Bringing Climate Change into the Classroom:

A teaching module for use with Nova Scotia's Grade 7 public school curriculum

A partnership between Dalhousie University and Nova Scotia Education
Supported by the Nova Scotia Department of Environment Climate Change Adaptation Fund

OVERVIEW

LESSON	OBJECTIVES	MAIN ACTIVITIES	CURRICULUM OUTCOMES*
1: Climate Change Advertisements	*Review types of advertisements and explore how advertisements can be used to communicate messages and information about climate change	*Discuss different types of advertisements and the roles they play *Identify ways that messages about climate change can be communicated; discuss strengths and limitations *Create climate change advertisements	**Visual Arts:** *construct art that embodies meaning (2.1) *explore how visual images influence their daily lives, including mass media and popular culture (3.1) *analyze artwork and make conjectures as to the artist's intention (8.1) **Science:** *communicate questions, ideas, intentions, plans, and results using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means (211-2)
2: Causes, Mitigation, Adaptation, & the Roles of NGOs	*Introduce causes of climate change and differences between mitigation and adaptation *Familiarize students with ways that NGOs are involved in climate change issues and have students start thinking about how they can be involved in climate change mitigation and/or adaptation	*Distinguishing between climate change causes, mitigation, and adaptation card game *NGO small group online research activity	**Science:** *use various print and electronic sources to research individuals or groups in Canada interested in protecting the environment (112-4, 112-8, 209-5) *select and integrate information from various print and electronic sources, or from several parts of the same source (209-5)
3. Vulnerabilities to Coastal Erosion	*Review erosion and discuss ways that climate change may affect rates of coastal erosion *Identify features of coastal areas that are likely to affect their vulnerability to erosion	*Read newspaper article on coastal erosion *View pictures of different coastal areas in Nova Scotia and hypothesize whether they are likely to be vulnerable to erosion *Complete activity on coastal erosion at Dunns Beach, including calculating rates of erosion based on actual data	**Science:** *identify, delimit, and investigate questions related to a local ecosystem (208-2, 208-3) *explain various ways in which rocks can be weathered (311-12) *state a prediction and a hypothesis based on background information or an observed pattern of events (208-5) **Math:** *determine and use the most appropriate computational method in problem solving situations involving whole numbers and/or decimals (B4) *determine measures of central tendency and how they are affected by data presentations and fluctuations (F8)
4. Forest Fires	*Distinguish between biotic and abiotic factors and discuss roles of fire within a forest ecosystem *Become familiar with	*Describe/sketch phases of succession after a forest fire in a boreal forest environment (with help from an online computer	**Science:** *describe interactions between biotic and abiotic factors in an ecosystem (306-3) *identify signs of ecological succession

	succession, specifically within a boreal forest ecosystem *Explore connections between climate change and forest fires and investigate forest fire trends in Nova Scotia	animation) *Using actual data on forest fires in Nova Scotia, create a graph and look for trends	in a local ecosystem (306-4) predict what an ecosystem will look like in the future on the basis of the characteristics of the area and the long-term changes (succession) observed in the site (208-5) *compile and display data, by hand or computer, in a variety of formats, including diagrams, tables, flow charts, bar graphs, line graphs, and scatter plots (210-2)
5. Crops and the Climate Change Connection	*Review conditions essential to the growth and reproduction of plants *Explore the connection between climate change and agricultural productivity *Introduce issue of food security and discuss the importance of adaptation to ensure continued agricultural productivity	*Reading activity comparing agriculture and climate change issues in Nova Scotia and China *Watch short video clip from NASA's series *Science for a Hungry World* and explore the connection between climate change, agricultural productivity, adaptation, and food security	**Science:** * describe conditions essential to the growth and reproduction of plants and microorganisms in an ecosystem, and relate these conditions to various aspects of the human food supply (air, temperature, light, moisture, etc.) (304-3) *select and integrate information from various print and electronic sources, or from several parts of the same source (209-5) *propose a course of action on social issues related to science and technology, taking into consideration personal need (113-11)
6. Urban Areas & Climate Change	*Become familiar with ways that urban areas both contribute to climate change and are likely to be affected by climate change *Discover benefits of urban forests, green roofs, and 'cool' buildings	*Carry out small-group activity to determine differences in temperature around the school and surrounding areas *Conduct online research on urban trees, green roofs, and 'cool' buildings and design a climate change-friendly building	**Science:** *describe interactions between abiotic and biotic factors in an ecosystem (306-3) *provide examples of scientific knowledge that have resulted in the development of technologies (111-1) *use instruments effectively and accurately for collecting data (209-3)
7. Using Art to Reveal the Different Faces of Climate Change	*Reflect on previous 6 lessons and the information learned about climate change *Discuss similarities and differences between how climate change is likely to affect Nova Scotia and other parts of the world	*Create a piece of art to capture students' understanding of local effects of climate change *Look at climate change art from different countries and compare/contrast	**Science:** *communicate questions, ideas, intentions, plans, and results using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means (211-2) **Visual Arts:** *construct art that embodies meaning (2.1) *analyze artwork and make conjectures as to the artist's intention (8.1)

***Note: Applicable English Language Arts curriculum outcomes are not included as there are many opportunities for inclusion and individual teachers may integrate English Language Arts outcomes to suit their individual classes.**

CLIMATE CHANGE ADVERTISEMENTS

LESSON 1

Introduction:

Advertisements are designed to attract attention, and are often used to increase awareness of brands and/or companies and organizations, and to help sell products and services. However, advertisements can also be used as a way of attempting to get other messages across to wide audiences. For example, non-government organizations (NGOs) use non-profit advertising (including television, online, and print advertisements) to raise awareness of social and environmental causes and to call people to action. With climate change a growing concern for many, it is not surprising that many NGOs and other organizations and even government departments have been investing in climate change advertisements. While some of these advertisements have been criticized for being overly pessimistic and even misleading (e.g., two ads developed on behalf of Britain's Department of Energy and Climate Change that used nursery rhymes to illustrate potential effects of climate change were banned for exaggerating the impacts), many serve as creative ways of communicating important messages about climate change to large audiences.

Objectives:

Students will discuss different roles of advertisements. Students will create advertisements with the goal of raising awareness about how they may be impacted by climate change. Students will look at different examples of climate change advertisements and discuss what they liked/disliked, what was effective, etc. Students will brainstorm other ways that messages can be communicated about climate change (e.g., books, newspaper articles, television commercials, radio advertisements, Facebook pages, Twitter, etc.) and discuss potential benefits and limitations of these different methods of communication.

Specific Curriculum Outcomes:

Students will be expected to…

- communicate questions, ideas, intentions, plans, and results using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means (Science, 211-2)
- construct art that embodies meaning (Visual Arts, 2.1)
- explore how visual images influence their daily lives, including mass media and popular culture (Visual Arts, 3.1)
- analyze artwork and make conjectures as to the artist's intention (Visual Arts, 8.1)

Materials:

- Samples of different kinds of advertisements (Teaching Resources 1.1-1.3)
- Art supplies for creating climate change advertisements (paper, colouring pencils, etc.)
- Samples of climate change advertisements (Teaching Resources 1.4 -1.6)

Time Frame:

- 1-2 hours

Activities:

1. Show students advertisements (Teaching Resources 1.1-1.3) and invite students to explain what the advertiser is hoping to accomplish with each of the advertisements (i.e., 1 = sell a product (MacDonald's hamburgers), 2 = promote a service (dental services of a particular dentist), and 3 = a message (warn about potential health risks as a result of smoking)).

2. Tell students that they will be discussing how advertisements can be used to communicate science-related messages (advertisements have a long history of shaping public perception of science), and will eventually be creating their own advertisement.

3. Ask students to think about science-y topics that might feature in advertisements.

4. Have students comment on how useful advertisements might be for communicating messages about science. Why might an organization choose to use an advertisement as a way to raise awareness about a science-related issue?

5. Explain to students that climate change advertisements are meant to raise awareness about climate change, and can be used to encourage viewers to think about how climate change might affect their lives and/or how their actions can help mitigate climate change (e.g., reduce greenhouse gas emissions).

6. Tell students that they will be learning about climate change in class and that they will be creating their own climate change advertisements as a way of communicating their understanding of how climate change might affect them.

7. Encourage students to be creative but to ensure that their advertisement communicates their understanding of a way/ways that climate change could impact their lives.

8. Give students time to plan and create their advertisements (use available art materials, e.g., pencil crayons, paint, materials for collage, electronic sources, etc.).

9. Provide students with paper on which to write a few sentences explaining their artwork (i.e., what have they drawn, what impact are they depicting, etc.)

10. Allow students to share and discuss their advertisements with the rest of the class (optional).

11. Show students the climate change advertisements (Teaching Resources 1.4 – 1.6). Have students comment on the advertisements, suggest what messages they are attempting to communicate, comment on their effectiveness, preferences, etc.

12. Introduce students to the following quote from Mark Twain: “Many a small thing has been made large by the right kind of advertising” and/or the quote by Norman Douglas “You can tell the ideals of a nation by its advertisements.” Have students discuss what these might mean, and whether they agree.

13. Challenge students to think of other ways that the general public receives messages/information about science (e.g., Internet, television, books, magazines, Twitter, etc.) and briefly discuss benefits/limitations of different methods of communicating messages about science.

Assessment:

Use students’ advertisements to assess their ability to communicate their ideas about climate change. Students’ contributions to the classroom discussions can also be used to gauge their level of understanding about the roles of advertisements and how advertisements can affect their lives.

Enrichment:

Explore opportunities to include a sample of some of students’ climate change advertisements in a school or class newspaper or newsletter. Students can vote on top choices, possibly including a short explanation of why they feel their choices make particularly effective advertisements.

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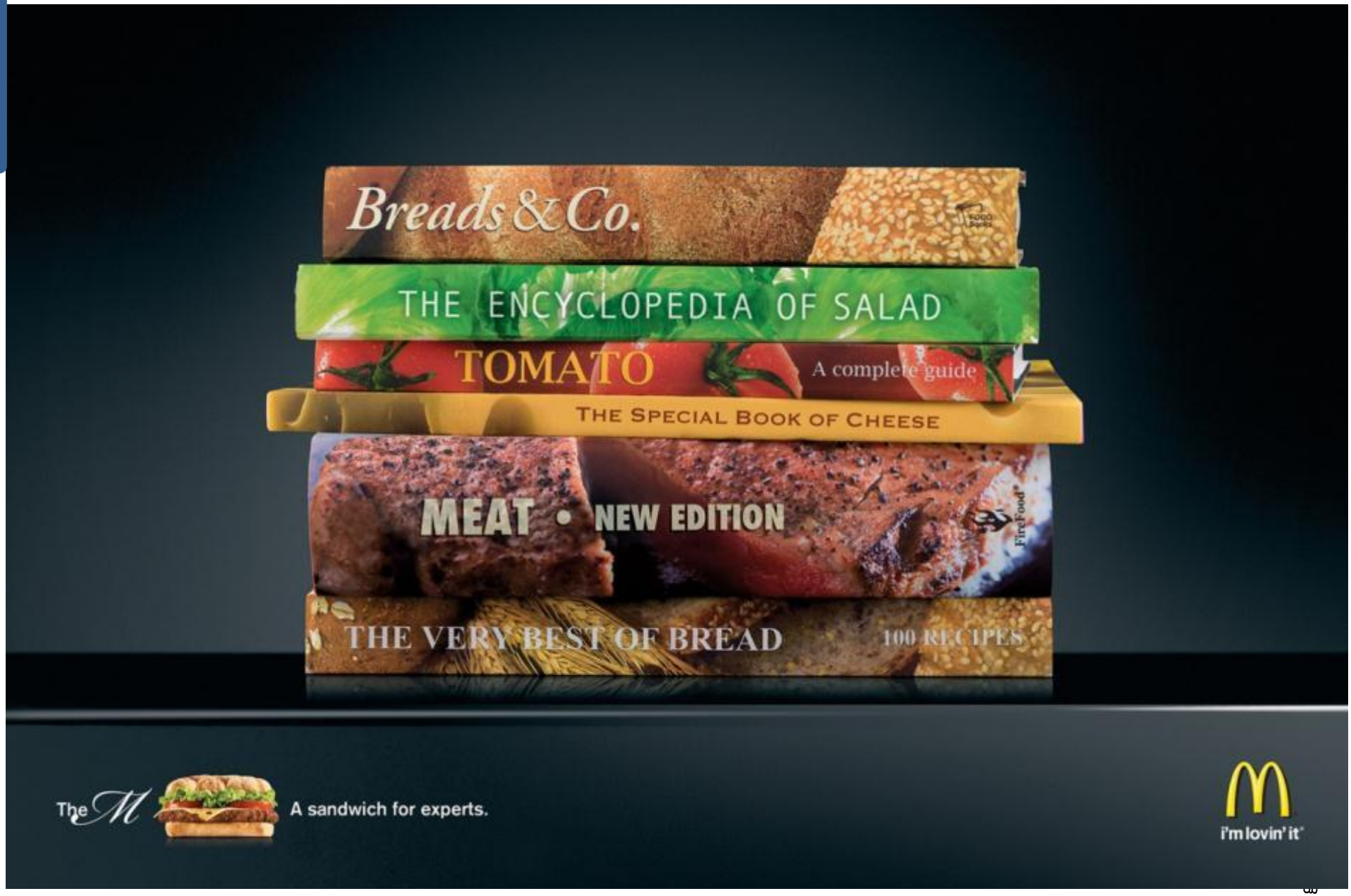

