Bringing Climate Change into the Classroom:

A teaching module for use with Nova Scotia's Grade 10 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: Public Perceptions of Climate Change	*Introduce brief history of climate change *Discuss factors that affect/shape public perception of environmental issues such as climate change *Make connections between sustainability and behaviours that contribute to enhanced climate change	*Create artwork to capture students' understanding of climate change *Conduct interview on changing perceptions of climate change (Homework)	**Science:** *question and analyse how a paradigm shift in sustainability can change society's views (114-1) **Visual Arts:** *demonstrate an understanding of how meaning is embedded in works of art (PR 6.5)
2: Working with Climate Change Data	*Brainstorm ideas, prior knowledge, and questions about climate change *Discuss the importance of reading material critically and being aware of potential biases *Review difference between climate and weather and the importance of large data sets *Emphasize that effects of climate change vary between regions	*Create a climate change concept map (Large group activity) *Read *The Cooling World* and view and discuss interpretations of climate data to emphasize the importance of reading information and data critically *Plot and analyze actual temperature data from Kentville, NS to look for trends	**Science:** *identify questions and analyse meteorological data for a given timespan and predict future weather conditions, using appropriate technologies (214-10, 331-5, 212-1) *identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10) **Math:** *analyze graphs or charts given of situations to determine specific information (A2) *construct various displays of data (F3)
3. Sea Level Rise & Coastal Adaptations	*Introduce sea level rise as a result of thermal expansion and glacial melt *Become familiar with some of the ways that sea level rise is likely to affect coastal residents of Nova Scotia, specifically people in Halifax; discuss options for appropriate adaptations	*Thermal expansion demonstration *Complete reading and accompanying questions on glacial melt, including calculations involving the rate of melt of present day glaciers and their contributions to sea level rise *Read article *Halifax Harbour faces rising waters* and write a letter of reflection and critical enquiry to the mayor of Halifax	**Science:** *identify questions and analyse meteorological data for a given time span and predict future weather conditions, using appropriate technologies (214-10, 331-5, 212-1) *describe how the atmosphere and hydrosphere act as heat sinks in the water cycle (331-3) *predict and analyse the impact of external factors on the sustainability of an ecosystem, using a variety of formats (212-4)
4. The Forest-Carbon Connection	*Review the carbon cycle and discuss roles of trees as potential carbon sinks *Explore opportunities for trees/forests to be used to help mitigate and/or adapt	*Calculate and compare carbon storage potential of various tree species; answer accompanying questions *Conduct online research to gain more information on the	**Science:** *identify, investigate, and defend a course of action on a multi-perspective social issue (118-9, 215-4, 118-5) *use library and electronic research

	to climate change *Become familiar with the United Nations' program Reducing Emissions from Deforestation and Forest Degradation (REDD+) and investigate potential benefits and limitations (optional)	UN's Reducing Emissions from Deforestation and Forest Degradation (REDD+) program and write a short piece of persuasive writing arguing for/against Canada's involvement with REDD+ (optional)	tools to collect information on a given topic (213-6) *select and integrate information from various print and electronic sources or from several parts of same source (213-7) *develop, present, and defend a position or course of action, based on finding (215-5)
5. Sustainable Agriculture	*Discuss how climate change is likely to affect agriculture in Nova Scotia (both positive and negative effects) *Explore connection between agriculture and climate change, including contributions to enhanced greenhouse effect, potential appropriate adaptations, sustainability of different agricultural systems	*Group role play exercise to explore hypothetical introduction of a new industrial scale poultry farm in Nova Scotia and connections to climate change *Complete online diet activity as a way of beginning to think about connections between food and carbon; write journal response to activities	**Science:** *identify, investigate, and defend a course of action on a multi-perspective social issue (118-9, 215-4, 118-5)
6. Cities, Climate Change, & the Importance of Public Education	*Compare/contrast ways urban and rural areas contribute to, and are likely to be affected by, climate change *Emphasize the importance of public education as a way of helping people respond and adapt to climate change	*Complete a Venn diagram to compare climate change and urban vs. rural areas *Working in small groups, prepare an informative pamphlet or poster designed to educate citizens in a specific urban area of NS about climate change, including information on causes, mitigation, and adaptations	**Science:** *predict and analyse the impact of external factors on the sustainability of an ecosystem, using a variety of formats (212-4, 214-3, 331-6) *diagnose and report the ecosystem's response to short-term stress and long-term change (213-7, 215-1, 318-4)
7. Photography Challenge	*Reflect on previous 6 lessons and the information learned about climate change *Discuss use of photography to communicate feelings, messages, experiences, etc. related to climate change	*Revisit climate change concept map and expand with additional information *Visit websites to view and compare photographs related to climate change from different countries and cultures *Use photography to represent students' understanding of climate change and climate change impacts and/or adaptations	**Science:** *question and analyse how a paradigm shift in sustainability can change society's views (114-1) **Visual Arts:** *demonstrate an understanding of how meaning is embedded in works of art (PR 6.5)

***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.**

PUBLIC PERCEPTIONS OF CLIMATE CHANGE

LESSON 1

Introduction:

Although most people think of climate change as a relatively recent phenomenon, the reality is that scientists have been thinking, and writing, about the possibility of climate change for decades. For example, an article that appeared in *Time* magazine in 1939 suggested that the world was getting warmer. While the possibility of a warming planet was slow to be widely accepted, the idea of anthropogenic climate change has been met with considerable resistance and, as such, has been even slower to gain acceptance. Although the scientific consensus is that human actions are contributing to an enhanced greenhouse effect and thereby accelerating climate change, many people have yet to be convinced. Given that mitigating and adapting to climate change requires humans to change their behaviours and lifestyles, it is important to consider how public perception of climate change has evolved, and how changes in public perception can translate to responses with the goal of slowing down climate change and protecting ecosystems and their inhabitants.

Objectives:

As an introduction to climate change, students will be given a brief history of climate change with a focus on major scientific developments and how public perceptions have changed over time. Students will be asked to produce a drawing that captures their perception of how they may be affected by climate change and, after being introduced to a short history on perceptions of climate change, will consider how their drawings might have looked different if they were produced at earlier points in history. After introducing students to some projections of changes due to climate change, students will be encouraged to comment on the sustainability of certain actions/behaviours/lifestyles that contribute to climate change. Students will discuss how scientific consensus concerning the role of human activity in contributing to global climate change and may lead to changes in human behaviour.

Specific Curriculum Outcomes:

Students will be expected to…

- question and analyse how a paradigm shift in sustainability can change society's views (Science, 114-1)
- demonstrate an understanding of how meaning is embedded in works of art (Visual Arts, PR 6.5)

Materials:

- Teaching Resource 1.1 - 1.3
- Art supplies for creating climate change drawings (paper, colouring pencils, etc.)

Time Frame:

- 1-2 hours

Activities:

1. Have students guess when the concept of what is now known as global climate change first surfaced.

2. Once students have made some guesses, explain that climate change is not a recent phenomenon as many people think. Use Teaching Resources 1.1 and 1.2 to help give students a sense of some of the important events and dates in the history of climate change.

3. Explain that, not surprisingly, the public's perception of climate change has also changed considerably over the same time period. Have students suggest events that may have been particularly important in shaping public perception.

4. Explain to students that they will be creating a drawing to capture their perception of how they may be likely to be impacted by climate change. Have students write a short explanation of what they have attempted to communicate to accompany their illustration.

5. After students have finished, students can be encouraged to share their work. Invite students to suggest different sources of information that have shaped public perceptions of climate change (e.g., Internet, television, school, newspapers, Twitter, etc.). Have students comment on which sources are most influential, reliable, etc.

6. Have students comment on how the generations of their parents and/or grandparents may have completed this activity differently. How would they expect their pictures to differ? What sources of information would they have been likely to have relied on?

7. Explain to students how important public perception of environmental problems is in order to motivate people to change their behaviour and accept regulations, policy changes, etc., that attempt to respond to growing environmental problems.

8. Introduce homework activity, Teaching Resource 1.3. Tell students that they are to ask an adult in their lives, ideally someone older such as a parent or a grandparent, about their experiences with climate change. Tell students that they will discuss some of their findings at the start of the next class on climate change.

Assessment:

Students' contributions to classroom discussions can be used to assess their understanding of how public perceptions of climate change can change over time and some of the reasons why these changes occurred. Students' homework assignments can also be used to assess their ability to comment on how public perception has changed, and is likely to change, over time.

References:

Environment Canada. (2010). Global response to climate change: Timeline. Retrieved from http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=856B1CA2-1.

Evans, A. & Steven, D. (2007). Climate change: The state of the debate. *Center on International Cooperation.* Retrieved from http://www.cic.nyu.edu/staff/docs/d_steven/LondonAccordclimatepaper.pdf.

Leiserowit, A. (2007). Public perception, opinion and understanding of climate change – current patterns, trends and limitations. *Human Development Report 2007/2008.* Retrieved from http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/leiserowitz_anthony.pdf.

