the warmest decades on record, with 1998 the warmest
- The 10 warmest years in global meteorological history have all occurred in the past 15 years.
- The 20th century has been the warmest globally in the past 1000 years.

Try this experiment with invisible infrared light and see how it might cause the greenhouse effect on the science.ca website at www.science.ca/scientists/viewactivity.php?aID=21.

EXPLORE

If the climatic patterns change within a biome, what impact would this have on the current vegetation, the animal life that it supports, the bodies of water on which it relies, and the soil resources? Brainstorm your initial ideas in the grid below.

Vegetation	Vegetation
Vegetation	Vegetation

What impact would it have on the human population in this biome?

Use your responses as a starting point to brainstorm additional questions that would help you explore the extent that climate change has on the environment.

The impact of global climate change

Climate affects everything from the plant and animal life of a region, to the heating and cooling requirements of homes and businesses. When climate begins to change, all living things must adapt their lifestyles in order to survive. Global climate change can affect agriculture, ecosystems, forests, sea level, regional weather, human health and human economics.

How could climate change have far-reaching effects?

Agriculture

- As temperature and precipitation patterns change, the length of growing seasons and photosynthesis rates may also change. This can result in decreased variations in crop yield, the types of crops that can be grown in certain areas and the nutritional profile of the crops grown. For example, the canola oil in the seed can vary by as much as 4 percent, depending on climatic conditions. How does this affect its products? If the oil decreases, the amount of protein increases, affecting prices for food processors.
- A major cause of global climate change—increased concentrations of atmospheric carbon dioxide (CO₂)—may actually cause some plants to grow better, as carbon dioxide is a primary input for photosynthesis. However, water is also another primary input. Increased CO₂ demand can ultimately drive up the demand for water. Only if these two inputs can be increased in harmony can the rate of photosynthesis increase. Water vapour is also a product of hydrocarbon combustion—but is there evidence that the amount of precipitation is also increasing at the same rate as CO₂ build-up in the atmosphere?

Ecosystems

- The characteristics of biomes, which are closely related to the temperature and precipitation of a region, can change. For example, some forest regions could warm up, dry out and become deserts. Warmer temperatures in northern latitudes may cause alpine forests to disappear as temperate forests migrate northward into areas that had previously been too cold for them to survive. In turn, alpine forests could migrate into tundra areas for the same reasons.

Sea Level

- Increasing temperatures can result in melting polar ice sheets, which increases the amount of water flowing into the sea and raises the sea level.
- Coastal flooding can result from rising sea levels.

Weather

- A warmer atmosphere, with higher energy levels, can result in more extreme weather conditions and increased numbers of storms.
- Storms and more extreme weather conditions can have economic consequences, resulting in losses for agriculture if they occur at sensitive times within the growing season and affect large agricultural areas.

Spheres

- Climate change has an effect on the "spheres:" the **atmosphere**; the **hydrosphere** (the earth's oceans and water); the **cryosphere** (the areas of the planet covered by snow and ice); and the **biosphere** (the living organisms inhabiting all these domains).

Water Availability

- Higher temperatures and lower precipitation can result in higher demands on ground water for personal, industrial, manufacturing and agricultural uses.

Human Economics

- If temperatures increase and precipitation decreases, crop, livestock and fishery yields may decrease. This can have an effect on people's ability to make a living.
- Lower levels of crop production, manufacturing and food production can also result in increasing prices for consumers.

EXPLORE

With your group members, use Internet, classroom, library and media sources to collect information on one of the questions below.

1. What are the causes of climate change?
2. What patterns provide evidence that supports concerns over climate change?
3. What are the effects of climate change on the environment?
4. What are the effects of climate change on human activities?
5. What evidence suggests a link between human activity and significant climate change?
6. In what ways is technology used to measure and interpret data on climate change?
7. What are the limitations and uncertainties associated with research and data on climate change?

Find Information

Explore these websites to find additional information and research sources.

Maps that show some of the changes that can occur with a doubling of the current levels of carbon dioxide and the sensitivity of landscapes and ecosystems to climate change can be accessed in *Sensitivities to Climate Change in Canada* from Natural Resources Canada at www.nrcan.gc.ca/earth-sciences/climate-change/landscape-ecosystem/419.