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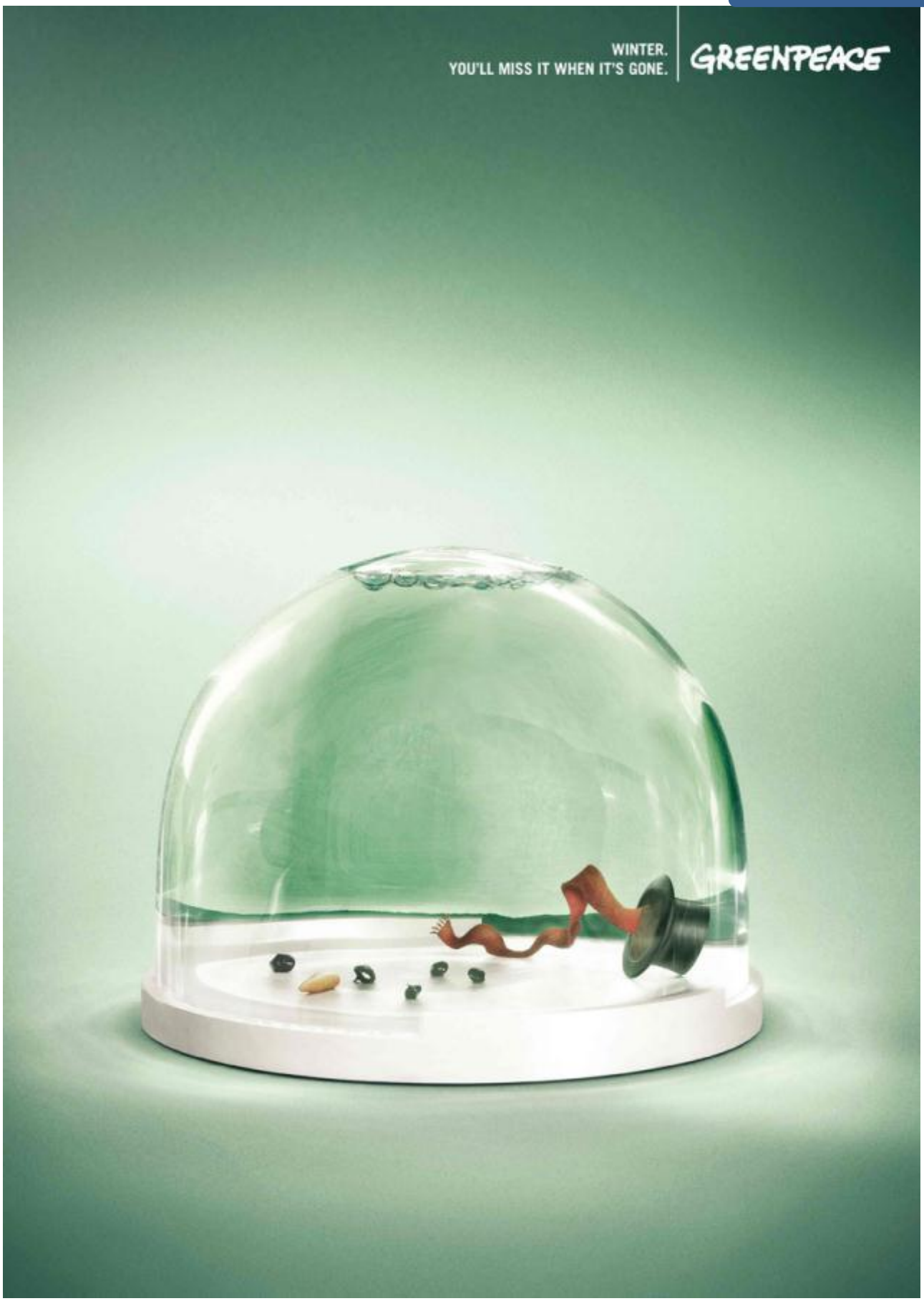

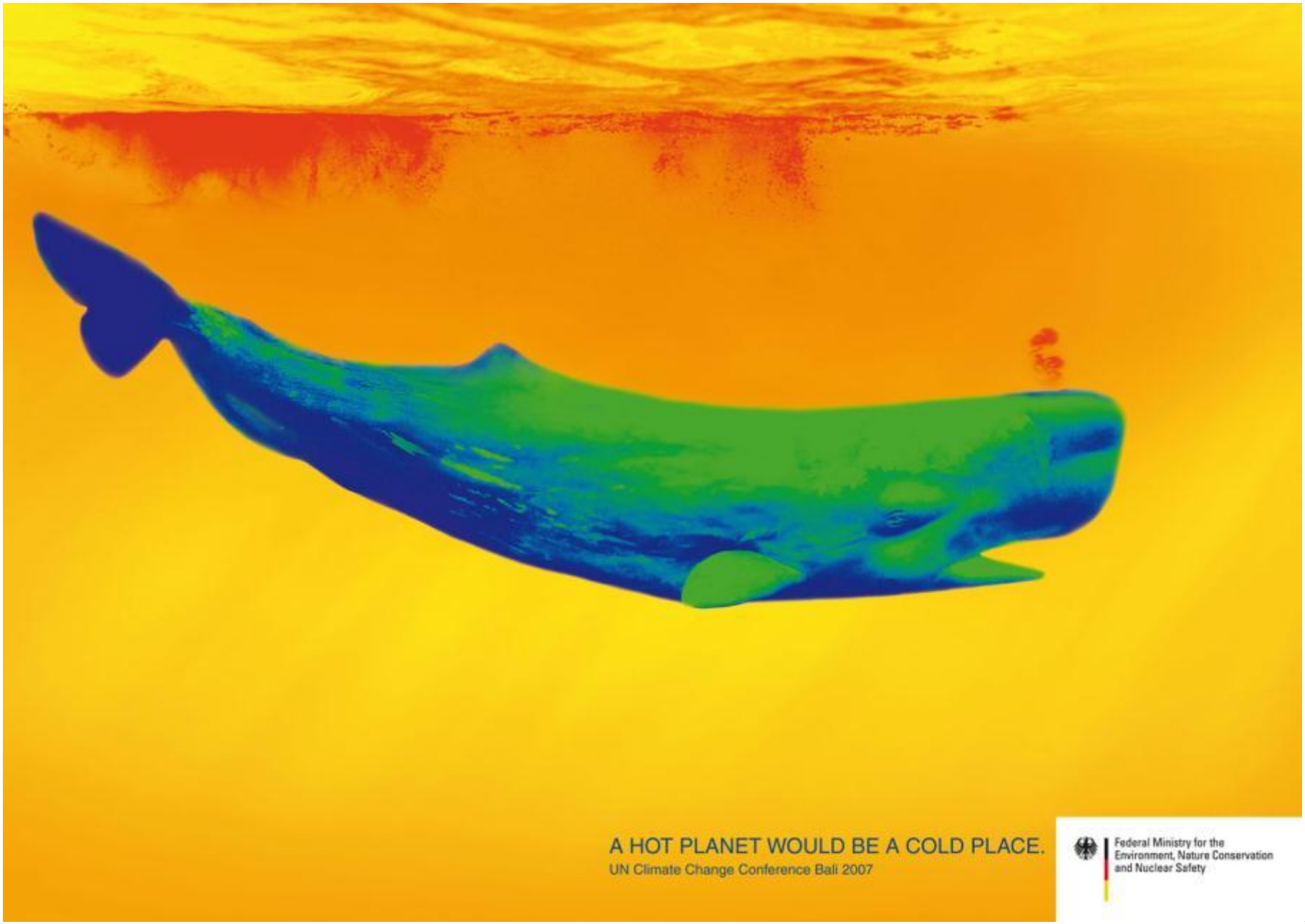

CAUSES, MITIGATION, ADAPTATION & THE ROLES OF NGOs

LESSON 2

Introduction:

Although there is uncertainty as to the rate and specific effects of climate change, the scientific consensus is that humans are contributing to an enhanced greenhouse effect and accelerating global climate change. In addition, there is generally agreement that any approaches to dealing with anthropogenic climate change must involve both mitigation and adaption. In order for mitigation and adaptation efforts to be successful, however, there must be support across scales (e.g., individual, community, government, etc.). While non-governmental organizations (NGOs) have been involved with efforts to promote sustainable development at the international level, NGOs have also played important roles at both national and local levels to encourage sustainable development and also raise awareness of pressing issues such as climate change. Local NGOs are recognized as having important contributions to make to climate change adaptation initiatives. For example, NGOs tend to be in key positions to help build adaptive capacity by facilitating collective learning and providing connections to other communities and organizations.

Objectives:

Students will be introduced to the differences between mitigation and adaptation and will practice distinguishing between causes of climate change, mitigation measures, and adaptations as part of a group activity. Students will be encouraged to consider the advantages and limitations of adaptation and mitigation and will share their thoughts on whether there should be a focus on one or the other (or both). Students will also discuss where they have learned about climate change (e.g., television, Internet, school, parents, etc.) and will look at the roles that NGOs play in also raising awareness of climate change and providing educational material on climate change. Students will research different NGOs (in Nova Scotia and across Canada) and report back to the class on what they have learned.

Specific Curriculum Outcomes:

Students will be expected to…

- use various print and electronic sources to research individuals or groups in Canada interested in protecting the environment (Science, 112-4, 112-8, 209-5)
- select and integrate information from various print and electronic sources, or from several parts of the same source (Science, 209-5)

Materials:

- Teaching Resources 2.1 and 2.2 *Causes, Mitigations, and Adaptations* answer key and activity cards

- Chart paper (or table prepared on blackboard) divided into columns Causes, Mitigation, and Adaptations
- Teaching Resource 2.3 *Climate Change and Canada's Environmental Organizations: What do They Have to Say?* worksheets
- Access to computers to research Canadian NGOs

Time Frame:

- 1-2 hours

Activities:

1. Explain to students that they will be learning more about climate change, and to start, will be discussing the difference between causes of climate change and mitigation and adaptations.

2. Introduce students to the definitions of mitigation and adaptation (i.e., Mitigation – actions taken to reduce greenhouse gas emissions that contribute to climate change, and Adaptation – actions taken to adjust to the impacts of climate change and reduce vulnerability to the potentially harmful effects of climate change).

3. Tell students that they will be working in pairs (or small groups) to try to distinguish between causes of climate change, mitigation measures, and climate change adaptations. Divide the cards (Teaching Resource 2.2) among the pairs/groups. Give students a few minutes to decide whether their cards are describing a cause of climate change, a possible mitigation measure, or an adaptation.

