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Overview

This teachers guide is designed to accompany the Natural Resources Canada report called Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (2014), available at www.nrcan.gc.ca/environment (Climate Change > Impacts and Adaptations). This report addresses current sensitivities to climate, as well as the risks and opportunities that climate change presents. The report also discusses adaptation options, approaches, and planning. It aims to inform the public and decision-makers about the importance of employing both adaptation and mitigation measures to significantly reduce the risks and magnitude of climate change.

By participating in activities like the ones in this module, students will develop a better understanding of the factors that contribute to climate change and of the effects of climate change on biodiversity and the living world. They will also explore the notion of adapting to climate change — both its existing effects and expected ones — to help maintain a healthy and balanced environment.

The activities in this module aim to develop a variety of 21st-century skills such as critical thinking, creativity, collaboration, and communication. Teachers can present the activities as a module or individually.

Teacher Backgrunder¹

Climate Change: A Definition

What is climate change?

The term climate change refers to significant changes in average weather patterns (i.e., precipitation, temperature, wind, and other indicators) that persist within a climate system, caused directly or indirectly by human activity.² Climate change can involve both changes in average conditions and changes in variability, including extreme events. While there has always been variation in the Earth’s climate, there is consensus in the scientific community that since the Industrial Revolution, human activity has increased the amount of greenhouse gases being released into the atmosphere; and that this is leading to a statistically significant increase in the Earth’s temperature — hence the expression “global warming.” Climate change is happening now.

It is this human-induced enhancement of the greenhouse effect that is of concern. Ongoing emissions of greenhouse gases have the potential to warm the planet to levels that have never been experienced in the history of human civilization.

Environment and Climate Change Canada www.climatechange.gc.ca/default.asp?lang=En&n=65CD73F4-1

¹ Most of the information contained in this section, unless otherwise noted, is taken from the report Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, F.J. Warren and D.S Lemmen, editors (2104); Government of Canada, Ottawa, ON. www.nrcan.gc.ca/environment

² The Intergovernmental Panel on Climate Change uses the term “climate variability” for changes in weather patterns due to natural causes, and reserves “climate change” for shifts due to direct or indirect human activity.
How does climate change affect us?

Researchers agree that we are seeing the impacts of climate change in Canada in various areas, including the following.

- **Natural resources development (forestry, energy, mining):** Climate change exacerbates climate extremes (e.g., extreme heat, cold, precipitation) and the resulting impacts and hazards. It also leads to gradual changes, such as permafrost degradation, sea level rise, and plant species migration — all of which affect the forestry, energy, and mining sectors. Climate change will also present new opportunities for the natural resource sectors, particularly in relation to northern economic development.

- **Industry:** Industrial activity is sensitive to variations in weather and to extreme events. The type of impacts and their extent depend on the industry, but production, operations, and revenue among and within sectors can be affected.

- **Human health:** Climate-sensitive diseases and disease vectors are moving northward into Canada (e.g., Lyme disease) and will likely continue to expand their range. In addition, new research suggests climate change will exacerbate health issues related to air pollution in some parts of Canada.

- **Water resources and infrastructure:** Well-maintained infrastructure is more resilient to a changing climate. This is especially true with respect to gradual changes in temperature and precipitation patterns. But there are key vulnerabilities associated with extreme weather events, which can overwhelm the capacity of water infrastructure.

- **Food production:** The impacts of climate change differ significantly between agriculture, fisheries, and non-commercial food supply, but common effects include increased losses from invasive pests and diseases, and risks to the transportation systems these sectors rely on.

- **Biodiversity:** Climate-related shifts in species distributions have already been documented for plants and animals in Canada. In many areas, shifts in species range are likely to result in novel ecosystems that have different species combinations, structural attributes, and ecological functions than existing ones.

**Biodiversity**

Biodiversity refers to the variety of species and ecosystems on Earth and the ecological processes which they are a part of. Biodiversity is the natural capital on which Canadians base most of their social and economic well-being. It plays a role in the purification of air and water, in climate regulation, in carbon capture and storage, in pollination, and in flood regulation. Humans take advantage of biodiversity directly and indirectly, for example, as a source of food and fibre, as a material resource for clothing manufacture, in forest products, and to facilitate recreational activities.
Climate Change Effects on Biodiversity

Climate is a key driver of ecosystem composition, structure, and function. It also interacts with other factors that influence biodiversity, such as pollution and land use change. Key conclusions related to biodiversity arising from ecological studies\(^3\) include the following.