Find information on different aspects of global climate change in the *Global Climate Change* research explorer on Exploratorium at www.exploratorium.edu/climate/primer/index.html.

Find out more about *Canada's Action on Climate Change* at www.climatechange.gc.ca.

Read *Inuit Observations on Climate Change* from Community Adaptation and Sustainable Livelihoods at www.iisd.org/casl/projects/inuitobs.htm.

Find out about Climate change and human health from the World Health Organization at www.who.int/globalchange/en/.

Explore the *Climate Hot Map: Global Warming Effects around the World* at www.climatehotmap.org/. Click on the Impacts and Solutions links.

Explore the Sierra Club of Canada's perspective on climate change in *Ten Popular Myths about Global Climate Change* at www.sierraclub.ca/national/programs/atmosphere-energy/climate-change/ten-myths.html.

The Canadian government's report, *Climate Change: We Are at Risk* provides a number of perspectives on climate change for agriculture, forests, water, rural communities and Aboriginal peoples at www.parl.gc.ca/Content/SEN/Committee/372/agri/rep/repfinnov03-e.htm.

Research Sources Chart

Research Question		
Source 1	Source 2	Source 3

LESSON SEQUENCE THREE: NEEDS & INNOVATIONS

Overview

In Lesson Sequence Three, students explore the impact of climate change on agriculture, and assess the potential effects of agricultural activities on changing climatic patterns. Students use examples from agricultural practices to analyze differing perspectives on climate change.

Rationale

Students should understand the effect that climate change has had on agriculture; and that agricultural activities can also contribute to climate change. Students should appreciate the work that agricultural practitioners and researchers are doing to reduce negative effects on the environment.

Presenting students with “I can...” statements can help focus their learning and provide a context for assessment with this lesson sequence’s activities.

Inquiry

What impact does climate change have on agriculture?

Key Concepts

Agriculture

Global warming

Climate change

Biodiesel

Preparation

Suggested Time: 2 to 3 50-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
 - Briefing Notes 3A: Climate Change & Agriculture
 - Student Resource 3B: Cause and Effect Chart
 - Student Resource 3C: Wheel Chart
 - Student Resource 1B: KWHL Chart (from Lesson Sequence One)
- Poster paper
- Agricultural land use maps of Canada and the world
- Internet, library, classroom and textbook resources, with information on climate change and agriculture
- Internet access and interactive whiteboard to display and share website links

“I CAN”

Lesson Sequence Three encourages students to demonstrate their learning by developing understandings such as the following:

- **I can** describe the relationship between agricultural activities and climate change, including the effect that climate change has on agriculture; and the effect that agriculture has on climate change.
- **I can** assess and discuss the risks and benefits of human activities, such as agriculture, on the world’s biomes.

Lesson Sequence Three

Grade 10 Science Curriculum Connections

Inquiry

Climate Change & Agriculture

What impact does climate change have on agriculture? (Lesson Sequence Three)

Knowledge

Focusing Questions

- Is human activity causing climate change?
- How can we reduce our impact on the biosphere and on global climate, while still meeting human needs?

4. Investigate and interpret the role of environmental factors on global energy transfer and climate change

- Describe the role of technology in measuring, modeling and interpreting climate and climate change (e.g., *computer models, devices to take measurements of greenhouse gases, satellite imaging technology*)
- Describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., *predicting the direct and indirect impacts on Canada's agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns*)
- Assess, from a variety of perspectives, the risks and benefits of human activity, and its impact on the biosphere and the climate (e.g., *compare the Gaia hypothesis with traditional Aboriginal perspectives on the natural world; identify and analyze various perspectives on reducing the impact of human activity on the global climate*)

Skills

Initiating and Planning

- Identify science-related issues

Performing and Recording

- Research and synthesize information relevant to a given question, problem or issue
- Identify data and information, from various print and electronic sources, that are relevant to the issue
- Select and integrate information from various print and electronic sources, or from several parts of the same source

Analyzing and Interpreting

- Apply given criteria for evaluating evidence and sources of information
- Apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments

Communication and Teamwork

- Assess potential decisions; and recommend the best decision, based on findings
- Make clear and logical arguments to defend a given decision on an issue, based on findings
- Evaluate individual and group processes used in investigating an issue and in assessing alternative decisions

Attitudes

- Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., *choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions*)
- Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., *recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment*)

Lesson Sequence Three Teaching and Learning Strategies

What impact does climate change have on agriculture?