4. Have students volunteer to explain how they classified their cards and place the cards under the correct columns on chart paper or a table drawn onto the blackboard. Discuss their reasoning and correct their placements if necessary.

5. Once all the cards have been correctly placed, ask students whether they believe mitigation or adaption is more important, or whether responses to climate change should focus on both. Have them explain their reasoning and help them to understand why both are important.

6. Explain to students that now that they have begun to think more about what human activities that contribute to climate change, and have also been introduced to some mitigation and adaptation options, they will have a chance to work with their partners/group to learn more about how different non-governmental organizations in Nova Scotia and Canada are dealing with climate change.

7. Show students the WWF advertisement (Teaching Resource 1.4) from the first lesson. Ask students if they are familiar with the World Wide Fund for Nature (World Wildlife Fund in Canada and the US). Explain that the WWF is a large and well known international non-

governmental organization – an organization that operates independently from any government).

8. Explain that while NGOs can be dedicated to a wide variety of causes, and that the WWF is an example of an environmental NGO that is focused on causes related to the environment, such as climate change.

9. Tell students that they will be working in the same small groups as for the previous activity and their job will be to conduct online research in order to learn more about an environmental NGO. Specifically, they will be looking to learn about the NGOs position on climate change and to figure out what kinds of mitigation and/or adaptations they recommend.

10. Assign each group an NGO (suggestions provided in the box to the right). Have students do online research to fill in the activity sheet (Teaching Resource 2.3). Recommend that students start their research on the NGO's official website.

11. Return to class and have groups share some of their findings about the NGOs they were researching.

12. Encourage interested students to learn more NGOs on their own time.

SUGGESTED ENVIRONMENTAL ORGANIZATIONS

Nova Scotia Environmental Network

Ecology Action Centre

Clean Nova Scotia

World Wild Fund for Nature (WWF)

David Suzuki Foundation

Canadian Parks and Wilderness Foundation (CPAWS)

Nature Canada

Assessment:

Students' participation in the causes, mitigation, and adaptations activity can be used to assess their understanding of the differences between the three as they relate to climate change. Students' NGO activity sheets can also be used to assess their ability to find and record the requested information about their assigned NGO.

Enrichment Opportunities:

Have students work in their small groups to write a letter (or email) to their NGO. Invite them to comment on what they have learned about the NGO, to ask questions, and explain why they are interested in learning more about climate change.

Invite a representative from a local NGO to come to the class to talk to the class about their organization. Let them know in advance that you are learning about climate change, and specifically about impacts in Nova Scotia, and are interested in learning about mitigation and adaptation measures.

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Causes, Mitigation & Adaptation

Building coastal defenses such as dikes (Adaption)	Investing in more energy-efficient appliances and technologies (Mitigation)
Changing to no-till agriculture in order to keep soil below the surface cooler and wetter (Adaptation)	Investing in building flood-proof structures (Adaptation)
Carrying out deforestation that both releases carbon dioxide and also reduces the amount of trees available to remove, and store, carbon dioxide from the air (Cause)	Adjusting the types of crops planted and/or the dates that crops are planted and harvested (Adaptation)
Relocating buildings away from low-lying coastal areas (Adaptation)	Carrying out large scale, industrial agricultural practices that release methane into the atmosphere (Cause)
Improving crop and grazing land management practices to increase the ability of soil to store carbon (Mitigation)	Transporting water to areas where there are water shortages (Adaptation)
Switching fertilizer types to reduce nitrous oxide emissions (Mitigation)	Avoiding deforestation/investing in reforestation (i.e., protecting forests) (Mitigation)
Planting vegetation in areas at risk of erosion to make them less vulnerable (Adaptation)	Protecting the natural biodiversity of an ecosystem to make it less vulnerable (Adaptation)
Promoting conservation of water (Adaptation)	Using forestry products for bioenergy to replace fossil fuel use (Mitigation)
Increasing our ability to store water by investing in reservoirs and dams (Adaptation)	Applying large amounts of fertilizers to agricultural crops that release nitrous oxide into the atmosphere (Cause)
Disposing of large volumes of waste in landfills that decompose and release methane gas into the atmosphere (Cause)	Reducing water demand for irrigation by importing products (Adaptation)
Continuing to rely on energy-intensive heating and air-conditioning in homes and other buildings (Cause)	Investing in more solar and/or wind-powered electricity options (Mitigation)
Using energy-intensive building materials such as cement (cement manufacturing requires the burning of large amounts of fossil fuels) (Cause)	Using more recycled products (e.g., recycled aluminum or steel instead of newly manufactured materials) (Mitigation)
Driving vehicles (or relying on other types of transportation) with high consumption of fossil fuels (Cause)	Supporting manufacturing industries that are energy-intensive and release large amounts of greenhouse gases (Cause)
Switching to less carbon-intensive fuel (e.g., biodiesel) for vehicles (Mitigation)	Investing in water saving appliances (e.g., more water-efficient washing machines and dishwashers) (Mitigation)
Turning appliances and electronics off when they are not in use (Mitigation)	Planting more trees in urban areas and investing in the development of green roofs (Adaptation/Mitigation)

Building coastal defenses such as dikes	**Investing in more energy-efficient appliances and technologies**
Changing to no-till agriculture in order to keep soil below the surface cooler and wetter	**Investing in building flood-proof structures**
Deforestation that releases carbon dioxide and also reduces the amount of trees available to remove, and store, CO_2 from the air	**Adjusting the types of crops planted and/or the dates that crops are planted and harvested**

Relocating buildings away from low-lying coastal areas	**Carrying out large scale, industrial agricultural practices that release methane into the atmosphere**
Improving crop and grazing land management to increase the ability of soil to store carbon	**Transporting water to areas where there are water shortages**
Switching fertilizer types to reduce nitrous oxide emissions	**Avoiding deforestation/investing in reforestation (i.e., protecting forests)**

Planting vegetation in areas at risk of erosion to make them less vulnerable	**Protecting the natural biodiversity of an ecosystem to make it less vulnerable**
Promoting conservation of water	**Using forestry products for bioenergy to replace fossil fuel use**
Increasing our ability to store water by investing in reservoirs and dams	**Applying large amounts of fertilizers to agricultural crops that release nitrous oxide into the atmosphere**

Disposing of large volumes of waste in landfills that decompose and release methane gas into the atmosphere	**Reducing water demand for irrigation by importing products**
Continuing to rely on energy-intensive heating and air-conditioning in homes and other buildings	**Investing in more solar and/or wind-powered electricity options**
Using energy-intensive building materials such as cement that require burning large amounts of fossil fuels	**Using more recycled products (e.g., recycled aluminum or steel instead of newly manufactured materials)**

Driving vehicles (or relying on other types of transportation) with high consumption of fossil fuels	**Supporting manufacturing industries that are energy-intensive and release large amounts of greenhouse gases**
Switching to less carbon-intensive fuel (e.g., biodiesel) for vehicles	**Investing in water saving appliances (e.g., more water-efficient washing machines and dishwashers)**
Turning appliances and electronics off when they are not in use	**Planting more trees in urban areas and investing in the development of green roofs**

Name(s): _____ Date:_____

Climate Change and Canada's Environmental Organizations: What do They Have to Say?

Name of environmental organization:

How can people get involved?

Are they concerned about climate change? How do you know?

What are some things you learned about climate change from their website?

What other environmental issues are they concerned with?

What kinds of mitigation and/or adaptations do they recommend?

What interesting facts did you learn about this organization? (e.g., what is their history? Have they received any awards or do they have any major achievements, etc.?)

What are two questions about climate change that you would be interested in asking someone from this organization after visiting their website?

What other information about this organization do you think is particularly important?

VULNERABILITIES TO COASTAL EROSION

LESSON 3

Introduction:

Erosion of Nova Scotia's coastlines occurs naturally as a result of interactions with wind, ice, water, and waves. However, while coastal erosion is a natural process, climate change is expected to increase the rate and severity of erosion. For example, climate-related factors such as increased flooding, sea level rise, and increased storm surges are expected to negatively impact parts of Nova Scotia where the coastlines are particularly vulnerable. As Nova Scotia's 7600 kilometers of coastline are far from uniform, it's important to understand the characteristics of a coast that may it more vulnerable to coastal erosion, and identify coasts where adaptation measures may be appropriate in order to prepare for the impacts of climate change.

Objectives:

By reading a newspaper article from the *Halifax Commoner*, students will be introduced to the fact that coastal erosion is a concern in Nova Scotia. Students will review the concept of erosion and discuss ways that climate change can accelerate coastal erosion. With the help of pictures of various coastlines, students will begin to think about factors that make coastlines more or less vulnerable to erosion. In addition to discussing how slope, the presence of vegetation, rocks and/or landforms, and human-made structures (e.g., dykes and sea walls) can affect the vulnerability of a coast, students will also be encouraged to consider how soil type can affect the vulnerability of a coast to erosion. Students will calculate rates of erosion and average amounts of erosion and erosion rates for Dunns Beach and will answer questions related to the vulnerability of Dunns Beach to coastal erosion.

Specific Curriculum Outcomes:

Students will be expected to…

- identify, delimit, and investigate questions related to a local ecosystem (Science, 208-2, 208-3)
- explain various ways in which rocks can be weathered (Science, 311-12)
- state a prediction and a hypothesis based on background information or an observed pattern of events (Science, 208-5)
- determine and use the most appropriate computational method in problem solving situations involving whole numbers and/or decimals (Math, B4)
- determine measures of central tendency and how they are affected by data presentations and fluctuations (Math, F8)
- design and conduct a fair test of soil properties (Science,209-1) (Enrichment activity)

Materials:

- Teaching Resources 3.1-3.

- Variety of soil types for use by students in their experiments (e.g., sand, clay, mixture of clay/silt, coarse sediment, etc.) (Enrichment activity)
- Plastic trays/containers for experiments, as well as access to water (and containers for transporting water) (Enrichment activity)

Time Frame:

- 1-2 hours

Activities:

1. Remind students that one place where they can learn about climate change and its impacts is by reading newspaper articles.

2. Have students read, or read as a class, the article from the *Halifax Commoner:* Erosion threatens N.S. coastline. Review the concept of erosion with the class and distinguish from weathering.

3. Encourage students to suggest ways that climate change is expected to contribute to increased rates and severity of coastal erosion in Nova Scotia (i.e., sea level rise, increased flooding and storm surges).

4. Have students suggest ways that humans can be affected by coastal erosion and ask students to identify some of the adaptations that were discussed in the article (e.g., building seawall and building further back from coasts).

5. Have students suggest why coastal erosion as a result of climate change is a particularly big concern for Nova Scotia.

6. Explain to students that certain coastlines have features that make them more vulnerable to erosion than others. Have students suggest features of coastlines that might make them more or less vulnerable to coastal erosion. Prompt if necessary.

7. Have students suggest how soil type can influence the vulnerability of a coastline to erosion. Ask students to consider what types of soils would be vulnerable/more resistant to coastal erosion. (E.g., would soil with high sand or clay content be more vulnerable? Why?). Have students suggest a simple experiment that could be carried out to test their hypothesis.

8. Use Teaching Resources 3.3 – 3.9 to look at different coastlines and have students describe features of the coastlines that might increase/decrease their vulnerability to coastal erosion. (E.g., in addition to soil type, discuss how geological features (e.g., rock formations) can reduce risk, as well as presence of human-made structures such as seawalls and dikes, the effects of the slope of the land, presence of vegetation, orientation of the coast, etc.). (Note: When discussing Teaching Resource 3.6, have students suggest what other climate change impacts are likely to have profound effects on this land mass – i.e., sea level rise).)

9. Briefly show the Coastal Sensitivity to Sea Level Rise (Teaching Resource 3.2) produced by Natural Resources Canada to illustrate how the coasts of Atlantic Canada have been assessed and ranked in terms of their vulnerability to coastal erosion, as well as other impacts related to climate change such as sea level rise.