1. Climatically suitable ranges (or climate envelopes) for many species will likely shift northwards in response to warming temperatures. This will have major implications for people who rely on the current structure of ecosystem types.
2. Biodiversity may also be affected when species shifts are limited by physical conditions (barriers to movement) and biological processes (reduced access to food at critical times in the life cycle, such as breeding and rearing periods). Resulting changes in species composition can have varying consequences, such as disruptions in predator-prey and host-parasite relationships.
3. Although forest productivity could increase with higher atmospheric carbon dioxide concentrations and longer growing seasons, increases in the frequency and intensity of fires, insect outbreaks, drought, and icing events could offset potential gains. In addition, climate change impacts interact with other human-induced and natural stresses, including habitat loss and fragmentation, pollution, overharvesting, forest fire, and invasive species. The cumulative effects of these stresses could threaten many species.
4. Increased moisture stress in prairie ecosystems will likely decrease productivity in natural grasslands, although longer growing seasons and reduced competition from shrubs and trees (because of drier conditions) may partly offset the effects of reduced moisture.
5. Coastal and estuary ecosystems are at risk from increased erosion and “coastal squeeze,” which could eliminate habitat for some species.
6. Climate change impacts on water quantity and quality are a concern for lakes and rivers across Canada. Higher temperatures are affecting the thermal habitat of many fish species, increasing potential habitat for invasive species and creating favourable conditions for unwanted algal blooms.
7. Climate change impacts on species distribution, abundance, physiology, and life cycle timing will alter interspecific relationships and habitats. The earlier onset of spring is changing the timing of growth and reproduction of many plant species that provide food and habitat for a variety of species. For example, the blossoming date of Trembling Aspen in Alberta has advanced by 26 days in the past 100 years. Such timing shifts can cause decoupling of species that have co-evolved.
8. Given that several pests and pathogens are currently limited by winter temperatures, the range and severity of diseases and pest outbreaks are likely to increase as winter temperatures rise. In addition, the harassment of insects can affect summer grazing, which will have physical consequences on animals.

\(^3\) As outlined in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (Warren and Lemmen, 2014) and From Impacts to Adaptation: Canada in a Changing Climate (Lemmen et al., 2008).
Adaptation and Mitigation Measures

A changing climate presents both risks and opportunities for Canada’s regions and resource sectors. In this vast country with its diverse climate and economy, addressing climate change requires targeted and collaborative action that reduces greenhouse gas emissions (mitigation) and helps us adapt to climate impacts (adaptation).

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptation involves modifying our decisions, activities, and ways of thinking to adjust to a changing climate. Here are some examples of adaptation measures in support of ecosystem resilience:</td>
<td>Mitigation aims to reduce the causes of climate change. It is designed to reduce greenhouse gas emissions at the source or to support “sinks” that absorb or eliminate greenhouse gases. Here are some examples of mitigation measures that deal with forests:</td>
</tr>
<tr>
<td>• Protecting intact ecosystems and the diversity of species and processes that are part of them</td>
<td>• Limiting deforestation and reducing greenhouse gases connected with forestry development</td>
</tr>
<tr>
<td>• Connecting protected areas through sustainably managed landscapes and waterscapes</td>
<td>• Creating new forests, as well as improving energy efficiency in all economic sectors to reduce our dependence on fossil fuel consumption</td>
</tr>
<tr>
<td>• Restoring degraded ecosystems, and supporting species recovery</td>
<td></td>
</tr>
<tr>
<td>• Maintaining or restoring natural disturbance regimes to reflect the natural range of variability characteristic for a particular ecosystem</td>
<td></td>
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<tr>
<td>• Including conservation measures that protect and manage range limits</td>
<td></td>
</tr>
<tr>
<td>• Considering active management approaches, such as assisted migration, where appropriate</td>
<td></td>
</tr>
</tbody>
</table>

There can be co-benefits, or synergies, between these two responses to climate change: in some cases, actions taken to adapt also serve to reduce greenhouse gas emissions, or mitigation actions also reduce vulnerability to climate change (see Figure 1). For example, green roofs — where vegetation is planted on the roofs of buildings — have adaptive benefits (e.g., moderated stormwater runoff, reduced urban-heat-island effect, and improved air quality) as well as mitigative value (e.g., reduced energy consumption, reduced greenhouse gas emissions, and increased carbon dioxide absorption). However, there is also the potential for conflict between adaptation and mitigation, where adaptation choices can increase greenhouse gas emissions. Using air conditioners to deal with higher temperatures, for example, means increased energy use and related emissions.
Climate change is happening now, which is why government, industry, and social enterprises around the world are actively engaged in developing adaptive strategies to reduce the negative impacts to society and the environment.
Glossary and Key Vocabulary

Adaptation measure: Any action that reduces the negative impacts of climate change or allows us to take advantage of new opportunities resulting from climate change.

