



Impacts of Climate Change on Natural Systems

In order for students to fully appreciate the impact of climate change on natural systems, and consequently human systems, this lesson first encourages students to directly connect how their basic needs are met by Earth's natural systems through a "survivor" scenario. Students then develop an understanding of how increasing average global temperatures affect one natural system, the global climate system, resulting in the current change in climate. Finally, global and regional impacts of climate change on natural systems are explored as students research and create statements they use in a "Two Truths and a Lie" challenge.

Learning Objectives

- Identify Earth's natural systems and primary interconnections
- Understand the range of potential impacts of climate change on Earth's natural systems
- Appreciate the source of human basic needs

Activity Time

- Two 30 – 50 minute periods (assuming the research component is assigned as homework)

Setting

- Indoor or outdoor learning area

Materials

- Access to computers or print information for research

Subject Areas/Grade Level

Science 10; Social Studies 11; Civic Studies 11, Geography 12

Keywords

Natural systems, global climate system, hydrological cycle, carbon cycle, nitrogen cycle, rock cycle, global energy budget, biosphere, geosphere, hydrosphere, atmosphere, climate change

Prescribed Learning Outcomes

Science 10: Earth and Space

- evaluate possible causes of climate change and its impact on natural systems

Science 10: Life Science

- explain the interaction of abiotic and biotic factors within an ecosystem
- explain various ways in which natural populations are altered or kept in equilibrium

Science 10: Process of Science

- demonstrate scientific literacy
- demonstrate ethical, responsible, cooperative behaviour

Social Studies 11: Skills and Processes

- apply critical thinking
- demonstrate effective research skills
- demonstrate effective written, oral and graphic communication skills
- demonstrate skills and attitudes of active citizenship

Social Studies 11: Human Geography

- assess environmental challenges facing Canadians, including: global warming, ozone layer depletion, fresh water quality and supply



Impacts of Climate Change on Natural Systems

Prior Knowledge Required

- possible causes of climate change
- global climate system
 - basic functioning, including role of solar energy, atmosphere and greenhouse gases
 - enhanced greenhouse effect and increasing average global temperature
- ecosystems: interactions and relationships between abiotic and biotic factors, including climate based abiotic factors
- understanding of systems thinking

See **Resources**, *Climate Change Challenge Primer* and other Climate Change Challenge lessons (www.wildbc.org, under programs) for more information on these concepts.

Introduction

Regionally and globally our climate is changing. To fully grasp the implication of a changing climate upon Earth and ourselves, we need to have an appreciation of the range of natural systems and how they are interconnected. **Systems thinking** is the approach of studying the interactions amongst components within the context of a whole system, as well as the interactions between systems. Earth is composed of many natural systems with numerous interactions within and between these systems. Due to this level of complexity, one small change can lead to numerous significant changes in one or more of the systems.

The main natural systems of Earth include:

- **biological systems**, i.e., individuals, species populations, and communities;
- **ecosystems**, i.e., the interactions amongst living organisms and physical and chemical factors in the environment;
- **global energy budget**, i.e., flow of energy originating from the Sun into and out of Earth's systems;
- **water cycle** (hydrological cycle);
- **cycling of carbon, nitrogen**, and other elements or molecules (biogeochemical cycles);
- **rock cycle**, i.e., geological processes; and the
- **global climate system**, i.e., the interactions that create the climates and weather patterns throughout Earth.

Also, Earth can be divided into distinct physical zones or “spheres”, including the geosphere (the solid parts of Earth), the hydrosphere (the oceans and fresh water parts), the atmosphere (the area above the surface of Earth containing gases), and the biosphere (the living component). The natural systems often involve energy flowing and elements or compounds cycling through these spheres.

Climate change is an example of how one change can lead to multiple impacts. As the **average global temperature** (i.e., global warming) increases due to an enhanced greenhouse effect, there are numerous and far ranging effects within the **global climate system**. These changes within the global climate system are collectively called climate change. They include: increased evaporation of fresh and ocean water leading to increased atmospheric moisture; change in the amount and pattern of precipitation; variable temperature changes in specific climatic areas; change in overall distribution of normal weather events; increased intensity and frequency of extreme weather events; change in wind intensity; and warming of oceans resulting in rising sea level. Because the natural systems of Earth, including the global climate system, are complex and interconnected, the impact of changing one aspect of one system reverberates throughout all of Earth's systems.

The **impacts of climate change** on natural systems are far ranging. For example, the impact on the water cycle includes changes in the size of fresh water reservoirs as seen by the melting of glaciers, ice caps, and permafrost and the evaporation of lakes; and increased amount of water vapour in the atmosphere, which affects the amount of solar energy that is reflected back into space or absorbed within the atmosphere and increases the amount of precipitation. These changes can then have an effect on the global energy budget and subsequently the global climate system leading to further climate change.