10. Tell students that they will be working on an activity looking at how coastal erosion has affected a particular beach in Nova Scotia. Introduce Dunns Beach to students with Teaching Resource 3.10 and go over instructions with students on Teaching Resource 3.11 (including reminders of how to calculate averages and rates).

11. Once students are finished, discuss their findings as a class.

12. Encourage students to consider ways that using human-made structures to protect coastlines can result in both benefits and additional problems. E.g., invite students to imagine that a dike or sea wall is installed to protect the coastline at Dunns Beach. What do students think might happen to the coastline at either end of the dike or wall, where the coast is left unprotected?

Assessment:

Students' contributions to classroom discussions can be used to assess their understanding of features that might make a coast more or less vulnerable to coastal erosion. Students' activity sheets can be used to assess their ability to calculate rates of erosion and calculate averages, as well as their ability to discuss the data in terms of what it suggests about the vulnerability of Dunns Beach to coastal erosion.

Enrichment Opportunities:

Challenge students to design a simple experiment to test the vulnerability of different types of soil to erosion by water. Have students work in small groups to design and carry out their experiment. Explain to students they will need to start with a hypothesis (their prediction of which soils will be more or less vulnerable to erosion), list materials needed, and explain the steps required to carry out the experiment (methods). If possible, give students an opportunity to carry out their experiment, following up with a discussion of their results and ways that students might change their methodology if they could carry out another experiment.

Take class on a field trip to look at a local coastal area in order to identify features of the site that might affect its vulnerability to coastal erosion and have students comment on the overall risk to coastal erosion. Look for any signs of adaptation and discuss adaptations that might be appropriate for this site in the future.

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HALIFAX COMMONER
University of King's College School of Journalism

Erosion threatens N.S. coastline

January 12, 2011

By Katie Ingram

Most homes don't have seawater or seaweed in them, but Mary Mouzar found both in her basement after a storm.

Mouzar has lived on the waterfront in Hunts Point on Nova Scotia's south shore for more than a decade, which has proved problematic.

Being a peninsula, Nova Scotia is almost completely surrounded by water. This puts parts of the province at risk for severe weather which can cause coastal erosion.

"A primary concern is the rising ocean levels themselves and a second concern is the increased intensity of storms along the coast and that's apparent of climate change," says meteorologist Richard Zurawski.

Canada's East Coast has seen a lot of damage in recent years. This past December saw an increased number of severe storms in places such as New Brunswick, where high waves and winds damaged the shore.

Parts of Nova Scotia's coastline, like this cliff in Cow Bay near Halifax, are vulnerable to erosion when powerful storms pass through. (Photo: Katie Ingram)

"A lot depends on where you are," says Danika van Proosdij, associate professor of geography at Saint Mary's University. "A lot depends on the slope of the land and the landscape."

Over the years, storms and high waves have washed away soil and spruce trees that once protected Mouzar's oceanfront property, leaving her with only a few metres of lawn.

"Big waves sometimes wash over the lawn within a couple feet of the house," says Mouzar. "It was becoming a concern and actually very scary when another storm is forecasted."

Although this damage had Mouzar concerned, it was when Hurricane Bill came to Nova Scotia in 2009 that she decided to take action.

During the storm, rocks also washed up onto her lawn and one smashed into her house, causing water and seaweed to seep in and destroy parts of her basement.

"That was the last straw," says Mouzar. "I just realized at that time, I cannot stay here as it is. It's not safe for me."

Even though her house was damaged, Mouzar didn't want to be forced from her home, so she had a seawall built along the edge of her property to keep her and her house safe.

Although Mouzar has found a solution, she's not the only one affected by erosion.

Linda Rafuse has a cottage in Pugwash and is facing a similar problem.

"We've been there about 16 years and we've lost maybe 10 feet of shore front property," says Rafuse, "At this rate, in 20 years the beach will be up to our front doorstep."

Rafuse adds that when building the cottage, she and her husband knew that the area had problems with erosion. They made sure they were away from the shore, but the shore has come to them.

"Sometimes it's a real head-scratcher because you just don't know what to do to get ahead of Mother Nature," says Rafuse.

Van Proosdij says erosion may be problematic, but it's part of a cycle.

For places such as Nova Scotia's Cow Bay, where a cliff is quickly eroding, what is being washed away is actually helping the surrounding area since a small shoreline is more at risk than a larger one.

"The material is moved from the base of the cliff and moved to the beach to help it recover from things like storm events," says van Proosdij.

Mouzar says that her experience has shown her that people should make sure they are as far back from the shore as they can get.

Van Proosdij says erosion is an on-going process and agrees that people should be wary of erosion when building near the coast.

"Don't build on the edge of the cliff; you're asking for trouble if you build on the edge of Nova Scotia," says van Proosdij.

Those who live along the shore have to be wary of losing some of their land, but overall Nova Scotia is safe. In addition to a lot of high land areas, some areas of the province, such as the Bay of Fundy, go through cycles where the shore is pushed back and forth over the years.

"It's not going to continue to eat its way through Nova Scotia," says van Proosdij.

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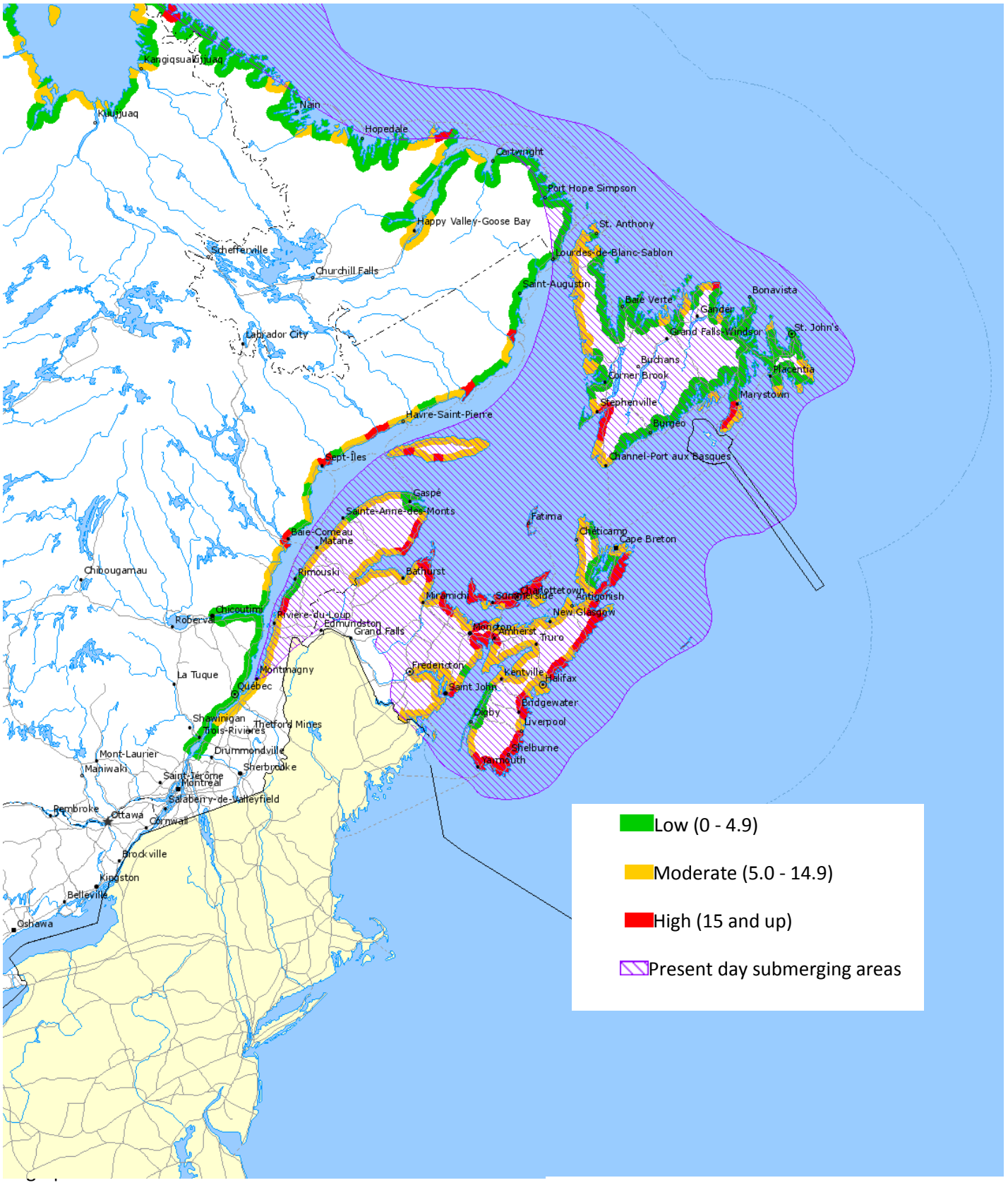
Coastal Sensitivity to Sea Level Rise