Office of the Auditor General of Canada [OAG]. (2007). *Exhibit 4—Timeline of key international and domestic climate change events.* 2006 September Report of the Commissioner of the Environment and Sustainable Development. Retrieved from http://www.oag-bvg.gc.ca/internet/English/att_c20060900se01xe04_e_14553.html.

Early Climate Change Timeline: Some Highlights

1827

French scientist Jean-Baptiste Fourier recognized the warming effect of an enhanced greenhouse effect

1896

Swedish chemist Svante Arrhenius calculated how increasing concentrations of CO_2 in the atmosphere would affect temperatures (while Arrhenius predicted that more atmospheric CO_2 would increase temperatures, he also argued that this would ultimately be beneficial as he predicted more enjoyable climates and better growing conditions for crops)

1930s

Possibility of a warming world enters the public imagination; Media coverage raising possibility of warming planet (e.g., *Time* magazine ran a cover story on possible global warming in 1939)

1957

Roger Revelle and Hans Suess published a paper warning of uncertainty and potential dangers of anthropogenic warming, describing humans as carrying out a "large-scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future"

1960s

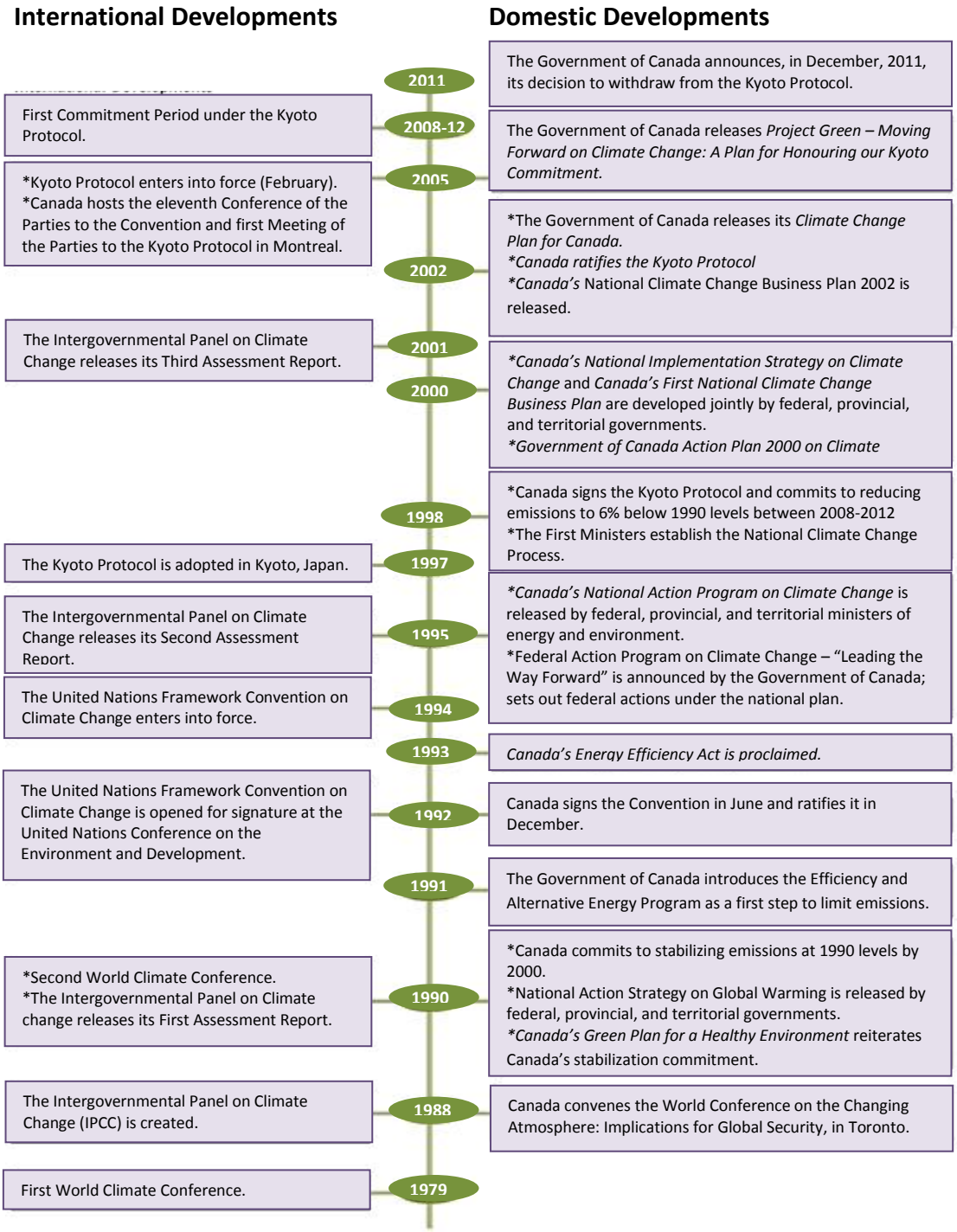
There are increasing concerns about pollution and smog; Rachel Carson publishes her influential book *Silent Spring* which further raised awareness about dangers of pollutants; relatively sparse media coverage of climate events

1972

First year during the 20th century when widespread climate disasters (e.g., serious droughts and the collapse of Peruvian fisheries during an El Niño event) really began to enter the consciousness of the media and public

What has Canada and the International Community been up to since?

Timeline of Some Major Developments since the 1970s



Original image courtesy of the Office of the Auditor General, 2007

Name: _____ **Date: _____**

Changing Climate Change Perceptions

Name of Interviewee:	Age:
When did you first remember hearing about climate change?	
Through what kinds of media, or other sources of information, did you first become familiar with climate change?	
How has your understanding of climate change evolved over the years? Do you think climate change is a more important issue now?	
Can you remember any events or news items that have changed your perception of climate change either in recent years or earlier?	
Has information about climate change caused you to change your behavior in any way (e.g., influence your energy consumption patterns, decisions about where to live or travel, etc.)?	

WORKING WITH CLIMATE CHANGE DATA

LESSON 2

Introduction:

Despite the fact that the scientific consensus is that humans are contributing to an enhanced greenhouse effect and causing global climate change, a small number of vocal climate change denialists and biased and misinformed reporting can make understanding climate change science especially confusing. However, the scientific community, and the Intergovernmental Panel on Climate Change (IPCC) in particular, has also been charged with downplaying complexities and uncertainties which can fuel public distrust of climate change science. Confusion, complacency, distrust, and denial are common among the public and policymakers, compromise efforts to modifying behaviour and gain support for policies and programs requiring mitigation and adaptation measures. By helping to educate people about the complexities of climate change science and encouraging the public to be critical readers, public acceptance and willingness to respond to climate change may be increased.

Objectives:

By reading a news article (*The Cooling World*) from *Newsweek* published in 1975, students will both gain a better understanding of how public perceptions of climate change have evolved over time, and will also begin to understand the importance of critically reading articles and interpreting data related to climate change. Analysis and discussion of two problematic interpretations of data will further highlight the importance of being aware of potential biases and flawed interpretations of data. Students will have an opportunity to plot their own line graphs with mean temperature data from Kentville, Nova Scotia as a way of looking into local weather patterns and discussing possible trends that may be related to climate change. Looking at an image of changes in global mean temperatures will help students realize that climate change does not affect areas uniformly.

Specific Curriculum Outcomes:

Students will be expected to…

- identify questions and analyse meteorological data for a given timespan and predict future weather conditions, using appropriate technologies (Science, 214-10, 331-5, 212-1)
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (Science, 214-10)
- analyze graphs or charts given of situations to determine specific information (Mathematics, A2)
- construct various displays of data (Mathematics, F3)

Materials:

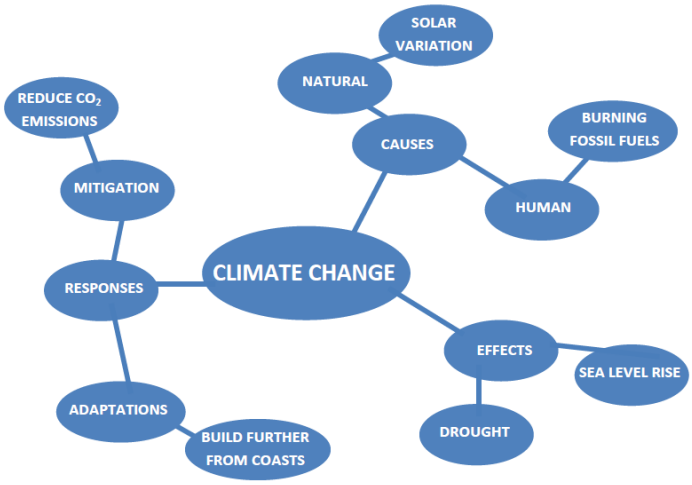
- Teaching Resources 2.1 – 2.4
- Copies of *The Cooling World* (available as .pdf online)

Time Frame:

- 1-2 hours

Activities:

1. With students' help, create a climate change concept map on the board (see example). Encourage students to share what they know/think they know about climate change. Ideas that students are uncertain about, or any myths/misinformation should be recorded separately under a 'To Be Explored' section.