Introductory Activity

Students consider how agricultural activities are linked to population density in biomes.

Instructional Strategy: Map Analysis

Asking students to draw conclusions and develop generalizations about patterns and recurring ideas develops critical thinking skills. Activities that ask students to analyze data, including that provided on maps, encourages critical thinking.

PROCESS

1. Ask students to review what they have learned about climate change from Lesson Sequence Two. Introduce the inquiry question to students: What impact does climate change have on agriculture? Challenge students to discuss and share their opinions to questions such as:
 - How do you think agricultural activities are affected by increases in temperatures?
 - What agricultural activities do you think are most affected by average temperature changes?
2. Have students work in small groups and use online or print maps that show agricultural land uses in Canada. Have each group compare this agricultural land use to population distribution in biomes.
3. Have each group discuss the following questions:
 - What impact do you think agriculture has on climatic change?
 - What effect do you think climate change has on agricultural land use?
4. **Extend:** Have students find and use a population density map of the world to identify agricultural land use patterns in global biomes and compare activities to population distribution patterns. Make comparisons to Canadian agricultural land use.



DIFFERENTIATE

Students can be challenged to analyze land that is suitable for agriculture using Agriculture and Agri-Food Canada's AgriMap feature at www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1228838087110&lang=eng.

A variety of different maps are available, including a drought watch map with averages for precipitation, temperature and growing degree days as well as agri-environmental indicators and farm area according to the 2006 Census of Agriculture.



Briefing Notes Activity

Students read and discuss the Briefing Notes with a small group. They focus on causes and effects of climate change on agriculture.

Instructional Strategy: Cause and Effect Chart

A visual organizer such as a cause and effect chart is an effective way for students to develop research skills in both collecting and organizing research data, emphasizing relationships, sequence and patterns in data.

Instructional Strategy: Jigsaw

A modified jigsaw cooperative learning strategy is an effective way to encourage collaboration and shared research tasks. In the modified jigsaw, students work with a small group to become an expert in a particular area. They develop a product that describes their findings. Groups are then re-formed, with one member from each expert group joining members from other groups to share their expertise. This can be done by numbering each expert group member and grouping the 1's, 2's, 3's, 4's, etc. to form new groups and share their findings.

PROCESS

1. Provide each student with **Briefing Notes 3A: Climate Change and Agriculture**. Ask students to discuss or respond in writing to the Predict questions at the beginning of the handout.
2. Have students work with a small group to research one of the environmental factors identified in the Briefing Notes. Provide students with **Student Resource 3B: Cause and Effect Chart** to help them organize their research and analyze connections between climate change and agriculture. Each group member should have a copy of this visual organizer.
3. Have group members form new groups to share and compare their research findings.



DIFFERENTIATE

Students can be provided with the option of using a different visual organizer, such as a mind map, to organize and present their research synthesis.



Closing Activity

Students use a benefits-challenges wheel to analyze how the same agricultural practice can have both positive and negative consequences.

Instructional Strategy: Benefits-Challenges Wheel

A benefits-challenges wheel can encourage students to consider intended and unintended consequences and effects of human activities. Students describe beneficial or positive effects of a human activity or action in every alternate section of the wheel. They then describe challenges or negative effects that the activity or action can have in the opposite section of the wheel.

PROCESS

1. Have students continue to work with their research groups to brainstorm examples of common agricultural practices. Provide them with **Student Resource 3C: Wheel Chart** and have them identify and describe one practice in the center of the chart.
2. Use the chart to record data, evidence and/or examples of two beneficial or positive effects and two challenges that result from this practice. *(For example, crop rotation enhances the nutrient content of soils and prevents soil erosion. It also produces more methane gas as a result of decomposition.)*
3. Ask the class to share their examples and discuss the issue of balance between activities that protect the environment and those that meet economic and social needs.
4. Have students revisit the KWHL chart they completed in Lesson Sequence One. Ask them to fill in the last column and share observations about their learning with a partner or small group.