Map prepared by Natural Resources Canada

Peggy's Cove, Nova Scotia

Cape Breton, Nova Scotia

Used with permission of the photographer, Alain Belliveau

Cape Breton, Nova Scotia

Used with permission of the photographer, Alain Belliveau

Cape Breton, Nova Scotia

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Port Mailand, Nova Scotia

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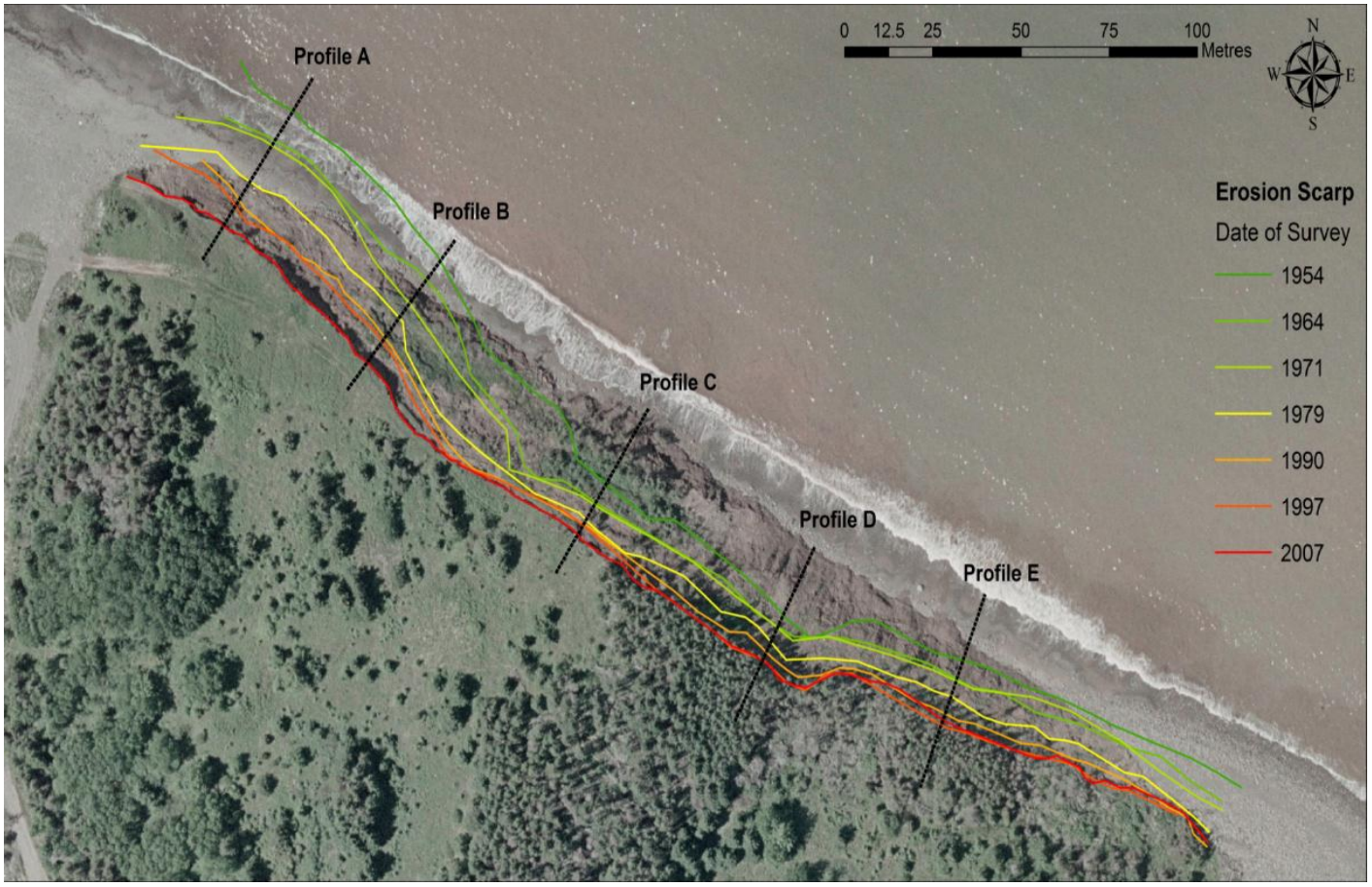
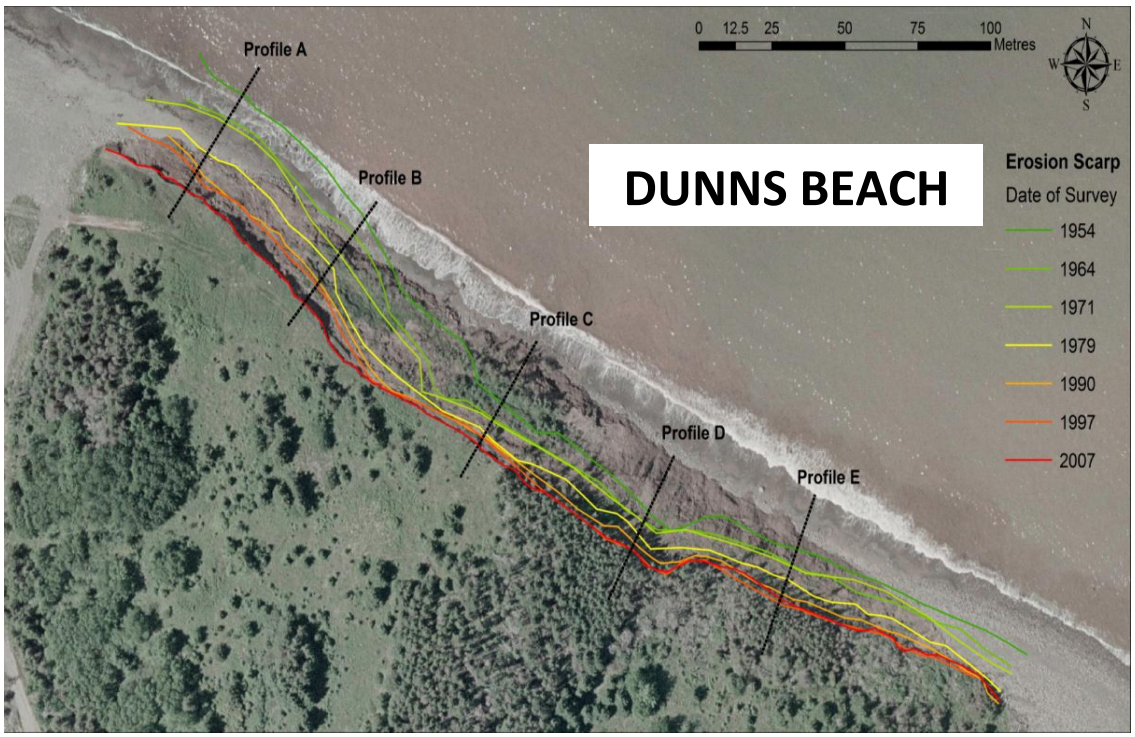
Coastal Erosion of Dunns Beach



Images used with permission from Webster et al. (2011), *Antiaonish Floodrisk and Erosion Climate Chanae Proiect*

Coastal Erosion of Dunns Beach

The picture below is an aerial photograph of Dunns Beach in Antigonish County, Nova Scotia. The beach was purchased by the province in 2002 and is now one of Nova Scotia's protected beaches. Dunns Beach is recognized as having important habitat for the endangered Piping Plover, and also a large drumlin (relatively smooth hill) that has been gradually eroding. Your job is to use the data provided to figure out how fast the erosion has been occurring at three sites along Dunns Beach, and to also suggest reasons why Dunns Beach is vulnerable to erosion.



	PROFILE A		PROFILE C		PROFILE E	
YEARS	Retreat (m)	Rate (m/yr)	Retreat (m)	Rate (m/yr)	Retreat (m)	Rate (m/yr)
1954-1964	8.5		5.2		4.7	
1964-1971	1.4		0.6		0.5	
1971-1979	10.4		4.3		3.9	
1979-1990	5.1		1.1		4.3	
1990-1997	1.7		0.3		2.8	
1997-2007	5.6		2.7		-1.1	
AVERAGE						

Image and data are used with permission from Webster et al. (2011), *Antigonish Floodrisk and Erosion Climate Change Project*

After filling out the missing data on rates of erosion and average retreat and rates, answer the following questions.

1. Which section of Dunns Beach experienced the most erosion between 1954 and 2007? Suggest some reasons that parts of Dunns Beach might be more vulnerable to coastal erosion than others.

2. What was unusual about the period between 1971 and 1979 for Profile A? How might this be explained?

3. What do you think the negative sign is telling you for under Profile E during the period between 1997 and 2007? How could you explain this?

4. There is no bedrock present at the base of the drumlin at Dunns Beach. How might this affect the beach's vulnerability to erosion? Also, how might the presence of large boulders (likely remains from old eroded drumlins) affect coastal erosion?

5. How might climate change affect the coastal erosion that is already occurring at Dunns Beach? Explain.

FOREST FIRES

LESSON 4

Introduction:

Forests are complex ecosystems. While the scientific consensus is that climate change is affecting forests, and will continue to do so as climate change continues and even escalates, scientists tend to be less certain exactly nature of how, and how much, climate change will impact forests. Despite this uncertainty, researchers have projected that the greatest impacts to forests will be a result of extreme weather conditions and disturbance events such as forest fires. An increase of forest fires seems particularly likely as other impacts of climate change (e.g., droughts and tree mortality from pests and storms) can make forests even more vulnerable to potential fires. Compared to other parts of the country, however, Nova Scotia may experience fewer forest fires as certain areas become wetter. Although parts of Nova Scotia may experience a reduction in their risk of forest fire, other parts of the province, as well as areas across the country, are expected to be at an increased risk of forest fires as climate change continues.

Objectives:

Students will review abiotic and biotic factors of ecosystems and identify abiotic and biotic factors that may be present in a forest ecosystem. Students will classify fire as an abiotic factor and discuss how fire impacts other abiotic and biotic factors in an ecosystem. Students will also use a computer animation to help learn about how succession occurs after a forest fire. Students will discuss how climate change may increase the likelihood of forest fires, and will plot forest fire data from Nova Scotia in order to look for trends. Finally, students will be encouraged to think about other ways that climate change can impact forests, and suggest possible adaptions that might be necessary to cope with an increased risk of forest fires.

Specific Curriculum Outcomes:

Students will be expected to…

- describe interactions between biotic and abiotic factors in an ecosystem (Science, 306-3)
- identify signs of ecological succession in a local ecosystem (Science, 306-4)
- predict what an ecosystem will look like in the future on the basis of the characteristics of the area and the long-term changes (succession) observed in the site (Science, 208-5)
- compile and display data, by hand or computer, in a variety of formats, including diagrams, tables, flow charts, bar graphs, line graphs, and scatter plots (Science, 210-2)

Materials Required:

- Teaching Resources 4.1 and 4.2 *Identifying Abiotic and Biotic Factors*
- Teaching Resources 4.3 and 4.4, *Figuring out Forest Fire Trends* and *Understanding Forest Succession*
- Access to computers

Time Frame:

- 1-2 hours

Activities:

1. Review definition of abiotic and biotic and practice identifying abiotic and biotic factors with students using Teaching Resources 4.1 and 4.2 (this can be done with the whole class or in small groups with photocopies of the Teaching Resources).

2. Have students suggest different abiotic and biotic factors that might be part of a forest ecosystem in Nova Scotia. Record students' ideas. Note: students might find soil tricky. Ask students why soil can be considered an abiotic and a biotic factor (soil is a mixture of abiotic components such as mineral matter – e.g., clay, silt, sand -, water, and organic material, and biotic components such as bacteria and other microorganisms).

3. If students do not suggest fire, ask students whether fire would be an abiotic or biotic factor. Have students explain their reasoning.

4. Ask students to share their thoughts on a possible connection between climate change and forest fires. Invite students to suggest how some changes/trends associated with climate change might lead to more or less forest fires. What about warmer temperatures? Drier periods? More precipitation? Etc.

5. Explain to students that they will be using actual data on forest fires in Nova Scotia to look for trends. Introduce the *Figuring out Forest Fire Trends* activity (Teaching Resource 4.3). Give students time to independently work through the assignment.

6. Once students have completed the activity, discuss the results as a class. What did students notice? Explain to students that it is difficult to identify trends with confidence based on small sets of data. Let students know that despite the fact that there seem to be more forest fires caused by lighting in recent years, many scientists have projected that there may actually be fewer forest fires in Nova Scotia as climate change will make parts of the province wetter. Ask students why it is important to know what caused the fires? (This is important if you are trying to look for a connection between climate change and increased fires, because some of the fires will not have started as a result of natural causes. warmer and drier conditions, however, may still have been partially responsible for the fires taking hold and spreading).

7. Ask students to consider whether forest fires are always 'bad'? Have students think of ways that a forest fire affects the biotic factors in a forest ecosystem. Record students' ideas. If students are having trouble thinking of how fire can benefit certain biotic components of a forest ecosystem explain that certain trees are more successful after forest fires have opened the canopy and increased sunlight, e.g., birch trees and Jack pines, and blueberries prefer to grow in burned zones, and animals such as the black-backed woodpecker are commonly found in

recently burned forests because the insects they prey on are more readily visible on the burned trees.

8. Ask students how they think a forest fire might affect soil? (Fire burns leaf litter, which can affect soil's ability to retain water and nutrients, fire can also kill microorganisms in soil). Now invite students to consider how forest fires can impact the abiotic factors of a forest ecosystem. Tell students to focus on water and air. Prompt to help students. (E.g., what happens when ice gets really hot? Fires can cause water to evaporate and dry out an area, alternatively, can cause water to melt from higher elevations (e.g., mountains) and increase water in an area. Water quality often decreases from increased sediments in the water. Air quality is negatively affected because burning releases carbon dioxide into the air. Why might this be important when thinking about climate change?).

9. Explain to students that even though forest fires may be beneficial in some ways, forest fires can result in serious disturbances to ecosystems. Explain to students that succession is the natural process in which an ecosystem gradually replaces plant or animal species that have been damaged or lost as a result of a disturbance such as a forest fire. (Review if this is not a new concept). Explain that succession involves separate stages with different communities of plants and/or animals that are gradually replaced until eventually the ecosystem reaches a more stable and complex condition.

10. Introduce or review forest succession with students. For example, tell students that they will be going to the computer lab to independently work through an online animation on forest succession (http://ecoplexity.org/node/496). Instruct students to complete Teaching Resource 4.*4 Understanding Forest Succession,* while they are working on the animation.

11. After reviewing/being introduced to succession, remind students that the potential for increased forest fires is not the only way that forests may be affected by climate change. Invite students to suggest other climate change impacts on forests (e.g., increased pests, change in climate can increase/decrease range of certain species, etc.).

12. Have students suggest some of the adaptations that might be appropriate/necessary in order for Nova Scotians to deal with a potential for more forest fires in the province.

Assessment:

Students' contributions to classroom discussions can be used to assess their understanding of abiotic and biotic factors. Students' *Figuring out Forest Fire Trends* and *Understanding Forest Succession* worksheets should be used to assess their understanding of potential relationships between climate change and forest fires, ability to interpret data and draw conclusions, and their understanding of succession.