In regards to **ecosystems**, the changes in regional climates are effectively changes in the abiotic components. Changes in temperature and precipitation patterns lead to shifts in the timing of seasons and thus reproductive timing of plants and



Impacts of Climate Change on Natural Systems

animals as well as length of growing season. Shifts in water availability and temperatures affect species distribution (e.g., location or range where found) and abundance (e.g., numbers of individuals in populations) due to loss/expansion of suitable habitat (e.g., melting permafrost in arctic). Some species may become extinct if they cannot adapt at a similar rate to the changes occurring, resulting in a loss of biodiversity, loss of pollinators and seed dispersers, and biological control of pests.

As a result of the many and varied effects of climate change on natural systems, there will also be many ways in which human systems are impacted. Our resource industries, food and health systems, production and manufacturing systems, and infrastructure all will be affected.

Procedure

1 Set survival scenario and list needs

Ask the class to imagine they must set-up camp on a deserted island after their ship has sunk at sea. The task is to determine what they would need in order to survive for at least one week until rescued. Assume the island is semi-desert and no one is injured. Emphasize identification of needs, not wants. Students can consult in small groups to provide suggestions for the creation of a class list visible to all.

Facilitate a short discussion that enables students to distinguish between basic biological needs (e.g., food, water, shelter, clothing for protection and/or warmth) and human health needs (e.g., medical aid and protection from disease and parasites for physical health; sense of safety and purpose for emotional/mental health; music for spiritual health). Emphasize how basic needs are met by Earth's natural systems whereas health needs are generally met through human systems. Note in most communities human systems facilitate access to basic needs (e.g., agriculture, water systems, building infrastructure, manufacture and transportation systems, etc.).

2 Connect source of basic needs to associated natural systems

In small groups, ask students to record: 1) where and how they might find, obtain and/or create each of the identified basic needs and 2) the natural system(s) from which the need is met. For example, break branches from shrubs to build a shelter; branches are part of an ecosystem, the carbon and nitrogen cycles, and the global energy budget (visible light is absorbed by plants during photosynthesis). The goal of this exercise is to encourage students to recall and identify as many natural systems as possible and to recognize their dependence upon these systems.

Invite each group to share their lists. As natural systems are identified, record them alongside the basic needs and draw lines to connect the need and associated natural system(s). After all groups have contributed, review and add any natural systems that may not have been identified (e.g., rock cycle, global energy budget). Note how Earth's natural systems are highly interconnected even though they are often compartmentalized for scientific study.

Set-up the next activity by telling the students that a change in one natural system can have multiple effects within that system as well as on other systems because of the interconnections. Climate change is an example.

3 Identify changes in global climate system

The climate change we are currently experiencing is due to human activities according to the Intergovernmental Panel on Climate Change (IPCC) and numerous other scientific groups around the globe. If necessary, review the enhanced greenhouse effect and how it is causing an increase in the average global temperature (i.e., global warming). With the class, determine the various ways this increase in temperature will affect the global climate system, leading to what is termed climate change. The effects include:

- increased evaporation of fresh and ocean water leading to increase atmospheric moisture,
- change in the amount and pattern of precipitation,
- variable temperature changes in regional climates,



Impacts of Climate Change on Natural Systems

- change in overall distribution and intensity of normal weather events,
- increased frequency and intensity of extreme weather events,
- change in wind intensity,
- warming of oceans resulting in rising sea level.

Remind students weather/climate variables are also some of the abiotic components of ecosystems.

4 Determine impact of climate change: Two Truths and a Lie statements

To explore some of the many possible impacts of global and regional climate change on natural systems, ask pairs to write three sentences that each explicitly state a possible impact on a natural system. Two of the statements must be true and one statement false, based their research using reliable sources. The statements can refer to specific, regional impacts (e.g., higher summer temperatures in the interior of BC) or global impacts. See Resources for potential sources of information students could use to base their statements.

5 Conduct the Two Truths and a Lie challenge

Taking turns, each pair reads their statements to the whole class. The other pairs write down the corresponding number for the statement they believe is false and then hold it up at the same time. Pairs that have correctly determined the false statement are awarded one point. If pairs can also identify and explain how other natural systems are impacted, an additional point is awarded. If they are unable to do so, other pairs can contribute, but are not awarded points.

Alternatively, in larger groups, ask pairs to take turns to read aloud their three statements. The challenge is for the other pairs to determine which statement is false.

Student pairs may challenge the accuracy of others' statements. The defending pair must be able to provide the source of their information as well the context and/or more detailed explanation if required. Throughout the challenge,

encourage discussion and refinement of the student's understanding of natural systems and impacts of climate change.

6 Explore impact of climate change on human systems

Choose a few true statements and brainstorm with the class how the impacts of climate change on natural systems may also affect our ability to meet our basic needs. Show the students the list of basic needs and associated natural systems created earlier. Also, remind students that in most human communities, access to these needs are facilitated by humans systems. Facilitate a discussion of how climate change will impact our lives. To end the discussion on a positive note, inform the students that governments and organizations are discussing how we can adapt to the changing climate and implementing new policies. As individuals, as well as communities, we can be informed, engaged citizens as well as take direct action to reduce greenhouse gas emissions. See the Climate Change Challenge lesson *Leap into Action* for more information.