DIFFERENTIATE

Students can be provided with a list of agricultural practices such as the following:

Crop rotation

Tilling

Fertilizer or pesticide use

Shelterbelts or wind breaks

Monoculture (growing one crop)

Use of fueled farm equipment

Irrigation



Extension Activity

Students develop position statements for use in a horseshoe debate.

Instructional Strategy: Horseshoe Debate

A horseshoe debate is an informal debating strategy that encourages students to research multiple positions and perspectives, analyze evidence and present opinions. In a horseshoe debate, desks can be arranged in an open semi-circle or horseshoe shape. Students on one half of the semi-circle are assigned the task of presenting a prepared statement and supporting evidence for one side of the issue. Students in the other half take the opposite position. Students take turns presenting the position and a brief summary of the evidence. Once students share their positions and evidence, the floor is opened for questions and challenges. Students can be assessed on both their research and presentation, as well as on their participation in the question and challenge component of the debate.

There are different options for structuring the debate process. Students can be asked to select the side they will present and defend and sit on that side of the semi-circle. Or, students can be asked to research and support multiple perspectives on an issue, and be assigned one perspective on the day of the debate.

PROCESS

1. Present the following issue to students: *Should significant changes be made in agricultural activities to reduce the negative effects of climate change?*
2. Have students work with a partner and use their research and conclusions to explore this issue question and identify different positions. Ask pairs to collect and organize evidence that supports these positions.
3. Have each pair prepare a position statement and evidence that supports both sides of the issue question.

Climate Change & Agriculture

Predict

How do you think climate change most affects agriculture?

What impact do you think agriculture has on climate change?

Human activity and climate change

A considerable amount of research has been conducted in Canada on the connection between climate change and agricultural activities. Agriculture depends on specific climatic conditions. Farmers need the right balance of sun, rain and temperature to get the maximum yield from their crops. Therefore, climate change can result in challenges that make it more difficult to grow crops.

There are a number of considerations when assessing the extent of climate change and the effects it can have on agricultural activities. Some of these considerations are described below:

- The earth's climate has always gone through changes. However, the current rate of change is faster than in other time periods.
- Carbon dioxide is an important greenhouse gas and is the fundamental building block of plant growth.
- Greenhouse gases occur naturally in the atmosphere. The greenhouse effect is what keeps the earth warm enough to be habitable.
- Warmer temperatures may make many crops grow faster and extend growing seasons, but may also reduce the crop yield.
- Changes in vegetation can have an effect on wind speed.
- Understanding the major greenhouse gases is necessary to identify the current trends in atmospheric concentrations and climate change.
- Living organisms in any ecosystem affect the atmosphere. People use and manipulate their surroundings and, therefore, have a significant impact on environmental conditions.

Is human activity responsible for the negative effects of climate change? Not everyone agrees. The climatic system is complex and strongly influenced by many factors other than greenhouse gas concentrations. This makes it difficult to link specific climatic events or characteristics to a single cause.



DID YOU KNOW?



Biodiesel is an alternative fuel for diesel engines that is made from vegetable oil or animal fats. Canola oil is used to produce biodiesel as it has a low saturated fat content, which makes it suitable for use in Canadian winters. Biodiesel reduces emissions of carbon monoxide and carbon dioxide. It is also a renewable energy source.

As a result, there are differing views regarding the extent and risks of global warming trends. Some believe that people and governments should make the effort to slow or reverse the build-up of carbon dioxide in order to slow global warming. Others believe that higher carbon dioxide levels are part of natural, long-term climatic cycles and that efforts to reduce carbon dioxide emissions may be unnecessary and have negative effects on economic growth.

Connections between agriculture and climate change

Scientists continue to learn how climate change can affect agricultural production. Many factors can have an impact on both precipitation and temperature levels. These factors include increased atmospheric carbon dioxide concentrations as well as enhanced UV-B intensity, acid rain and increased ground-level ozone. All of these factors may affect the growing time, crop yields and the introduction of different weeds and pests.