2. Tell students that they will revisit the climate change concept map activity at the end of the unit, at which time they will hopefully have information to add to the map. They may also have answers to some of their questions/uncertainties at this time, as well as additional questions.

3. Explain to students that they will be continuing to learn more about climate change. However, emphasize that it is important to be aware of the fact that climate change science can be difficult to follow and make sense of due to controversies, uncertainties in data, and biased reporting/misinformation that is common in the media.

4. Have students share some of their findings from the homework interview activity, in particular what they learned about ways that public perception can change over time.

5. Tell students that they will be reading *The Cooling World*, a news article from the 1970s, to get a sense of both how long ago people were exposed to ideas about climate change, and also to see that even decades ago the science was not straightforward. (Copies of original article are available online, e.g., http://www.winningreen.com/site/files/621/52303/206292/277692/coolingworld.pdf and http://denisdutton.com/newsweek_coolingworld.pdf.)

6. After reading the story, discuss students' reactions. Ask students to suggest whether they would expect to see a story like that published today. Why or why not?

7. Show students Teaching Resource 2.1, the graph that reveals how, even during the 1970s when *The Cooling World* was published, papers about global warming were much more common than papers on global cooling. Explain to students that the media has tremendous power in terms of its influence on the public perception of environmental issues and what stories get coverage. Explain to students that while they may still come across papers that argue against climate

change, possibly suggesting that the Earth is actually even cooling, it is important to read papers critically and pay attention to the scientific consensus on topics such as climate change.

8. Explain to students that it is also important to be careful about how they interpret data and graphs related to climate change, as they can be confusing and misleading. Explain biases to students and have students suggest reasons why someone might have a bias against climate change.

9. Show students Teaching Resource 2.2. Explain that graphs such as this have been used to support claims that there is not a clear connection between climate change and burning fossil fuels because temperatures were lower during the post WWII industrial boom (highlighted bar), and that there have been more years in which temperature has cooled than warmed during the entire time period represented on the graph. Help students to understand what is problematic about these examples. Ask students to suggest how they might affect public perception.

10. Tell students that they will have an opportunity to create their own graph of weather data and make interpretations. They will be using temperature data from Kentville, Nova Scotia to create a line graph and look for potential trends that may be related to climate change.

11. Give students time to complete Teaching Resource 2.4. Remind students to label their axes and give their graph an appropriate title. Suggest to students that, given the range of their data, they design their y-axis to span from 5 – 10 degrees Celsius.

12. Once students have finished their graphs and answered the accompanying questions, take up their answers as a class. Use Teaching Resource 3 to help students see a trend in their data. Discuss their findings and review the difference between climate and weather. Have students suggest why it is important to have a large data set, covering a long time period, in order to draw conclusions about changes in climate.

13. Ask students whether they would expect to see the same trends if they carried out the same data analysis for towns across Nova Scotia, Canada, and the world. Have students explain their answers. Use Teaching Resource 2.5 to help students realize that climate change is not uniform. While the global average surface area temperatures show signs of gradually increasing, the rate of increase varies between areas, and some places even have trends of slight cooling.

Assessment:

Students' participation in classroom discussions and their completion of Teaching Resource 2.4 can be used as assessment opportunities to gain a sense of whether students understand biases and difficulties with interpreting data, how perceptions have changed over time, and how actual data can be used to create graphs from which interpretations can be drawn and potential trends identified.

Enrichment Opportunities:

Have students find an article (can be published online or in print) related to climate change. Encourage students to read the article critically and write a one page reflection/response to the article. This can be completed as homework or as an in-class assignment provided that students have access to newspapers, magazines, and/or the Internet.

Recommended Reading:

What were the climate scientists predicting in the 1970s? Available at http://www.skepticalscience.com/ice-age-predictions-in-1970s-intermediate.htm

References:

Biermann, M. (n.d.) The role of local NGOs in anticipating and responding to climate change.*Pennsylvania State University.* Retrieved from http://www.ehs.unu.edu/file/get/4106.

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McKibbin, W.J., & Wilcoxen, P. (2004). Climate policy and uncertainty: The Roles of adaptation versus mitigation. Retrieved from http://www.brookings.edu/~/media/Files/rc/papers/2004/05globaleconomics_mckibbin/20040515_bdpie161.pdf.

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The myth of the 1970s global cooling scientific consensus

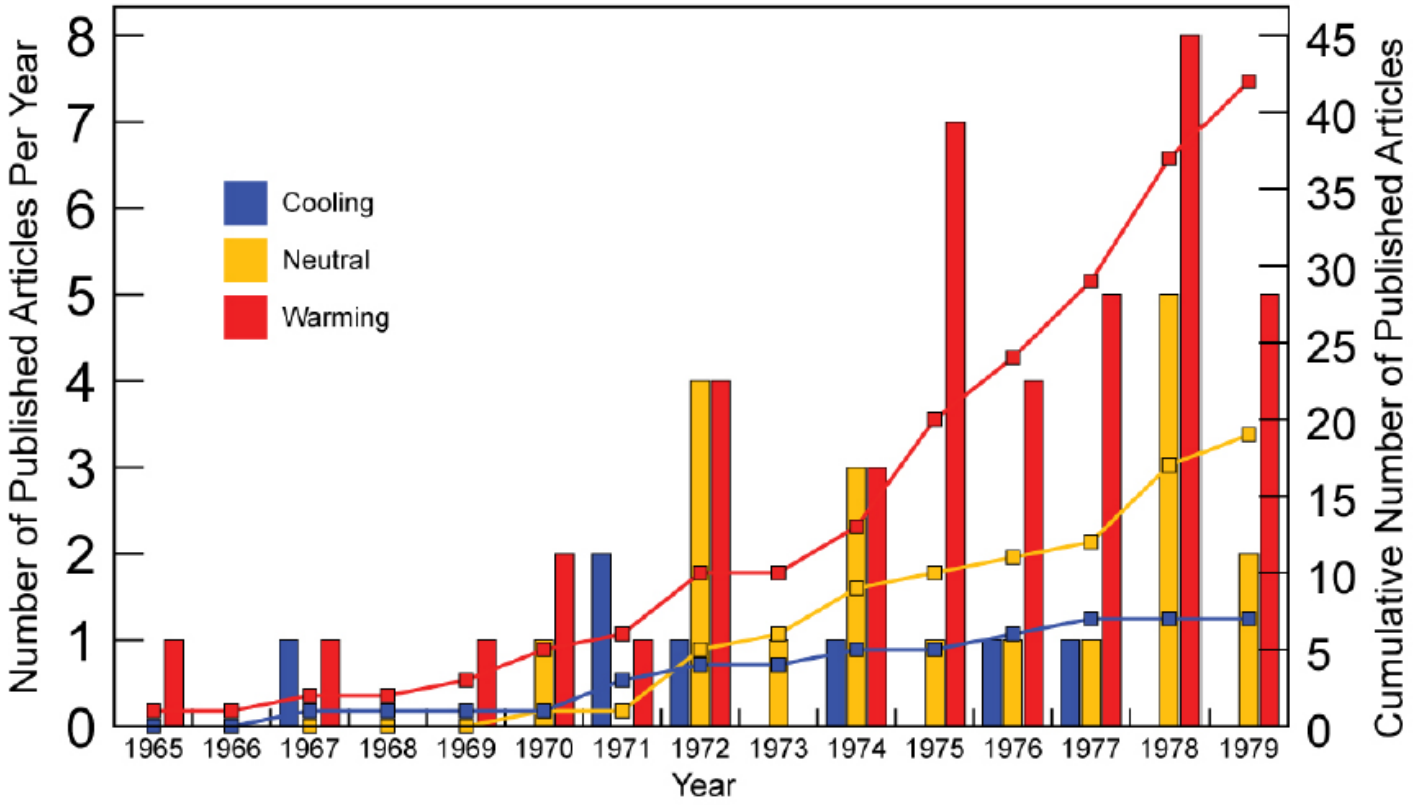
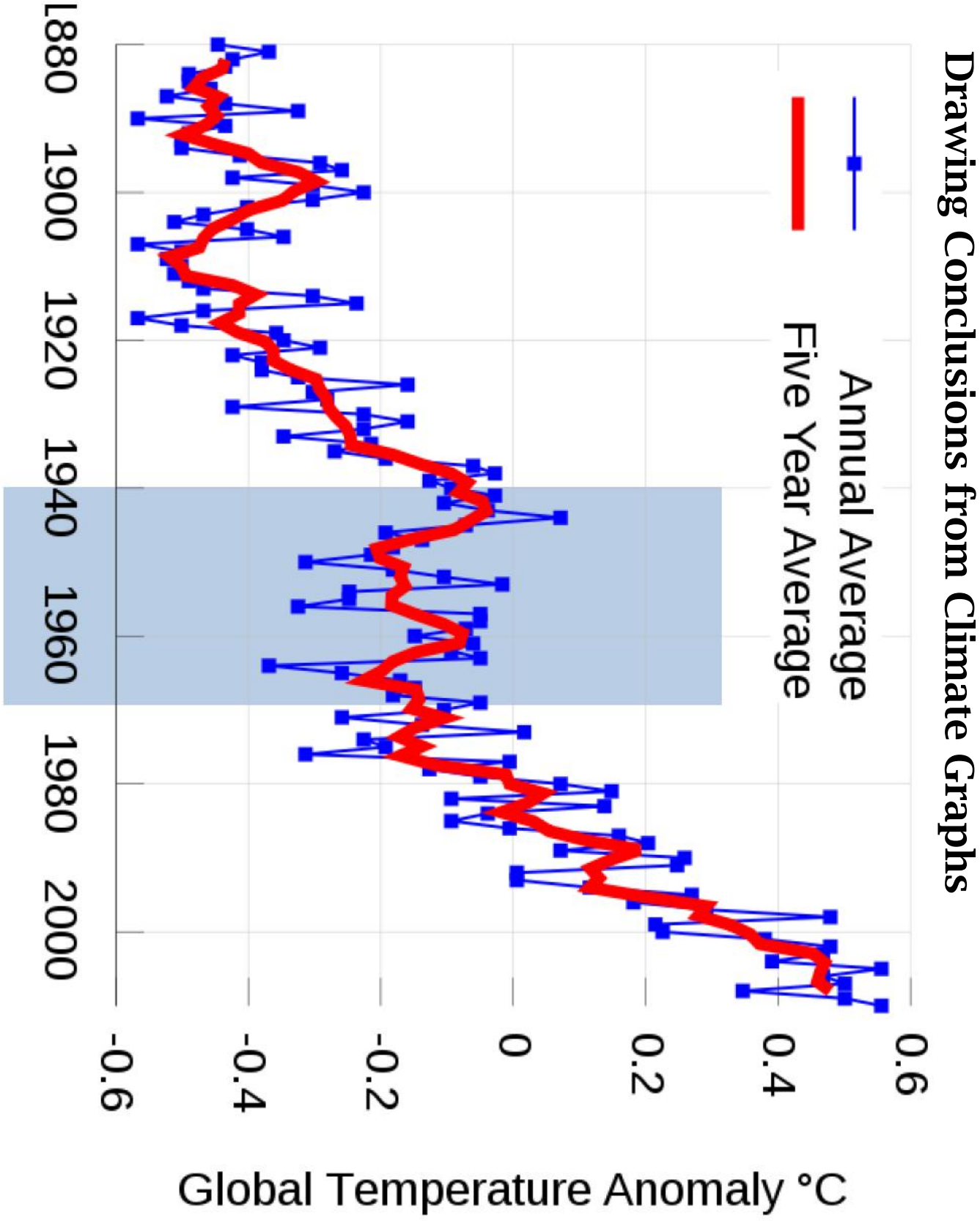