Assessment

- 1 Collect from each pair their three statements with the source of the information and a complete list of the natural systems impacted. Assess the quality and depth of research to prepare the three statements, taking into consideration the appropriateness, relevance and quality of the source(s) of information and the level of understanding required to accurately reflect the information in their statements. Also assess the degree of completeness of the list of impacted natural systems. The number of points awarded to each pair also can be used as an indication of their understanding of the concept of climate change and the process/functioning of each natural system.
- 2 Ask students to identify three natural systems and describe at least two impacts climate change will have on each system. Include a statement of how these impacts will affect human systems. Look for evidence of systems thinking and understanding of the type of natural systems on Earth and how they are interconnected.



Impacts of Climate Change on Natural Systems

Extensions

- 1 Lead students in a discussion of “adaptation” in biological terms as well as in regards to climate change. Connect natural systems to the natural resources in BC, e.g., forestry, fishing, agriculture, tourism and recreation, parks and protected areas (ecosystems), and energy. Tell students that governments at all levels are exploring and analyzing possible adaptations to our human systems, such as the above resource sectors, that are directly and indirectly connected to natural systems.

Assign groups of students with one resource sector to analyse. Provide them with the appropriate text from Natural Resources Canada’s “From Impacts to Adaptation: Canada in a Changing Climate 2007” (http://adaptation.nrcan.gc.ca/assess/2007/ch8/3_e.php), Chapter 8 “British Columbia: Sectoral Impacts and Adaptive Capacity”. Ask each group to prepare a short presentation.

- 2 Ask students how changes in the availability of energy derived from fossil fuels will have an impact on human and natural systems. For example, how will agriculture change as the cost of oil increases, assuming increase cost reflects decreased availability? How might we adapt?
- 3 Ask students to provide three examples of the effect climate change may have on the biotic, or living, component of ecosystems. Examples can include drought, flooding, extreme weather events, rise in sea level, change in ocean current patterns, etc. leading to reduced reproduction rate, extirpation, extinction, shifts in the distribution of populations, etc. Look for evidence of understanding of the relationship between biotic and abiotic components of ecosystems, especially how the change in the abiotic components relating to climate will impact living things.
- 4 Ask students to define and investigate the concept of “feedback” in relation to effects of global warming, discussing current research regarding both positive and negative feedback loops.

Resources

Global Climate System

Environment Canada, Science of Climate Change, Climate Change: Tampering with the Earth’s Thermostat
http://www.msc-smc.ec.gc.ca/education/scienceofclimatechange/IPCC/earth_thermostat_e.html

BC Ministry of Environment, About Climate Change, The Earth’s Climate System
<http://www.env.gov.bc.ca/epd/climate/about/what.htm>

GreenLearning’s Climate Change Resource Centre, The Global Climate System

<http://www.greenlearning.ca/climate/science/global-factors>

Causes of Climate Change

Environment Canada, Climate Change, Causes of Climate Change

<http://www.ec.gc.ca/cc/default.asp?lang=En&n=689C3F4B-1>

BC Ministry of Environment, About Climate Change, What causes climate change?

<http://www.env.gov.bc.ca/epd/climate/about/what.htm>

GreenLearning’s Climate Change Resource Centre, The Global Climate System, Contributing Factors

<http://www.greenlearning.ca/climate/science/global-factors/1>

Impacts

Environment Canada, Climate Change, Impacts of a Changing Climate

<http://www.ec.gc.ca/cc/default.asp?lang=En&n=3D00CF9C-1>

Natural Resource Canada, From Impacts to Adaptation: Canada in a Changing Climate 2007, Chapter 8 “British Columbia: Sectoral Impacts and Adaptive Capacity

http://adaptation.nrcan.gc.ca/assess/2007/ch8/3_e.php



Impacts of Climate Change on Natural Systems

Natural Resource Canada, Climate Change Impacts and Adaptation Division, “Adaptation 101”

- “Impacts: Physical / biological” http://adaptation.nrcan.gc.ca/101/phys_e.php
- “Impacts: extreme weather” http://adaptation.nrcan.gc.ca/101/extreme_e.php

BC Ministry of Environment, Climate Change and its Impacts: British Columbia
<http://www.env.gov.bc.ca/epd/climate/about/impacts-bc.htm>

GreenLearning's Climate Change Resource Centre: Enhanced Climate Change World-wide
<http://www.greenlearning.ca/climate/science/climate-and-weather/4>

GreenLearning's Climate Change Resource Centre: Ecosystem Effects

- <http://www.greenlearning.ca/climate/science/ecosystem-effects>

Climate Change Challenge Lessons

(<http://www.wildbc.org/programs-workshops/climate-change-program.php>)

- Connecting Ecosystems and Climate: Abiotic and Biotic Factors
- Causes of Climate Change
- Global Climate System

t