Water shortages or droughts may also result in changes to agricultural practices. As agricultural production increases, more water is needed for both industry and agriculture. Declines in glaciers that supply water to rivers, dwindling snow packs and higher precipitation evaporation may also affect the water available for these human activities.

Benefits or challenges?

There continues to be a debate on whether climate change may result in benefits or additional challenges for agricultural producers. The evidence on climate change suggests that climate change will result in average increases in temperature that can range from about 1.40C to 2.70C and average increases in precipitation from 2.6 to 7.6 percent over the next 20 years.

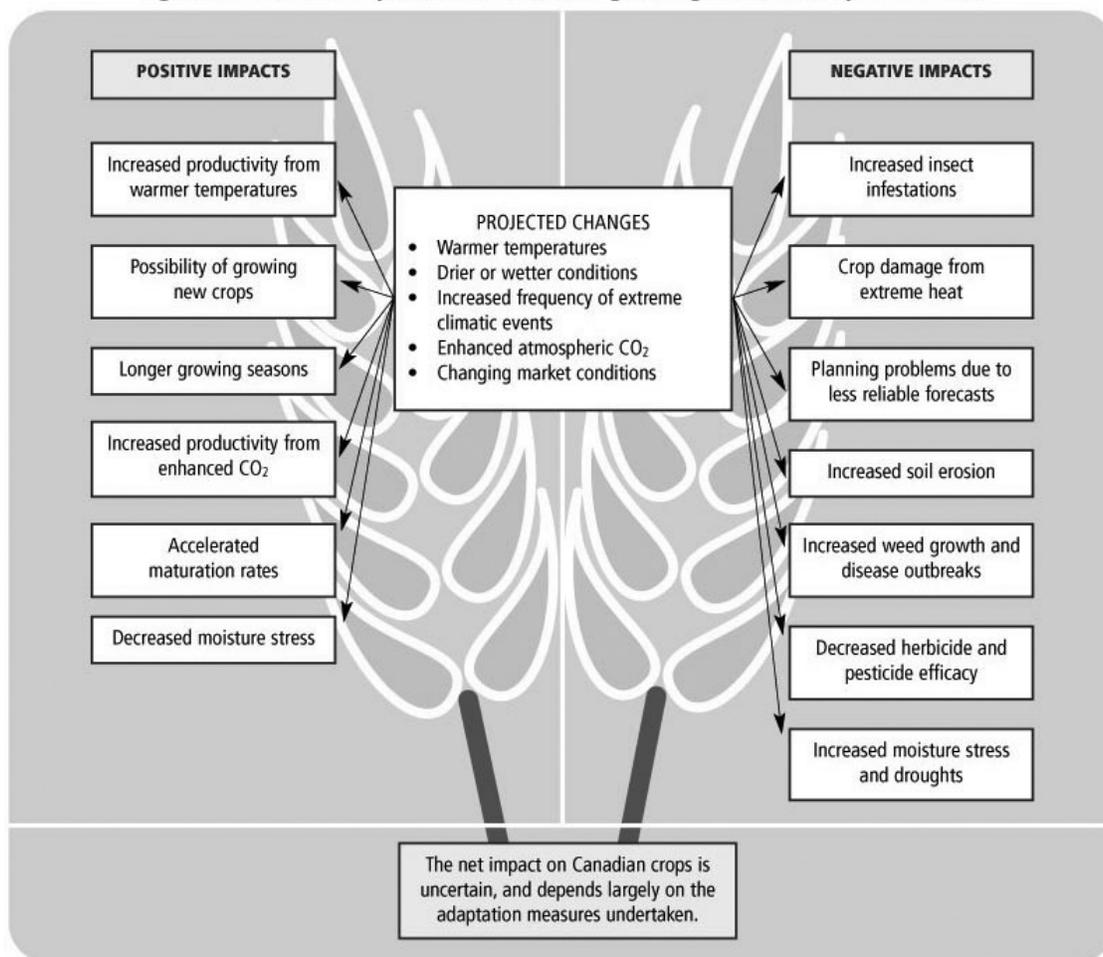
Temperature increases are expected to be more extreme in the northern areas, because of the faster melting rate of the polar ice cap. This occurs not just from the top due to warmer air around it, but also from below as surrounding ocean waters become warmer. Ultimately, heat from the gradually warming oceans will transfer into the atmosphere as well. The resulting rising sea levels can affect populated coastal areas. As average air temperatures increase, precipitation in inland areas may decrease. All of these factors may cause challenges on the availability of water and soil moisture levels.