Figure 1. The number of papers classified as predicting, implying or providing supporting evidence for future global cooling, warming and neutral categories as defined in the text and listed in Table 1. During the period 1965 through 1979, our literature survey found 7 cooling papers, 19 neutral and 42 warming. In no year were there more global cooling papers than global warming.

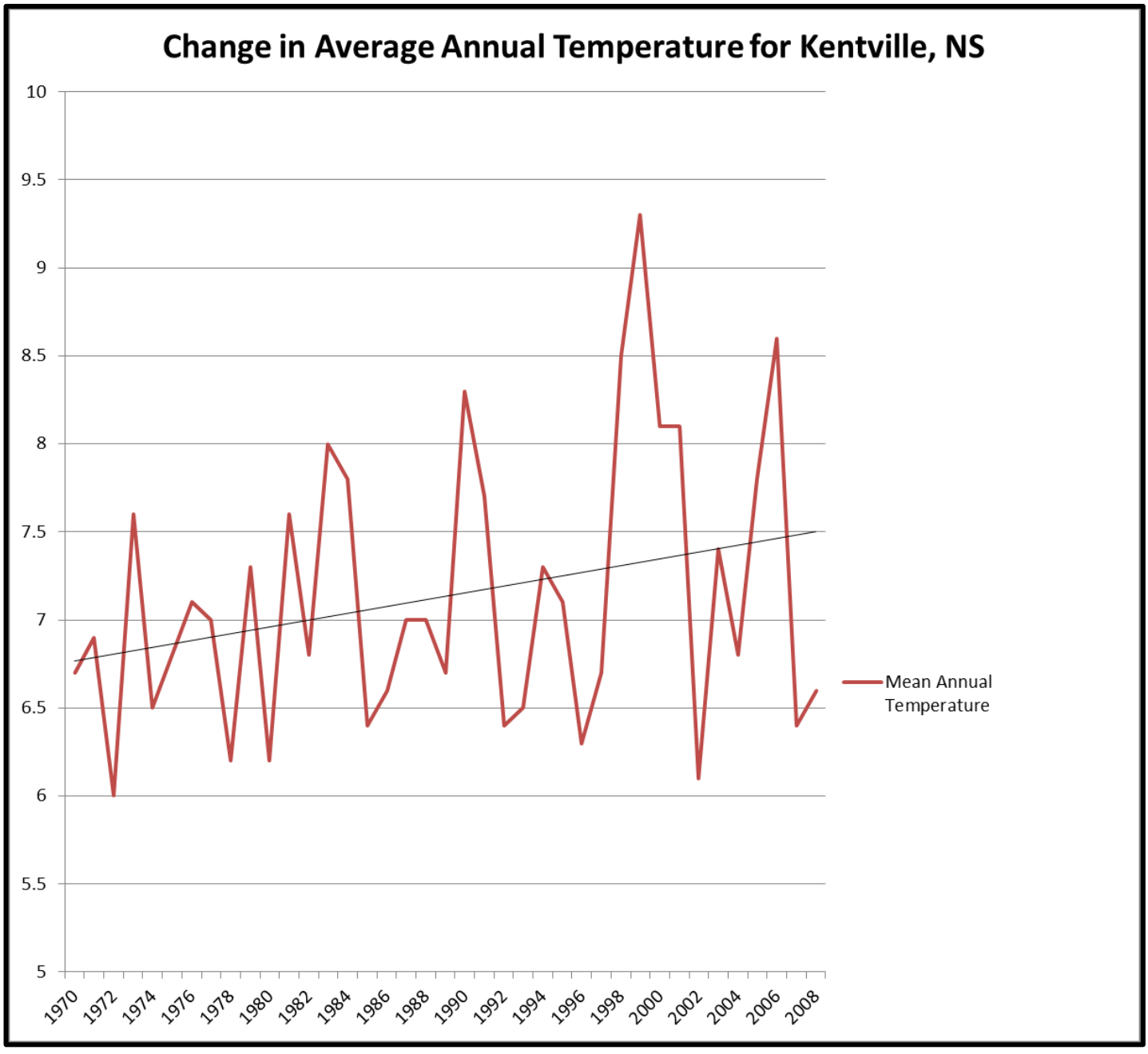
Reproduced with permission from Petersen et al. (2008)

Drawing Conclusions from Climate Graphs



Analysis of Temperature Data:

Challenges with interpreting data, identifying trends, and dealing with noise



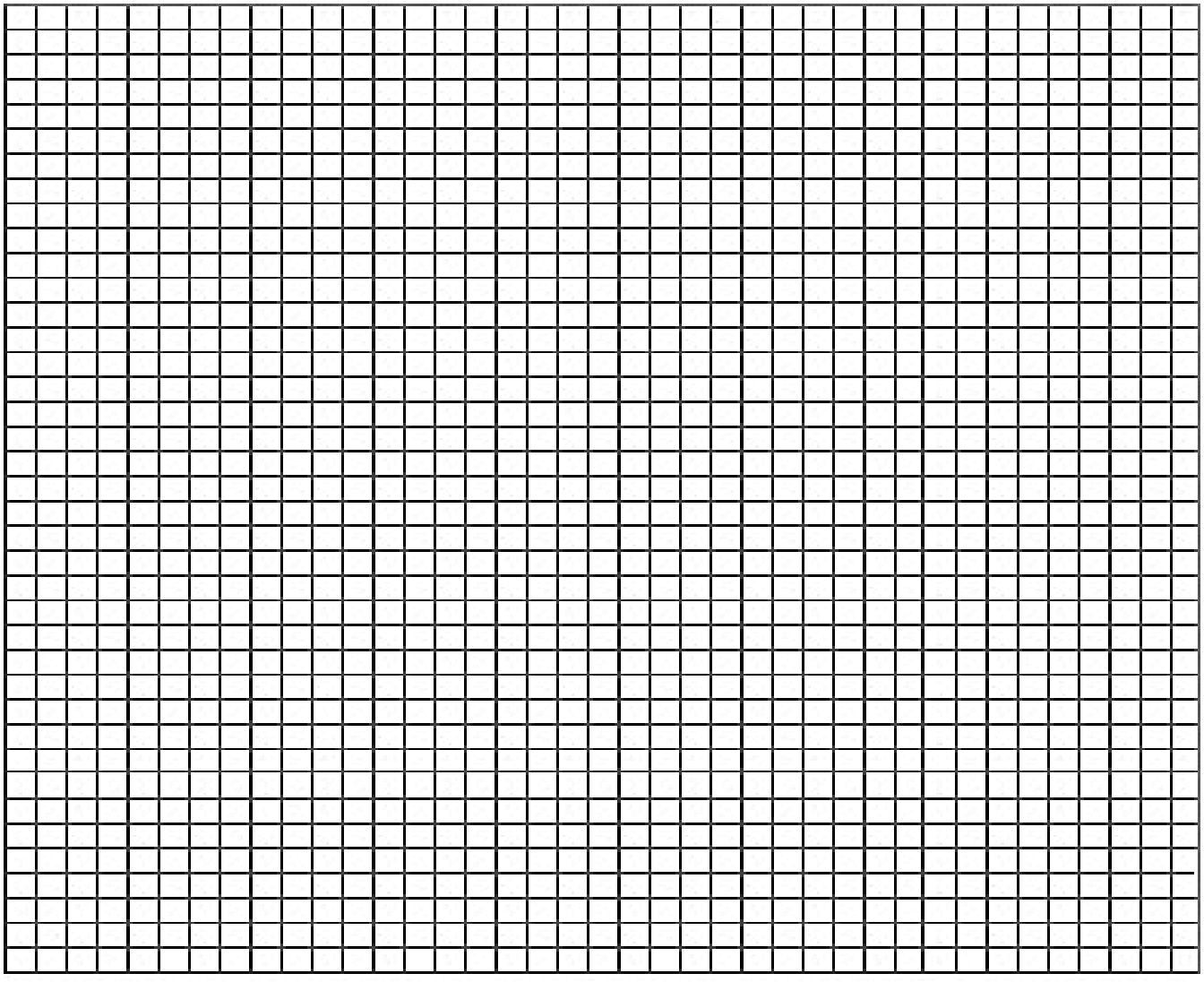
Name: _____ **Date:** _____

Analysis of Historical Temperature Data

Using the temperature data provided, create a line graph to reveal how the mean annual temperature has changed in Kentville, NS, in recent decades. Label your axes and give your graph an appropriate title.

Mean Annual Temperatures for Kentville, Nova Scotia, 1970-2007

1970	6.7	1980	6.2	1990	8.3	2000	8.1
1971	6.9	1981	7.6	1991	7.7	2001	8.1
1972	6	1982	6.8	1992	6.4	2002	6.1
1973	7.6	1983	8	1993	6.5	2003	7.4
1974	6.5	1984	7.8	1994	7.3	2004	6.8
1975	6.8	1985	6.4	1995	7.1	2005	7.8
1976	7.1	1986	6.6	1996	6.3	2006	8.6
1977	7	1987	7	1997	6.7	2007	6.4
1978	6.2	1988	7	1998	8.5	2008	6.6
1979	7.3	1989	6.7	1999	9.3		



After completing your line graph, answer the following questions in the spaces provided.

Looking at your line graph, what do you notice? Can you identify any trends? Describe what you see.

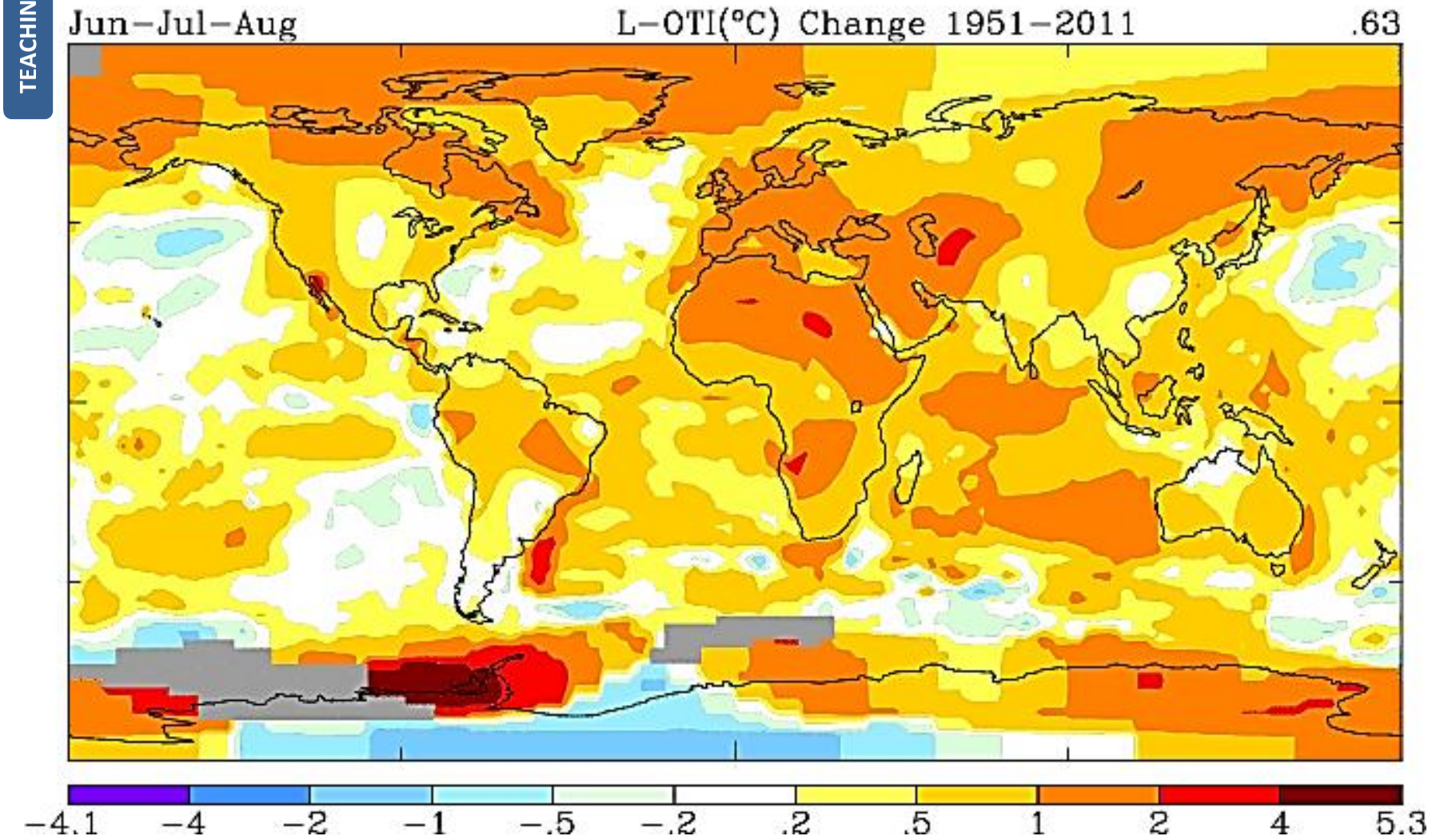
Do you think there is more than one way of interpreting your line graph? Explain.

What do you notice about the years 2007 and 2008? Do you think you could use this graph to make a convincing argument that global warming has stopped? Explain why or why not.

The data in your graph fluctuates considerably. Why do you think that it's difficult to make conclusions about climate trends based on limited data?

Your graph is based on historical data of mean annual temperatures. What other data do you think might be interesting to look at in order to increase your understanding of how the climate may be changing? Explain.

Changes in mean surface temperatures



National Aeronautics and Space Administration (NASA), Goddard Institute for Space Studies, 2011

SEA LEVEL RISE AND COASTAL ADAPTATIONS

LESSON 3

Introduction:

Global climate change is expected to result in numerous impacts to coastal regions, creating varying challenges for the people and settlements in these areas. While coastal regions will experience some of the same climate change impacts that will affect inland areas (e.g., increased temperatures, extreme weather events, and changes in precipitation patterns), sea level rise and coastal erosion, and the consequences of these effects, are additional concerns facing coastal areas. With more than 200,000 kilometers of coastline, Canada is expected to face challenges related to sea level. Similarly, sea level rise is also expected to be a significant issue for Nova Scotia; with approximately 7600 kilometers of coastline, the province must also prepare for the realities of sea level rise.

Glacial melt and thermal expansion, which are accelerating as a result of climate change (although are balanced in some places by isostatic rebound), are the processes behind sea level rise. While sea level has been rising for centuries (average increase of 17mm per century between 1000 and 1800), studies have indicated that the rate has been increasing. The mean rate of sea level rise has accelerated noticeably since the 19th century, increasing from 1.6mm/year in the 1800s to the modern rate of approximately 3.2mm/yr. Preparing for the effects of sea level rise remains one of the most important challenges for coastal areas today.

Objectives:

Students will be introduced to thermal expansion and glacial retreat as causes of sea level rise. An introductory demonstration on thermal expansion can be used to introduce students to the fact that oceans are slowly expanding as they heat up (students will be asked to make connections to climate change). Students will work through an activity sheet on glacial melt as a way of exploring the other main contributor to sea level rise and will begin to think about general effects of sea level rise and possible adaptations that may be appropriate. By reading *Halifax Harbour faces rising waters,* students will gain a better understanding of some of the ways that sea level rise and related climate change impacts are affecting people in Nova Scotia. Students will be encouraged to write a letter to the mayor of Halifax as a way of reflecting on the reading, commenting on adaptations that were discussed, and enquiring about new adaptations that are being explored.