Biodiversity: The variety of species and ecosystems and the relationships between them.

Climate change: A significant change in the Earth’s climate. The Earth is currently getting warmer because people are adding heat-trapping greenhouse gases to the atmosphere. The term “global warming” refers to warmer temperatures, while “climate change” refers to the broader set of changes that go along with warmer temperatures, including changes in weather patterns, the oceans, ice and snow, and ecosystems around the world. (epa.gov)

Crop management and planning: Planning and managing agricultural crops in order to optimize the use of soil nutrients.

Crop rotation: An agricultural term describing the rotation of plant crop locations to promote soil regeneration.

Ecological (or ecosystem) services: The variety of resources and processes that are supplied by ecosystems and benefit human societies. These include products like clean drinking water and processes such as the decomposition of wastes.

Ecosystems: Community of living organisms (plants, animals and microbes) that interact with the physical components of their environment (air, water, soil).

GHG sinks: Mechanism which is natural (e.g. photosynthesis) or man-made (e.g. underground carbon capture and storage) and which absorb atmospheric GHG (usually carbon or methane).

Greenhouse gas emissions (GHG): Gases that allow the Sun’s rays to reach the Earth, but which absorb the infrared radiation reflected back by the surface of the Earth. They trap a portion of the solar energy, which reheats the planet’s surface sufficiently to maintain life. The accumulation of greenhouse gas emissions due to human activity amplifies the natural “greenhouse effect” and is the main contributor to global warming. (NRCan)

Issues: Things that can be gained or lost in terms of money (economic), society (social), laws (political), or the environment (environmental).

Mitigation measure: Action designed to reduce greenhouse gas (GHG) emissions in the atmosphere or to support GHG sinks.

Pest: Organism that causes significant damage to vegetation. (NRCan)

Phenology: The study of plant and animal life cycles and how these are affected by variations in environmental factors.

Pollination: The action of transporting pollen in order to fertilize plants.

Vegetable garden: Plant, vegetable and fruit crops grown for culinary use.

Definitions by “NRCan” were taken or adapted from the Glossary of Natural Resources Canada, found at https://cfs.nrcan.gc.ca/terms
Suggested Resources

Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation
F.J. Warren and D.S. Lemmen, editors (2014); Government of Canada, Ottawa, ON
http://www.nrcan.gc.ca/environment

Canada’s Marine Coasts in a Changing Climate
D.S. Lemmen, F.J. Warren, T.S. James, and C.S.L. Mercer Clarke, editors (2016); Government of Canada, Ottawa, ON
http://www.nrcan.gc.ca/environment

Climate Change: What Is Happening and How Do We Know?
Katherine Hayhoe (Nov. 12, 2016); Presentation at the Science Teachers Association of Ontario conference (start at 4:00 minutes)
http://youtu.be/-9LKaPWmaMc?t=246

Les changements climatiques: l’état des lieux
Radio-Canada television (in French)

Natural Resources Canada glossary
https://cfs.nrcan.gc.ca/terms

Adapting to climate change
Quebec Centre for Biodiversity Science website
http://qcbs.ca/research/research-contracts/adapting-to-cc/

Adaptation and Mitigation Options
Intergovernmental Panel on Climate Change – See most recent Synthesis Report (indicators, impacts, adaptation and mitigation)
https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

Climate change
Natural Resources Canada website, Forest Topics (effects, impacts, mitigation, and adaptation)
http://www.nrcan.gc.ca/forests/climate-change/13083

Adaptation Library: Resources for Climate Adaptation
http://www.adaptationlibrary.com

Impacts and Adaptation
Natural Resources Canada website, Climate Change
http://www.nrcan.gc.ca/environment/impacts-adaptation

Forest pest management
Natural Resources Canada website, Forest topics (includes videos)
**Strategic Planning by Province**