Will climatic changes result in benefits or challenges for agricultural producers? The reduction of frost risk and the potentially longer growing season, as well as the potential for decreases in the time it takes crops to mature, will benefit the north more than the south, where current shorter crop maturation times reduce the yields presently experienced in these locations. In areas like Ontario and Quebec, climate changes may result in new opportunities to grow different crops, like corn, more effectively. Crops such as corn, soybeans and fruit may benefit from longer growing seasons. However, grain yields are more likely to decrease in grain producing areas in these provinces due to the increased potential for drought-like conditions, harsher storms, and an increased likelihood of pest infestations.

Many believe that wheat production in the prairies will be positively affected by climate change. Warmer, frost-free seasons can speed up the development of grain crops and reduce the time that is needed between seeding and harvest. Fertilizers may be more effective because of increased levels of carbon dioxide.

However, increases in crop moisture stress due to drought, combined with faster maturation rates, will affect crop yields negatively. There is increased potential for severe weather patterns, which can destroy large areas of crops very quickly. While crops like wheat, barley and canola may be negatively affected by climate change, other crops such as corn, sunflowers and soybeans may take their place, as they are more suitable for warmer growing conditions. However, these substitutions may also be limited by the availability of water and irrigation.

Figure 1: Potential impacts of climate change on agricultural crops in Canada



Source:

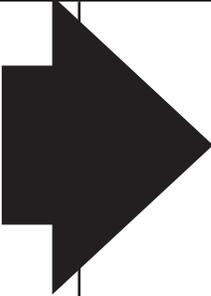
"Impacts on Agriculture." Climate Change Impacts and Adaptation: A Canadian Perspective: Natural Resources Canada. www.nrcan.gc.ca/earth-sciences/products-services/publications/climate-change/climate-change-impacts-adaptation/356#toc

EXPLORE

With your group, select one of the following environmental factors:

- Extreme weather events – droughts, floods
- Water supply
- Pests – insects and weeds
- Changing seasonal weather patterns – growing season, winter temperatures
- Greenhouse gas emissions
- Wind

Research how your factor is affected by climate change and how it relates to, and affects, agricultural activities. Consult extra sources of information and organize your research in a cause and effect chart, using the format below.

What causes changes to this factor	How changes in this factor affect agricultural activities
	

Find Information

Read the evidence and examples presented in *Impacts on Agriculture* from Natural Resources Canada at www.nrcan.gc.ca/earth-sciences/products-services/publications/climate-change/climate-change-impacts-adaptation/818.

Climate Change in Alberta, provided by Alberta Agriculture and Rural Development at [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/c19706/\\$FILE/ccamarch2007.pdf](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/c19706/$FILE/ccamarch2007.pdf), identifies some evidence of the potential opportunities and risks for agriculture as a result of climate change.

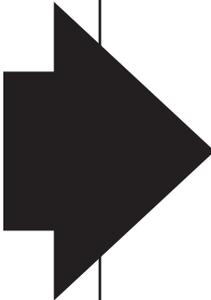
Causes and effects of greenhouse gases on agriculture can be found in *Climate Change and Agriculture*, provided by Alberta Agriculture and Rural Development at [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/c19706](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/c19706).

Explore *Climate Change: Questions and Answers* from Agriculture and Agri-Food Canada at www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1188220105158&lang=eng for more information about the causes and effects of climate change on agriculture.

Check *Future Outlook* and the links on this page for information on climate change and Canadian Agriculture, provided by Agriculture and Agri-Food Canada at www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1329321981630&lang=eng.

Cause and Effect Chart

What causes changes to this factor	How changes in this factor affect agricultural activities



Wheel Chart