Specific Curriculum Outcomes:

Students will be expected to…

- identify questions and analyse meteorological data for a given time span and predict future weather conditions, using appropriate technologies (Science, 214-10, 331-5, 212-1)
- describe how the atmosphere and hydrosphere act as heat sinks in the water cycle (Science, 331-3)

- predict and analyse the impact of external factors on the sustainability of an ecosystem, using a variety of formats (Science, 212-4)

Materials:

- Teaching Resources 3.1 - 3.3
- Materials for thermal expansion demonstration: bunsen burner or heat lamp, thermometer, flask, two holed cork for flask, glass tube, marker (to record height of water on glass tube – before and after)

Time Frame:

- 1 - 2 hours

Activities:

1. Have the thermal expansion demonstration* set up before class. (Set up may vary depending on available materials). Have students predict what will happen when the water in the flask is heated. Have a student volunteer use a marker to record the height of the water on the tube before the water is heated.

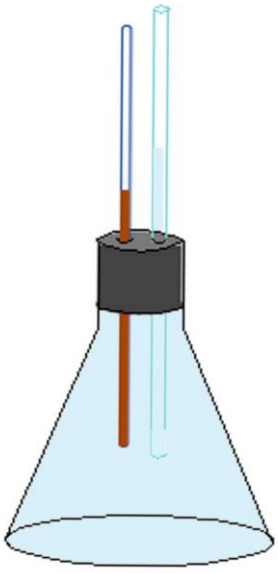


***Image and thermal expansion demonstration adapted from Centre for Ocean Sciences Education Excellence: http://cosee.umaine.edu/cfuser/resources/tr_sea_level.pdf**

2. Carry out the demonstration, giving the water time to sufficiently heat up. During this time, review the water cycle with the students (Teaching Resource 3.1), explaining how water bodies act as heat sinks.

3. When water has heated, have another volunteer measure the height of the water in the glass tube. Introduce students to the term thermal expansion. Help students understand the concept of thermal expansion and have students suggest how this could relate to climate change. While water bodies act as heat sinks, they can also expand when sufficiently heated, increasing in volume. Ask students to suggest how climate change will affect oceans. Help students see the connection to sea level rise.

4. Explain to students that thermal expansion is one of two major contributors to sea level rise. Have students suggest what the second might be (glacial melt).

5. Introduce students to Teaching Resource 3.2, *Glacial Melt and Sea Level Rise.* Give students time to work through the activity.

6. Once the majority of students have finished, as a class discuss some of their answers to the final three questions on the handout (i.e.: What are some of ways that sea level rise will affect the following: humans, animals, plants, and/or habitats?, Who and/or what is likely to be most vulnerable to sea level rise?, and What adaptions might be appropriate in order to cope with rising sea levels?).

7. Now that students have had a chance to share some of their ideas about how sea level rise might, in general, affect people and ecosystems, have students suggest areas in Nova Scotia that might be particularly vulnerable to sea level rise, and provide reasoning.

8. Introduce the article *Halifax Harbour faces rising waters* as a way of taking a more in depth look at some of the issues relating to sea level rise in Halifax, and a way of introducing adaptations that may enable Halifax to cope with sea level rise and other related climate change impacts. Explain that this article was originally printed in an October 2010 issue of *Canadian Geographic*.

9. Give students time to read the article and then have each student write a short (~ one page) letter to the mayor of Halifax. Instruct students that in their letters they are to reflect on the article, comment on some of the adaptations that they learned about, and enquire about new adaptations that are being considered in the time since the article was written.

Assessment:

Students' contributions to classroom discussions can be used to gauge their understanding of the water cycle and thermal expansion. Students' work on the *Glacial Melt and Sea Level Rise* activity and their letters to the mayor of Halifax can be used to assess whether they understand the connection between glacial melt, thermal expansion, and sea level rise, and their understanding of how sea level rise will affect humans and coastal ecosystems and settlements.

Enrichment Activity:

Have students design and carry out experiments to determine the effect of salt on thermal expansion. Have students predict what effect the presence of salt in sea water has on thermal expansion. Provide feedback on students' experimental designs before allowing students to carry out the activities. Have students make a hypothesis, record observations and results, and draw conclusions.

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The hydrologic cycle

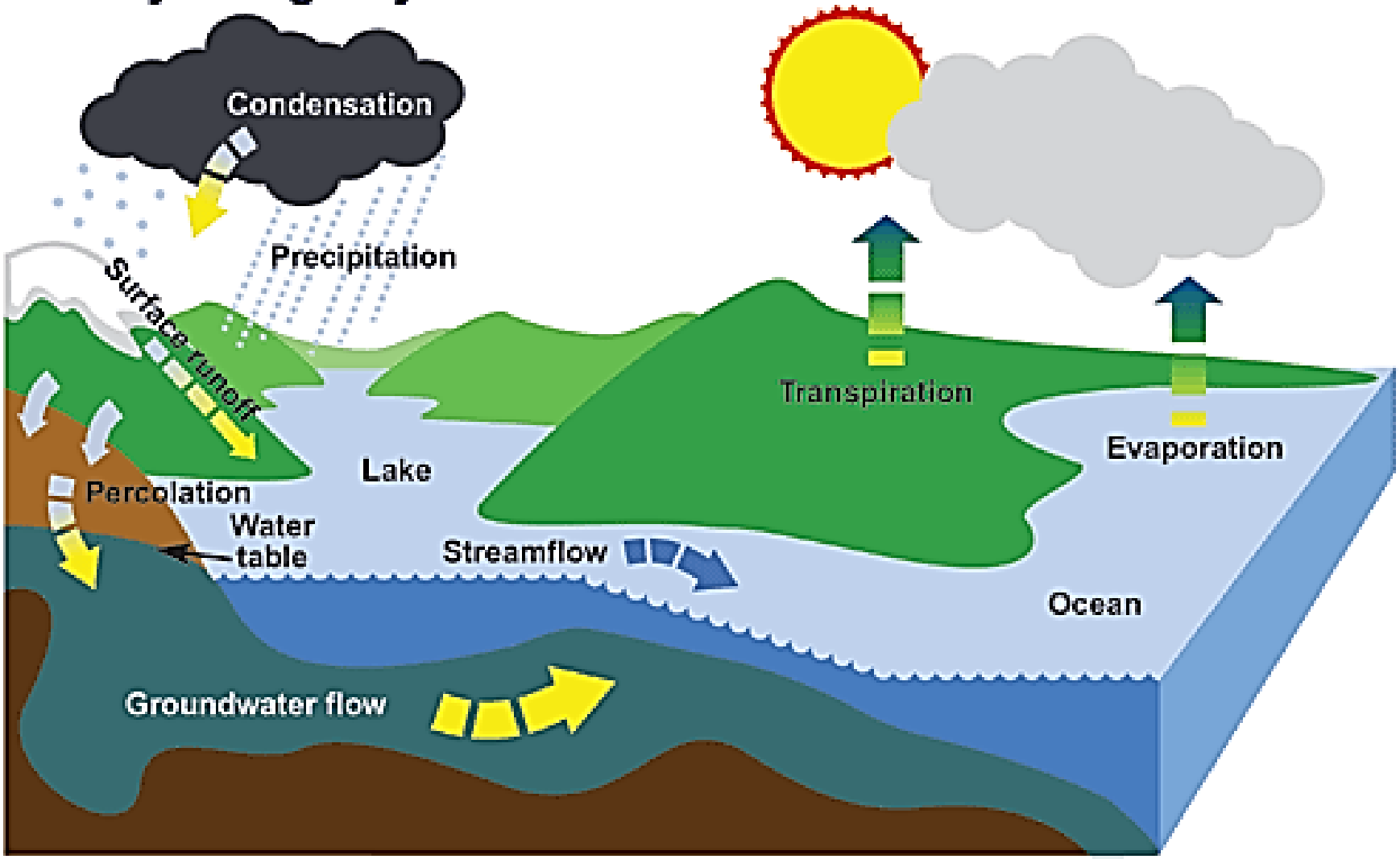

Image is courtesy of Environment Canada, 2011.

Name: _____ **Date:** _____

Glacial Melt and Sea Level Rise

Global sea level, the average sea level taking into consideration short term fluctuations, has fluctuated considerably over Earth's history. Currently, we are in a period of increasing sea level, a process that has been connected to climate change. The following text and questions are designed as an introduction to the connection between glacial melt and sea level rise.