Enrichment Opportunities:

Have students work in small groups to create murals to depict the stages of forest succession that occur after a forest ecosystem is disturbed by a forest fire.

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Identifying Abiotic and Biotic Factors

Identifying Abiotic and Biotic Factors

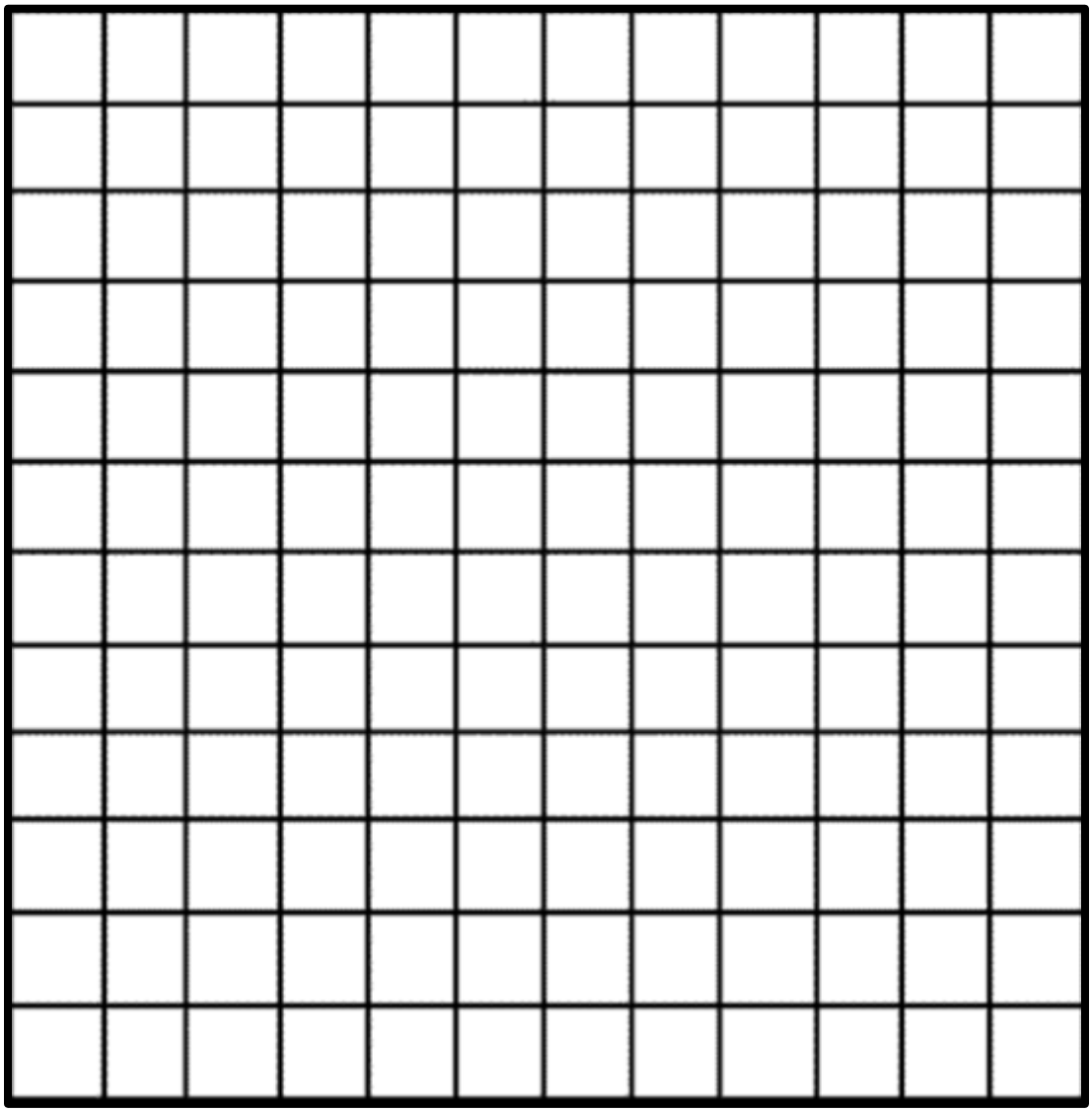
Name: _____ **Date:**_____

Figuring out Forest Fire Trends

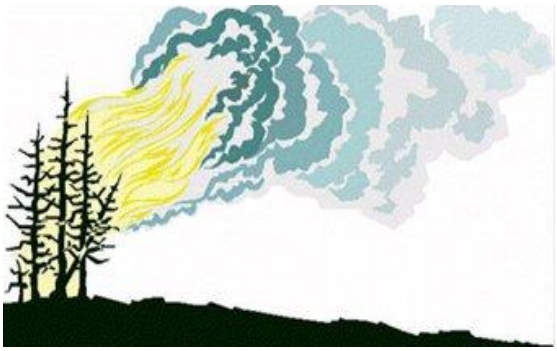
Use the data provided in the table to create a graph to show changes in the number of forest fires caused by lightning in Nova Scotia between 1929 and 2008.

Don't forget to label your X and Y- axes, and to give your graph a title!

Time Period	Number of Forest Fires
1929-1938	13
1939-1948	18
1949-1958	22
1959-1968	82
1969-1978	25
1979-1988	43
1989-1998	100
1999-2008	80



Answer the following questions in the spaces provided.



1. Describe the general trend that you have observed in your graph.

2. What might this tell us?

3. How else could you explain the trend?

4. The table below provides data on wildfires that occurred in Nova Scotia in 2010. Complete the last column of the table to show what percent of the fires were started by each general cause.

5. Why is it important to know what started a forest fire if you are trying to figure out if climate change is resulting in more forest fires in Nova Scotia?

General Cause of Fire	Number of Fires	Percent (%) of Total Fires
Forest Industries	4	
Arson	114	
Lightning	6	
Other Industry	10	
Railroad	2	
Recreation	15	
Residential	119	
Unknown	43	
Total	313	

The data for the two tables on this handout is from Nova Scotia's Department of Natural Resources.

Name: _____ Date:_____

Understanding Forest Succession

In the boxes below, use quick sketches to illustrate the different stages of forest succession. Include short notes to explain the important changes that occur at each stage.

Disturbance	**Herbs and Shrubs**
Notes:	**Notes:**
Young Forest	**Mature Forest**
Notes:	**Notes:**

Diversification/Climax	**Notes:**

In your own words, explain your understanding of forest succession below:

What other disturbances (besides fire) might also result in succession?

Crops and the Climate Change Connection

LESSON 5

Introduction:

According to a 2011 report by the Intergovernmental Panel on Climate Change (IPCC), climate change will impact both the extent and productivity of agricultural systems across the globe. Although there may be benefits such as longer growing seasons and opportunities for new crops, climate change may also negatively impact agriculture. For example, negative impacts include the possibility of increased drought, floods, pest invasions, and soil erosion. The worrisome reality is that climate change may reduce the ability of rural communities reliant on farming to secure livelihoods and also threaten the food security of urban areas. Given that agriculture is an important sector in Atlantic Canada, it is important to understand how agriculture in Canada and across the globe may be affected by climate change and explore adaptions that may help protect food supplies.

Objectives:

By reviewing and discussing what plants need to survive and reproduce, students will begin to think about how crops and agricultural production more generally can be affected by climate change. Students will complete a reading assignment looking at agricultural benefits and challenges as a result of climate change in Nova Scotia and China. Students will recognize that agricultural production is important for maintaining and/or achieving food security and will discuss various adaptations that may be necessary in order to maintain and even increase agricultural productivity in the face of climate change.

Specific Curriculum Outcomes:

Students will be expected to…

- describe conditions essential to the growth and reproduction of plants and microorganisms in an ecosystem, and relate these conditions to various aspects of the human food supply (air, temperature, light, moisture, etc.) (Science, 304-3)
- select and integrate information from various print and electronic sources, or from several parts of the same source (Science, 209-5)
- propose a course of action on social issues related to science and technology, taking into consideration personal need (Science, 113-11)

Materials:

- Teaching Resources 5.1 – 5.3, *Plant Growth Requirements, Crops, and the Climate Change Connection* and *Food Security*
- Access to laptop/computer to view part 6 of NASA's *Science for a Hungry World* video series

Time Frame:

- 1 hour

Activities:

1. Ask students if they have ever helped to plant and grow a garden. Has anyone worked on a farm before? Or tried growing a houseplant? Invite students to share ideas about some of the conditions that are important for plants to grow and reproduce (e.g., light, water, soil, proper temperatures, etc.)

2. Tell students that the agricultural sector in Nova Scotia and those across the globe have varying degrees of vulnerability to climate change. Have students suggest some ways that agricultural production might be affected by climate change. Encourage students to think about potential negative and positive impacts.

3. Explain to students that they will be completing an independent reading activity to learn more about the connection between conditions essential to plant growth, crop productivity, and climate change. Tell students that by looking at how climate change may affect crops in Nova Scotia and China, they will gain a better understanding of how different parts of the world will face both similar and different challenges and opportunities for agricultural production due to climate change.

4. Once students have completed the activity and answered the accompanying questions, take up the answers as a class. Focus on the last question and encourage students to think about why it is important for farmers to explore adaptations.

5. Tell students that they will be watching a short video produced by NASA as part of a series called *Science for a Hungry World*. Encourage students to particularly think about the last question from their worksheet while they are watching the video.

6. After the video, invite students to expand on their answer for the last question (and share with the class).

7. Introduce students to the idea of food security. Remind students that this was mentioned during the video clip. Ask students to share their understanding of food security based on the video.

8. Briefly discuss food security as it relates to climate change to reinforce the importance of adapting agricultural practices in order to continue to produce enough food in a changing climate. (Use Teaching Resource 5.3, *Food Security* to help, if needed).

Assessment:

Students' contributions to classroom discussions can be assessed in order to gauge their level of understanding. Students' answers on the *Plant Growth Requirements, Crops, and the Climate Change Connection* activity can also be used to assess their understanding of different conditions necessary for the growth and reproduction of plants, as well as their understanding of a connection between climate change and agricultural productivity and the importance of exploring adaptations.

Enrichment Opportunities:

Visit a local farm or invite a farmer into the classroom to discuss with the students his or her concerns about climate change, including any changes in their crop productivity that they may have already noticed, and any adaptive measures they have taken or plan to take.

Have students, working either in small groups or independently, choose a country and carry out online research to learn about important agricultural practices in the country, ways that the country's agriculture may be affected by climate change, any food security issues, and ways that the country's agricultural practices are being adapted in response to climate change.

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Plant Growth Requirements, Crops, and the Climate Change Connection

What is the connection between plant growth requirements, crops, and climate change? Read on to find out!

Plant requirements for growth and reproduction

Plants, like humans and other animals, require energy to grow and reproduce. While animals get their energy from the food they consume, plants get their energy from the sun through a process called photosynthesis. Photosynthesis is the chemical process through which plants absorb sunlight and convert carbon dioxide and water into oxygen and sugar. Although some plants have adaptations that enable them to grow in environments with less sun (e.g., some plants thrive in shady environments), all plants have certain light requirements in order to survive and grow. Although artificial lights can be used in place of sunlight to grow plants, they are generally considered poor, and more expensive, substitutes for natural light.

In addition to access to light, plants also require temperatures that will allow them to successfully grow and reproduce. For example, seeds require certain temperature ranges in order for germination to occur. While cold soil temperatures in the spring can delay germination, overly hot temperatures in the summer can also prevent seeds from germinating. Rates of photosynthesis and plant respiration also increase with warmer temperatures (up to a point), and the opposite is also true: plant growth tends to slow down with lower temperatures.

Plants also require more water as temperatures increase and, when water is limited, plant growth may be stunted. Other conditions can also influence the water demands of plants. For example, crops growing in dry and/or windy regions also tend to have higher water requirements. A summary of how different climatic factors can affect the water needs of plants is provided in the Table 1.