<table>
<thead>
<tr>
<th>Province</th>
<th>Planning Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>Climate Leadership Plan <a href="http://www.alberta.ca/climate-change.aspx">www.alberta.ca/climate-change.aspx</a></td>
</tr>
<tr>
<td>BC</td>
<td>Climate Leadership Plan <a href="http://climate.gov.bc.ca/">climate.gov.bc.ca/</a></td>
</tr>
<tr>
<td>MB</td>
<td>Climate Change and Air Quality <a href="http://www.gov.mb.ca/sd/climate/">www.gov.mb.ca/sd/climate/</a> (English only)</td>
</tr>
<tr>
<td>NS</td>
<td>Climate Change Nova Scotia <a href="http://climatechange.novascotia.ca/">climatechange.novascotia.ca/</a> (English only)</td>
</tr>
<tr>
<td>NB</td>
<td>New Brunswick: Climate Change <a href="http://www2.gnb.ca/content/gnb/fr/ministeres/egl/environnement/content/changements_climatiques.html">www2.gnb.ca/content/gnb/fr/ministeres/egl/environnement/content/changements_climatiques.html</a></td>
</tr>
<tr>
<td>NV</td>
<td>Climate Change Centre <a href="http://www.climatechangununavut.ca/">www.climatechangununavut.ca/</a> (English only)</td>
</tr>
<tr>
<td>ON</td>
<td>Climate change <a href="http://www.ontario.ca/page/climate-change">www.ontario.ca/page/climate-change</a></td>
</tr>
<tr>
<td>NFL</td>
<td>Climate Change <a href="http://www.ecc.gov.nl.ca/climate_change">www.ecc.gov.nl.ca/climate_change</a> (English only)</td>
</tr>
</tbody>
</table>
## Learning Outcomes in Geography and Science

<table>
<thead>
<tr>
<th>Physical Systems</th>
<th>Explain environmental phenomena using physical processes.</th>
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</thead>
<tbody>
<tr>
<td>Physical Systems</td>
<td>Explain ecosystem distribution, from a local scale to a global scale.</td>
</tr>
<tr>
<td>Physical Systems</td>
<td>Explain ecosystem functions and dynamics as they relate to precipitation and the water cycle.</td>
</tr>
<tr>
<td>Physical Systems</td>
<td>Predict the consequences of natural disasters on the Earth.</td>
</tr>
<tr>
<td>Places and Regions</td>
<td>Analyze physical and human characteristics of places.</td>
</tr>
<tr>
<td>Places and Regions</td>
<td>Explain how regions change in space and time.</td>
</tr>
<tr>
<td>Environment and society</td>
<td>Analyze the environmental consequences of changes brought about by humans to their physical environment.</td>
</tr>
<tr>
<td>Environment and society</td>
<td>Describe how humans prepare for natural disasters.</td>
</tr>
<tr>
<td>Environment and society</td>
<td>Identify and explain the consequences of changes brought about by humans in one region on the physical environment of another region.</td>
</tr>
<tr>
<td>Human Systems</td>
<td>Analyze and evaluate the issues involved in the spatial distribution of economic activities.</td>
</tr>
</tbody>
</table>

### Common Framework of Natural Science Training Outcomes, Grades 7 and 8 (1997)²

<table>
<thead>
<tr>
<th>Social and environmental contexts of science and technology</th>
<th>Give examples of how scientific and technological activities take place in a variety of individual or group settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating and planning</td>
<td>Identify questions to investigate rising from practical problems and issues</td>
</tr>
<tr>
<td>Initiating and planning</td>
<td>State a prediction and a hypothesis based on background information or an observed pattern of events</td>
</tr>
<tr>
<td>Initiating and planning</td>
<td>Propose alternate solutions to a given practical problem, select one, and develop a plan</td>
</tr>
<tr>
<td>Communication and teamwork</td>
<td>Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results</td>
</tr>
<tr>
<td>Grade 7 Life sciences: Ecosystems</td>
<td>Describe conditions essential to the growth and reproduction of plants and microorganisms grown in an ecosystem and relate these conditions to various aspects of the human food supply</td>
</tr>
<tr>
<td>Grade 7 Life sciences: Ecosystems</td>
<td>Describe interactions between biotic and abiotic factors in an ecosystem</td>
</tr>
<tr>
<td>Grade 7 Life sciences: Ecosystems</td>
<td>Apply the system concept as a tool for interpreting the structure and interactions of natural and technological systems</td>
</tr>
<tr>
<td>Grade 7 Earth and Space Sciences: The Earth’s crust</td>
<td>Relate various metrological, geological and biological processes to the formation of soils</td>
</tr>
<tr>
<td>Grade 8 Earth and Space Sciences: Salt water and fresh water</td>
<td>Analyze factors that affect productivity and species distribution in marine and fresh water environments</td>
</tr>
<tr>
<td>Grade 8 Earth and Space Sciences: Salt water and fresh water</td>
<td>Describe factors that affect glaciers and polar icecaps and describe their consequent effects on the environment</td>
</tr>
<tr>
<td>Grade 8 Earth and Space Sciences: Salt water and fresh water</td>
<td>Describe the interactions of the ocean currents, winds and regional climates</td>
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</tbody>
</table>