Accelerated melting of glacial ice is one of the effects of global climate change that receives the most attention. Glaciers and ice sheets are the largest reservoirs of fresh water on Earth, containing approximately 75 percent of global fresh water. Over the past century, many of these ice forms have lost mass, retreating (or melting) more quickly than the ice can be replenished. (Note: Glacial melt is a natural process; seasonal glacial retreat results in meltwater that is an important part of hydrological cycles. However, glaciers also increase in volume. During the last ice age, for example, an increase in glaciers and ice sheets caused sea level to drop by approximately 120 meters!) Glaciers and ice sheets require certain temperatures and levels of precipitation (snowfall) in order to retain their mass. As climate change affects global mean temperatures and changes precipitation patterns, the result is increased temperatures and periods of low or no precipitation which can result in ice melting more quickly than new ice is formed.

According to the Intergovernmental Panel on Climate Change (IPCC), glacial melt contributed to sea level rise by an average of approximately 0.7 mm/year between 1961 and 2003. However, the IPCC's data also indicates that the rate of sea level rise increased during this period. The IPCC estimates that between 1993 and 2003, glacial melt resulted in an average annual sea level rise of approximately 1.2 mm. While sea level rise can create considerable challenges for human populations, especially those in coastal areas, luckily the sea level is rising very slowly. Although the table below indicates that present day glaciers have the potential to raise sea level by 80.32 metres (that's a lot!), this will happen very slowly. Just how slowly, you may be wondering – well, that's for you to find out. Assuming that glaciers continue to contribute to sea level rise at a rate of 1.2 mm/year, how long would it take before the glaciers fully melt and increase sea level by 80.32 metres?

Location	Volume (km^3)	Potential sea-level rise, (m)
East Antarctic ice sheet	26,039,200	64.80
West Antarctic ice sheet	3,262,000	8.06
Antarctic Peninsula	227,100	0.46
Greenland	2,620,000	6.55
All other ice caps, ice fields, and valley glaciers	180,000	0.45
Total	32,328,300	80.32

Table 1. Estimated potential maximum sea-level rise from the total melting of present-day glaciers.

Source: Poore et al., 2000 (http://pubs.usgs.gov/fs/fs2-00/)

Answer the following questions, drawing on the information provided as well as your own personal knowledge and experience.

1. How long would it take before present day glaciers contribute to a sea level rise of 80.32 metres, assuming an average rate of 1.2 mm/year? (Watch out for units!) Show your work.

2. The data in Table 1 is for what is called land-based (or landlocked) ice as opposed to sea ice (any glacial ice that is floating in the sea). Why do you think sea ice is excluded from Table 1? What effect, if any, would melting sea ice have on sea level rise? Explain.

3. In addition to glacial melt, thermal expansion also contributes to sea level rise. Oceans have a tremendous ability to store heat (salt water has a higher mass than air and the heat storage capacity of oceans is thus orders of magnitude greater than that of the atmosphere); however, as global temperatures increase, oceans will gradually heat up and expand. This expansion results in an increase in volume, and therefore higher sea levels. The IPCC has stated that thermal expansion was responsible for an average annual sea level rise of 1.6 mm between 1993 and 2003. At this rate, how long would it take the average global sea level to increase by 1 metre? (Don't forget the effect of glacial melt!). Show your work.

4. What are some of ways that sea level rise will affect the following: humans, animals, plants, and/or habitats?

5. Who and/or what is likely to be most vulnerable to sea level rise?

6. What adaptions might be appropriate in order to cope with rising sea levels?

Halifax Harbour faces rising waters

By John Demont

Global warming is giving Halifax a sinking feeling. How is the maritime city planning for a future of rising sea levels and wilder weather?

As Hurricane Juan, a once-in-a-century storm, pounded his second-floor waterfront condominium, David Van Scoyk cowered in the dark thinking, Was this really a good idea? Six hours earlier, a firefighter had ordered Van Scoyk and his wife to evacuate their home on Bedford Basin, at the northwest end of Halifax Harbour. An experienced sailor and no stranger to bad weather, Van Scoyk had stayed put. At 1 a.m. on Sept. 29, 2003, Van Scoyk stood on his deck and peered in the direction of the approaching Category 2 hurricane, wondering what the fuss was about. Ten minutes later, with much of the Halifax waterfront a ghost town of deserted buildings with boarded-up windows, he found out.

Juan had already felled thousands of trees, smashed cars, blown the roofs off buildings and taken lives. Van Scoyk remembers the menacing roar of the wind and the basin's monstrous swells. A boat anchored nearby snapped its moorings, was pushed to shore and began slamming against the dock behind the Van Scoyks' condominium. As its gyrating mast threatened to break through the back window, Van Scoyk and his wife grabbed a few possessions and headed for safety. Fallen trees made the streets impassable, so they abandoned their car and left on foot for a friend's house a couple of kilometres away.

When they returned six hours later, the boat was on their back lawn, along with three telephone poles and the remains of a splintered wharf. The 158-kilometre winds and flooding had destroyed the unit downstairs. Four balconies in the complex, including the Van Scoyks', were ruined. The three metre storm surge shattered the seawall. On the grounds of the neighbouring yacht club, luxury vessels lay in stacks.

"The devastation was pretty unbelievable," says Van Scoyk, a trim man with grey hair and wire-rimmed glasses who sells promotional material for a living. On this pleasant May morning, the temperature sits at 18°C, a 10-knot breeze arrives from the southwest and there is barely a ripple on Bedford Basin. The condominiums, wharves and seawall have long since been repaired. The debris has been removed. Everything, in other words, is back to normal. Until the next time nature plays one of its nasty jokes.

Van Scoyk points to the reinforced siding installed in his condo to withstand hurricane-strength winds. He runs a hand along a new seawall — made out of shackled concrete blocks — which is almost one metre higher than the old one. Alarmist? Tropical storms seem to hit harder than when he moved here 20 years ago, he says. Back then, the basin's water almost never crested the wooden wharf behind his home. Now, during a full moon, nearly half a metre of water splashes over it. "Something," he says ominously, "is definitely happening."

Van Scoyk is right. Along Halifax's fabled harbour — where booty-laden privateers once docked and Second World War convoys massed before departing for Europe — several things are happening. Bad-weather events are getting harsher: when storms hit, there are higher waves, stronger winds, greater devastation. If that's not bad enough, the city's 261-year-old working waterfront is slipping under water due to rising sea levels and a sinking land mass.

A perfect storm is blowing across Atlantic Canada. Coastal erosion rates are forecast to double in Prince Edward Island. In New Brunswick over the next century, major storm surges will hit the province's coastline every 5 to 10 years instead of every 50 to 100 years. In Nova Scotia, the beaches on Bras d'Or Lake, Cape Breton's saltwater inland sea, are expected to be submerged by 2045.

In Halifax, as in so many low-lying, coastal communities, the question of global warming has gone from theoretical quandary to deep-seated anxiety. The city's planners, developers and scientists are considering how to best protect their community from its impacts. Thinking short term, Haligonians are shoring up their coastal defences. Looking to the long term, the city's Climate SMART (Sustainable Mitigation and Adaptation Risk Toolkit) strategy, formed in partnership with the federal and provincial governments and the private sector, is aimed at reducing greenhouse-gas emissions and slowing rising temperatures.

It is an effort worth noting: Halifax's flexible, multifaceted approach to adapting to the impacts of climate change could well be a model for how the rest of Canada can prepare for a warmer planet.

Donald Forbes sure hopes so. A bespectacled and grey-bearded scientist, a bit rumpled in appearance, Forbes likes nothing better than paddling a canoe, walking in the woods or rooting around in a cemetery or an archive where he indulges his love of all things old. Such lightness of spirit is surprising. As a Halifax-based research scientist with the Geological Survey of Canada, Forbes has seen first-hand what global warming has done to low-lying coastlines as near as Prince Edward Island and as far away as Fiji.

The day I met him in his office overlooking Halifax Harbour, Forbes was tying up some loose ends before heading to Inuvik, N.W.T., where he is the lead investigator in a study of the impact of global warming on the Mackenzie Delta. When asked about Halifax's rising water levels, he pauses before offering a somewhat reassuring answer: "We're not ready. But we have time to prepare if we arm ourselves with the right information."

Forbes is doing his best to get the word out. Hurricane Juan was the wake-up call to the dangers climate change pose for the Halifax area. Three years later, the Halifax Regional Municipality started developing its 25-year Regional Municipal Planning Strategy. Included in the overall game plan was a strategy for the harbour, which has been the beating heart of the community since the city's founding.

Forbes and a team of scientists were asked to predict where water levels were headed in the harbour. What they discovered by studying the tide gauge going back to 1920 was intriguing. For starters, there is confounding news for the deniers: global warming is causing ocean levels to rise. The living proof is Halifax, where relative water levels have risen by roughly 32 centimetres in the past 100 years, compared with a 15-to-20-centimetre rise in global sea levels.

"Coastal erosion is remaking Atlantic Canada. By 2045, the beaches on Cape Breton's Bras d'Or Lake are expected to be submerged."

The startling insight is that only half of the total increase is due to rising oceans. The other half is due to the land mass slowly sinking. Scientists blame the massive Laurentide Ice Sheet, which once covered most of Canada and the northern United States. When the ice began forming 100,000 years ago, the Atlantic region and other areas on the periphery of the glacier were pushed upward as mantle material flowed outward from the centre of the depression under the ice. Sometime between 10,000 and 20,000 years ago, the ice began retreating. "When the load was released, the mantle material moved back, leading to subsidence," explains Forbes. "Because the mantle behaves like an extremely viscous liquid, the return flow takes many thousands of years." Atlantic Canada has been slowly sinking ever since.