CLIMATIC FACTOR	WATER DEMANDS	
	High	Low
Sunshine	Sunny	Cloudy
Temperature	Hot	Cold
Humidity	Low (dry)	High (humid)
Wind Speed	Windy	Little Wind

Table 1. Ways that climate affects the water demands of plants.

While plants take up water from the soil, soil is also important for plant growth and reproduction for other reasons. For example, plants also get air and important nutrients from soil (e.g., phosphorous, nitrogen, and calcium). Soil also provides stability to plants by providing a substrate that roots can use to anchor plants into position, which also allows plants to remain upright.

Now that you have read about some of the factors that are important for plant growth and reproduction, can you think of ways that plants might be affected by climate change?

How does climate change affect agricultural crops?

Given that temperatures, sunlight, and water availability are all important to the growth and reproduction of plants, it should not come as a surprise that plants are affected by climate change. Although climate change is expected to result in benefits for some agricultural crops and regions, there are also many ways that climate change will have negative impacts on agriculture.

Some of the ways that climate change can be beneficial to agricultural practices include the following: extending growing seasons, allowing farmers to plant new crops and varieties, and increasing growth rates as a result of warmer temperatures and more carbon dioxide in the atmosphere.

Unfortunately, according to a report published by the International Food Policy Research Institute, the overall impact of climate change on agriculture is expected to be negative. For example, higher temperatures as a result of climate change can eventually be detrimental to crops, while at the same time, higher temperatures can create conditions that lead to more weed growth and the spread of existing and new pests. (Note: with more weeds and more pests, farmers are also likely to increase their use of pesticides and herbicides - another negative consequence of climate change!)

Changes in precipitation patterns (e.g., both more and less rain) can also contribute to short and long-term declines in crop productivity and crop failures. Increases in extreme weather events and drought can also result in more soil erosion. Farmers may need to respond by improving drainage systems, considering ways to reduce soil erosion (e.g., installing wind breaks and reducing soil exposure by leaving crop material on fields after harvests), and investing in better soil management practices.

Another important factor to consider is how climate change will affect microorganisms in soil. Scientists have projected that climate change will result in microorganisms being more active which will lead to less organic material and nitrogen in the soil, causing the soil to be less fertile and more prone to soil erosion.

How will local agriculture be affected?

You may be wondering how agriculture in Nova Scotia will be affected by climate change. If so, you're not alone. Researchers anticipate that Nova Scotian farmers will also experience both benefits and challenges as a result of climate change. However, in general, Nova Scotia is not expected to be as negatively affected as other regions of Canada and other parts of the world.

The results of a recent study suggest that in Atlantic Canada, longer growing seasons and warmer temperatures may allow farmers to carry out additional cuts of certain forage crops. For example, the growing season in Kentville, Nova Scotia might increase in the range of an additional 30 – 50 days by

2080, according to an estimate made by one of Environment Canada's chief meteorologists. Forage crops (e.g., timothy, bluegrass, and white clover) are crops used to feed livestock, and so they are necessary for animal production in Nova Scotia. The same study also concluded that warmer temperatures can be good for heat-loving crops like corn and soybeans, resulting in possible higher yields (i.e., bigger harvests!).

Given that agriculture is important to Nova Scotia, the province is working on a number of adaptation measures to help its agricultural sector deal with climate change. For example, the province developed a water resource management strategy that takes into account the effects of climate change on both water quantity and water quality. In other parts of Nova Scotia, the height of dykes is being increased in order to protect agricultural lands from sea level rise.

While climate change is likely to bring both benefits and challenges to farmers in Nova Scotia, the agricultural sectors in other parts of the world may face a more difficult future.

Will climate change affect agriculture in China differently?

With the largest population in the world (and one that is growing more quickly than most!), China has reason to be concerned with how climate change will affect the country's agriculture. Although the effects of climate change on China's crops will also be mixed, researchers have warned that the impacts are likely to be largely negative.

For example, some researchers have projected that rising temperatures will likely contribute to a significant drop in China's production of important crops such as rice, corn, and wheat. The problem is expected to be even worse in areas of China that are already dry, e.g., arid and semi-arid regions in northern China. Rising temperatures will likely exacerbate water shortages and reduce plant growth even further. Of course, not all of China is getting drier. Wetter regions in China are actually experiencing more precipitation. This can be a problem too, however. For example, low-lying areas along China's Yangtze River may experience more flooding which can damage and destroy crops. In addition to floods, more extreme weather events in general will also threaten China's agricultural production. On a positive note, however, climate change has also resulted in some crops (e.g., rice) being able to grow in more northern locations, and has allowed farmers in some regions of China to begin experimenting with new crops and developing multi-crop planting systems that would not have been possible without warming temperatures.

Some of the ways that farmers in China can adapt to climate change include switching to crops that have higher yields as well as crops that are more heat and insect-resistant, increasing irrigation and promoting water-saving technologies, and transitioning from conventional crops to more intensive production in greenhouses.

As China is huge and regionally very diverse, climate change will affect agriculture differently across the country. And just as Nova Scotia and China have different challenges and opportunities to deal with, so to do other countries across the globe. Hopefully this brief introduction to the situations in Nova Scotia and China has left you with a better understanding of the connection between climate change, plant growth, and agriculture.

Name: _____ Date:_____

Plant Growth Requirements and the Climate Change Connection

After completing the reading, answer the following questions in the spaces provided.

1. Describe two factors that are important for the growth and reproduction of plants.

2. Identify and explain one way that climate change might be beneficial to crop production, and one way that climate change could threaten crop production.

3. Describe one similarity and one difference between how agriculture in Nova Scotia and China may be affected by climate change.

4. Identify three adaptations that might help farmers in Nova Scotia and/or China cope with the effects of climate change.

5. Why is it important to adapt agricultural practices in response to climate change?

Food Security

Food security exists "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life"

World Food Summit, 1996

Is there a possible connection to climate change?

Who is at risk of being food *in*secure?

How can the province of Nova Scotia increase its food security?

URBAN AREAS & CLIMATE CHANGE

LESSON 6

Introduction:

Urban areas are the major sources of greenhouse gas emissions contributing to the enhanced greenhouse effect and climate change and are also expected to face many unique challenges as a result of climate change. For example, cities may be faced with increased temperatures (often made worse by the urban heat island effect), droughts, flooding, and storm events. Importantly, cities are also sites of climate change response, including policies and actions with the goal of reducing climate change and adapting to its impacts. One response that is frequently discussed within cities is enhancing urban forests.

Urban trees, and urban vegetation more generally, can have direct and indirect effects on air quality. For example, trees can effect temperature (often contributing to cooler temperatures) and reduce airborne pollutants including carbon and decrease smog (e.g., through uptake by leaves or absorption). Trees can also reduce cooling requirements for buildings as a result of the shade they provide, although the reverse may also be true, i.e., buildings may use more energy for heating as a result of the cooling effects of trees during the winter. The fact that trees also emit volatile organic compounds and can require energy intensive maintenance must also be factored into their net impacts. In addition to their effects on air quality, urban trees can reduce stormwater runoff, erosion, and water pollution.

However, while urban forests can be an important part of a city's response to climate change, trees are also vulnerable to the impacts of climate change and appropriate management plans may be required to ensure healthy and sustainable urban forests. Parts of Nova Scotia have already begun to recognize the values of urban forests and have been making plans to develop their urban forests as one of many climate change adaptations that are appropriate for urban areas. For example, members of Dalhousie University in Halifax have teamed up with the Halifax Regional Municipality to create an Urban Forest Master Plan with the goal of ensuring that the area's urban forest is protected and expanded.

Objectives:

Students will learn about some of the many ways that urban areas are likely to be affected by climate change and will discuss both mitigation and adaptations that are appropriate responses for people living in urban areas. In particular, through a discussion about how trees and plants interact with the air, students will learn about the benefits of expanding urban forests and investing in green roofs, as well as the benefits of using 'cool' building materials, reflective surfaces, etc. Students will conduct online research to learn more about ways that urban areas can help to mitigate the urban heat island effect, and will also design a 'cool' building that could be appropriate for construction in Halifax.

Specific Curriculum Outcomes:

Students will be expected to…

- describe interactions between abiotic and biotic factors in an ecosystem (Science, 306-3)
- provide examples of scientific knowledge that have resulted in the development of technologies (Science, 111-1)

- use instruments effectively and accurately for collecting data (Science, 209-3)

Materials:

- Teaching Resources 6.1 and 6.2, *Taking the School's Temperature* and *Designing 'Cool' Buildings*
- Thermometers for measuring outdoor temperatures around the schoolyard
- Access to laptop/computer to view urban heat island effect video(s)
- Access to computer lab for students to carry out online research

Time Frame:

- 1-2 hours

Activities:

1. Ask students whether they've heard the expression that it's so hot you can fry an egg on the street. Have students comment on this expression, e.g., can it get hot enough to actually cook an egg on pavement? Why are dark, paved surfaces hotter than surfaces that are light colours, or surfaces covered with vegetation?

2. Explain to students that you can, in fact, cook an egg on a paved surface (you can even tell them that Bill Nye the Science Guy recently carried out this experiment), it just takes much longer than it would on a stovetop.

3. Help students understand the reasons why built surfaces such as paved roads, sidewalks, parking lots, buildings, etc., tend to be hotter than natural surfaces or surfaces that are made of more reflective materials or lighter colours, (i.e., built surfaces tend to absorb significant amounts of solar radiation and then release this as heat – this is in contrast to natural surfaces that absorb solar radiation but then, through processes of evaporation, they release water vapour and help cool surrounding areas).

4. Have students suggest how this information relates to climate change. Help students begin thinking about how built surfaces can further increase temperatures, therefore amplifying temperature increases that occur as a result of climate change.

5. Ask students to suggest whether the temperature might vary at all around their own school yard. Have students make predictions and share hypotheses. Weather permitting, take students outside to measure temperatures in various locations around their school yard. Work as a class, or in smaller groups (depending on access to thermometers) to complete Teaching Resource 6.1.

6. Discuss students' hypotheses and/or results.

7. Introduce students to the idea of the 'urban heat island effect,' and explain that with so much of urban environments covered in buildings and other built surfaces (e.g., parking lots, streets, etc.), the temperatures in cities can actually be a few degrees warmer than outside of cities. Consider using online an online video(s) to help explain the concept to students (e.g. Urban Heat Island Effect – Mitigation prepared by U.S. EPA: http://www.epa.gov/heatisld/about/videos.htm).

8. Explain that while this is a particular problem for big cities (i.e., cities with populations of at least a million people), cities such as Halifax and Sydney can also benefit from considering ways to help cool down their urban temperatures.

9. Introduce students to actions that cities can take to help cool down and counter the urban heat island effect (e.g., use more reflective, lighter-coloured surfaces, increase tree cover, promote development of green roofs, etc.).

10. Tell students that they are to imagine they are urban planners, hired to design a new building in downtown Halifax.

11. Have students conduct online research to learn more about strategies they can incorporate into their design to help cool down their building, e.g., urban forestry, green roofs, 'cool' building materials, and other options that exist for cities to counter increasing temperatures. Suggested websites include: www.greenroofs.org, Cool Materials and Shade Trees - http://eetd.lbl.gov/l2m2/cool.html, http://www.coolroofs.org/, and http://www.treecanada.ca/site/?page=programs_urbanforestry&lang=en.

12. Tell students that they are to prepare a diagram of their building that specifically focuses on strategies they have incorporated into their design to keep the building cool. Instruct students that, in addition to their labelled diagram, they are to include a one page write-up explaining their design strategy drawing on the information they discovered during their research.

13. Give students time to share their plans, if desired, with classmates and discuss some of their ideas. What might be feasible? What challenges would exist? Etc.

Assessment:

Students' contributions to classroom discussion can be used to assess their understanding of how tempering the urban heat island effect can be described as an example of relationships between abiotic and biotic factors in an urban ecosystem. Students' predictions of the temperature recording activity and their contributions to classroom discussions can be used to assess their understanding of how and why built environments can be hotter than surrounding areas. The 'cool' building designs and accompanying write-ups can be used to assess students' understanding of how scientific knowledge of the absorption of solar radiation and the urban heat island effect has led to the use of different technologies to cool down urban environments.

Enrichment Opportunities:

Have students choose a major city (provide examples of major cities in Canada and from the international community) and research how this city may be affected by climate change, and ways that the city may be adapting. Similarly, students could explore ways that their school could adapt.

Recommended Readings:

Health Canada's Climate Change and Health: Adaptation Bulletin - The Urban Heat Island Effect: Causes, Health Impacts and Mitigation Strategies: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/climat/adapt_bulletin-adapt1/adapt_bulletin-adapt1-eng.pdf.

References:

Behan, K. (2009). Climate change and the urban forest: Toronto workshop – Proceedings. *The Clean Air Partnership.* Retrieved from http://www.cleanairpartnership.org/files/Climate%20Change%20and%20the%20Urban%20Forest%20Proceedings.pdf.

Health Canada. (2010). *The urban heat island effect: causes, health impacts and mitigation strategies*. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/climat/adapt_bulletin-adapt1/adapt_bulletin-adapt1-eng.pdf.

Lankao, P.R. (2008). *Urban areas and climate change: Review of current issues and trends*. Issues Paper for the 2011 Global Report on Human Settlements. Retrieved from http://www.ral.ucar.edu/staff/prlankao/GRHS_2011_IssuesPaperfinal.pdf.

McCarthy, M.P., Best, M.J., & Betts, R.A. (2010). Climate change in cities due to global warming and urban effects. *Geophysical Research Letters, 37*, L09705.

Nowak, D.J. (n.d.). *The effects of urban trees on air quality*. *USDA Forest Service.* Retrieved from http://www.coloradotrees.org/benefits/Effects%20of%20Urban%20Trees%20on%20Air%20Quality.pdf.

Nye, B. (2011). *So hot, you could fry an egg.* Retrieved from http://www.billnye.com/so-hot-you-could-fry-an-egg/.

Ross, J. & Duinker, P. (2011). *Turning over a new leaf: Halifax's Urban Forest Master Plan*. Retrieved from http://www.halifax.ca/RealPropertyPlanning/UFMP/index.html.

Names: _____ Date:_____

Taking the Schoolyard's Temperature

As a group, discuss your predictions about whether the temperature fluctuates between different areas in your schoolyard.

Record a group hypothesis:

Choose 4 locations within your schoolyard to record temperatures at. Try to choose locations that are noticeably different (e.g., paved surface, under a tree, beside a building, etc.). Record your data below:

Location 1: Brief description	Temp. at ground level: Temp.at shoulder level:	Location 2: Brief description	Temp. at ground level: Temp. at shoulder level:
Location 3: Brief description	Temp. at ground level: Temp. at shoulder level:	Location 4: Brief description	Temp. at ground level: Temp. at shoulder level:

Record your conclusion based on the above results:

Name: _____ Date:_____

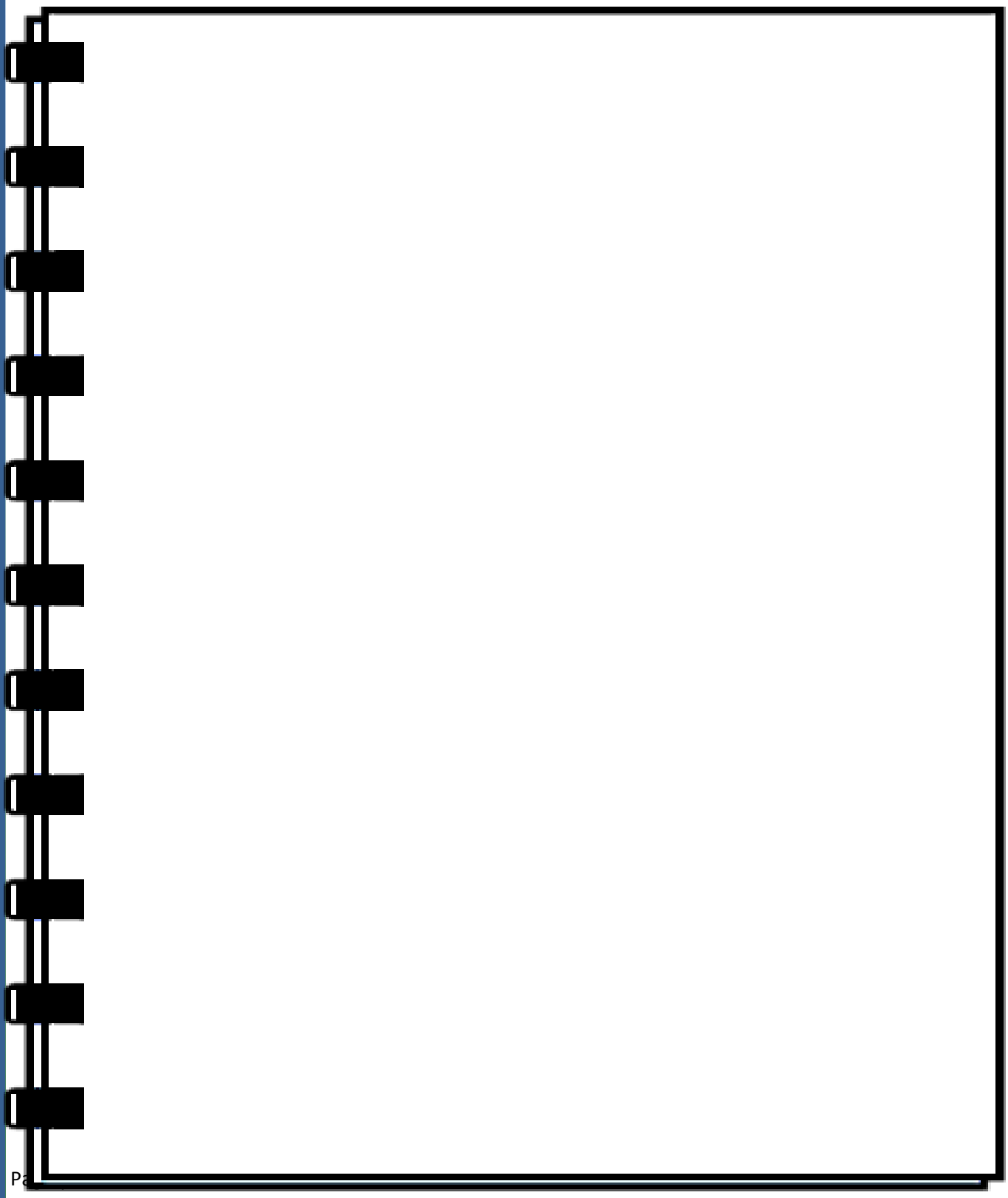
Designing 'Cool' Buildings

Imagine you have been hired as an urban planner with the Halifax Regional Municipality (HRM). Your job is to design a new building (your choice of type of building – e.g., apartment building, retail building, office complex, etc.) that will be located in Halifax's downtown core.

Halifax Regional Municipality is concerned about climate change and the urban heat island effect, and you have been instructed to incorporate strategies into your design that will help keep this new building cool. In particular, the HRM is interested in urban forestry, green roofs, and using 'cool' building materials.

In the space below, create a design for your new building. Label features that help keep the building cool. Remember to think about such things as rooftops, vegetation and trees, parking lots, building materials, size and location of the building, etc.

HRM has also requested that you include a write-up explaining your decisions as an urban planner with a focus on how you have attempted to keep the building cool. On the report paper below, describe different strategies that you have chosen to incorporate, including an explanation of their potential benefits. You may also choose to comment on any challenges that you expect to encounter.



USING ART TO REVEAL DIFFERENT FACES OF CLIMATE CHANGE

LESSON 7

Introduction:

Artists across the world have taken to creating art that communicates feelings, messages, and ideas inspired by the reality of global climate change. While individual artists have become known for their efforts to capture climate change, including the effects of a changing climate, through their art (e.g., Canadian artists Linda Mackey and Franke James), entire exhibitions and festivals have also been dedicated to the cause of raising awareness of climate change. Cape Farewell, which has been described as an ambitious artist-led program involving collaboration with members of the scientific community and other partners that produces climate change inspired art exhibitions, film, events, and media activities, is an example of how artists can use their creative works to engage audiences, encouraging them to think about climate change and understand the urgency of the climate change challenge. Not surprisingly, while climate change is a global issue, the content and focus of artistic creations tends to vary between countries and regions of the world where climate change may have significantly different impacts and create unique challenges. Cape Farewell, with contributions from artists around the world, captures some of this international variation.

Objectives:

As the culminating activity for this teaching module, students will be encouraged to reflect back on what they have learned about some of the ways that climate change will impact Nova Scotia, as well as mitigation and adaptations that might be appropriate for Nova Scotia in order to deal with the challenges created by climate change. Students will create a piece of art (e.g., painting, drawing, collage, etc.) that communicates their thoughts about how they might be affected by climate change. Students will be able to share their art and discuss their concerns and feelings about climate change. Finally, by looking at some additional pieces of work, students will be encouraged to think about how people in different parts of the world may be impacted differently than Nova Scotians.

Specific Curriculum Outcomes:

Students will be expected to…

- communicate questions, ideas, intentions, plans, and results using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means (Science, 211-2)
- identify questions to investigate arising from practical problems and issues (Science, 208-2)
- construct art that embodies meaning (Visual Arts, 2.1)
- analyze artwork and make conjectures as to the artist's intention (Visual Arts, 8.1)

Materials:

- Teaching Resources 7.1-7.3

- Art materials (paper, paint, paintbrushes, pencil crayons, etc.)

Time Frame:

- 1-2 hours

Activities:

1. Encourage students to think back over the past 6 lessons, and share some of the information that they learned about climate change. Give students a few minutes to write down some of their own ideas, and then give students a few minutes to discuss/compare ideas with a neighbour.

2. Record students' ideas on the board. Have students look for common themes.

3. Remind students about the first activity in the unit, i.e., how they created a climate change advertisement to try to capture their understanding of how they could be affected by climate change.

4. Tell students that, with their new knowledge about climate change, they will be creating a piece of art that will represent how they feel they might be affected by climate change. Explain to students that, as was the case with the advertisement, they can be creative with this exercise. Also, let students know that while their art might look quite different from their original advertisement, the two can also be quite similar.

5. Emphasize to students the importance of taking their time to produce their best quality work as it will be displayed in the classroom, or somewhere in the school, to help raise awareness about climate change.

6. Give students enough time to carefully complete their art. Instruct students to write one or two sentences describing that they have drawn. They may also decide to give their art a title.

7. Once students have completed their art, give students an opportunity to share their work with their classmates, and discuss some of their concerns, feelings, etc. at the end of this study of climate change.

8. Show students examples of other climate change art (Teaching Resources 7.1 – 7.3) and have students comment on the art and discuss why artists from different areas (this could be different parts of Canada or even different countries) might create very different art that deals with issues related to climate change.

9. Have students look back at the information that was recorded on the board about climate change. Invite students to think about any questions they still have related to climate change.

Encourage students to consider ways of finding answers to these questions and continuing to learn more about such an important global issue.

Assessment:

Students' artwork and their written explanations can be used to assess their ability to use art to express their understanding about how they might be affected by climate change. Students' contributions to classroom discussions can also be used to assess students' ability to respond to works of art and identify ways that people living in different parts of the world might be impacted by climate change.

Enrichment Opportunities:

Invite a local artist (ideally an artist interested in climate change or other environmental issues) to visit the classroom in order to discuss with students their work.

References:

Cape Farewell. (2011). *How Cape Farewell works.* Retrieved from http://www.capefarewell.com/about/about.html.

Climate Change on Canvas

Used with permission of the artist Ashley Cecil, Pittsburgh, USA (www.ashleycecil.com)

Climate of Hope

Used with permission of the artist, Linda Mackey

Beautiful Dead

Used with permission of the artist, Caroline Ellis, Australia (www.carolineellisart.com)