The average Haligonian, of course, would never notice. The more extreme weather that accompanies climate change, on the other hand, is harder to miss. Scientists believe global warming could be causing more intense tropical storms: warmer oceans and warmer air fuel powerful storms. Nova Scotia already experiences more hurricanes than anywhere else on North America's eastern seaboard, so the implications are significant. Historically, storms lose most of their strength by the time they near Nova Scotia. Scientific models show that

trend is shifting. In future, Nova Scotia likely will not see an increase in the number of storms but the storms that do hit, such as Hurricane Juan, will be more intense.

With rising sea levels, sinking land and more extreme weather in the forecast, Halifax has a significant risk management challenge on its hands. Along Halifax Harbour — where, on a summer weekday, office workers, pub crawling students and fanny-pack-wearing tourists wander — the warnings signs are there for anyone who knows where to look: the new, higher waterline on the old wooden piers; the undulating horizon that, in spots, dips precariously close to the murky harbour water; the busy commercial corner, a couple of football fields back from the water's edge, where the storm surge pooled during Hurricane Juan.

The question is, How can Halifax best manage the risk? The Intergovernmental Panel on Climate Change most recently predicted that global sea levels would swell 59 centimetres by 2100 due to global warming. But with the rise in sea levels tracking well above projections, the forecasts are already clearly out of date.

The same is true of the model used by the Halifax Regional Municipality in its long-range plan for developing the harbour. According to the existing scenario, a storm of less magnitude than Juan a century from now would send the harbour waters surging 2.67 metres above sea level (water levels climbed 2.1 metres during Juan). If that happened today, water would flood the city's naval dockyards as well as high-end shopping and dining complexes and the historic brick and stone buildings on Water Street. The seawalls around some of the city's historic fortifications would be swamped. Ocean water would wash out rail lines and wipe out restaurant patios. The fact that the calculations do not factor in the natural oscillation of a harbour or wave run-up simply adds to the unease. "We've only got half the picture," concedes city planner John Charles.

An avuncular graduate of the University of Guelph and Dalhousie University who moved to Halifax in 1979, Charles has been part of the harbour planning strategy since 2001 and has helped develop the municipality's response to climate change. The centrepiece of the city's strategy is the Climate SMART initiative, a groundbreaking collaboration that could serve as a template for other communities vulnerable to the impacts of global warming. The approach begins with a commitment to cut greenhouse-gas emissions by 20 percent below 2002 levels by 2012, with even more ambitious long-term cuts to come.

The municipality realizes that it cannot just sit and wait; instead, it has adopted a broad range of measures meant to blunt the impact of climate change. Halifax, for example, is forging a new green strategy for dealing with storm water via alternative landscaping practices. The city has also formed a committee spanning police, fire and other municipal departments to plan how to keep core services operating when extreme weather hits.

Overall, most of the preparation is focused on the waterfront, which is a planning nightmare. Governments control 80 percent of the real estate: Ottawa has the Canadian Navy, Canadian Coast Guard and Fisheries and Oceans Canada; Nova Scotia oversees the Port of Halifax; and the municipality operates the Halifax-Dartmouth ferry service. Industrial concerns, such as the Irving family-owned shipyard, Canadian National Railway and Imperial Oil's refinery, account for about 15 percent of the land. Private homes account for the remainder.

Part of Charles's job is to plan for the worst along the waterfront. Crumbling portions of the municipality's seawall, for example, will be elevated and built with more resistant materials. Restraining walls are being considered to protect municipal monuments from storm surges and waves. And, when it's time to rebuild, older wharves and piers are being raised in gradual increments.

In some cases — as with Georges and McNabs islands, a pair of drumlins that sit in the harbour — little can be done to counter the impact of fiercer weather and higher sea levels. But when it comes to protecting places where people live, work and play, Charles says, there is a sense of growing urgency. That is particularly true in the planning offices of the municipality, which controls some of the biggest chunks of undeveloped harbour lands.

Officials with the local government are understandably picky about who gets to erect a building or business on the municipally controlled section of the harbour. And they are getting pickier. Developers hoping to build along the waterfront have stiff criteria to fulfill before they can hope for council approval. The list now includes “provisions that mitigate potential damages from coastal flooding and stormsurge events.” Any development proposed for the shoreline outside of the harbour’s mouth, for example, must be 2.5 metres above the high-water mark and at least 20 metres back from the shoreline.

Within the harbour, however, there are no hard-and-fast development rules. Why? Charles says each proposed property has a different degree of vulnerability to water and weather depending on its location, topography and land use. Trying to come up with catch-all regulations appropriate to every development is all but impossible. “The onus is on the developers to prove that their plans have taken the rising sea levels and long-term extreme-weather forecast into account,” says Charles. “If they don’t, they won’t get a permit — it’s as simple as that.”

The local government cannot force the owners of existing waterfront properties to take steps to reduce the looming threat from rising water levels. But if an owner applies to redevelop an older property, the “reverse onus” provision kicks in. Precisely what will be deemed acceptable with city council varies from project to project. Building a concrete loading dock with two large steel storage lockers along the waterline would be an easy sell. Convincing city council to approve a large seniors’ residence — with an accompanying oil tank — on a flat section of land in an area facing the harbour will, at the very least, take a thorough plan with more safeguards than a CANDU nuclear power plant.

The harbour steering committee plans to ask for citizen input on the current evaluation criteria. If the criteria are found wanting, more stringent measures could be written into development bylaws. The risk is that new measures usually bring greater costs, scaring away developers. For now, though, the smart developers do their homework and submit meticulous proposals. Bankers and insurers want to know a project is safe before giving their blessing. So do the councillors who make the ultimate political decision on whether a plan goes ahead.

K. J. Gandhi is one of those smart developers. He hears what Forbes and others have to say about the future of Halifax’s climate, and he’s a believer. “What the scientists are telling us is scary,” he says one morning in his office, a short jog from Bedford Basin.

Compact, with grey hair and a goatee, Gandhi is an Indian-born architect with an M.B.A. from Norway who seems to have worked everywhere in his 30-year career. Today, he lives in Halifax, where he is involved in real-estate development. One of his projects is a six-storey waterfront apartment complex that, if approved, will be built on the Dartmouth side of Halifax Harbour. The 70-apartment building will be 15 metres back from the waterline, built on land that slopes on a steep grade down to the harbour.

Gandhi shuffles some architectural drawings around on his crowded desk until he finds the right one and unfolds it. The building’s main floor, he points out, will be roughly six metres above sea level, almost triple what the current regulations require for any developments outside the harbour. He stabs a finger at the plan, showing where a high-density concrete barrier will be built to protect against storm surges. “It will be 20 feet in height,” he says. “We just took what the city told us was necessary and doubled it.” In case a storm breaches the barrier, Ghandi plans to install a triple drain tile and a high-powered pump in the basement.

The chances of water ever flooding the bottom floor of the apartment building are slim, says Gandhi. But he is taking precautions. Before moving to Halifax, Gandhi spent 16 years working in the North Sea offshore oil industry. He was the principal architect for ExxonMobil’s offshore gas development. “Let’s just say,” he whispers, leaning forward in his chair, “I have a healthy respect for what the ocean can do.”

Article originally appeared in Canadian Geographic in October, 2010. Article is reprinted with permission of the author, John DeMont, and Canadian Geographic.

THE FOREST-CARBON CONNECTION

LESSON 4

Introduction:

Forests and wooded areas cover approximately 78 percent of the more than 5.5 million hectares of land in Nova Scotia. As these forests provide a range of benefits, including economic, social, environmental, and spiritual benefits, it is important that they are sustainably managed. This is particularly important given that forests are expected to be faced with climate change impacts ranging from changes to forest composition and habitats, to increased stress from expanding pest invasions, and damages from severe weather events and forest fires. Managing forests and treed areas is also important as trees can help offset carbon emissions due to their ability to act as carbon sinks. As such, protecting and expanding forested areas in Nova Scotia (including enhancing urban forests) can be part of the province's response to climate change. Furthermore, deforestation and forest degradation is a significant contributor to greenhouse gas emissions, being responsible for approximately 18 percent of global CO_2 emissions.

Objectives:

Students will be encouraged to consider ways that forests in Nova Scotia may be impacted by climate change, and will identify ways the forests can be used to mitigate climate change, as well as climate change adaptations that may involve forests and/or trees. Students will review the carbon cycle and become familiar with the idea of trees as potential carbon sinks. By completing an activity involving calculating carbon storage and CO_2 sequestration in local trees, students will gain a sense of the roles of different trees in carbon storage and CO_2 sequestration. Finally, students will be introduced to Reducing Emissions from Deforestation and Forest Degradation (REDD+), a United Nations program that Canada currently supports as a way of contributing to meeting the country's CO_2 emissions targets. Through independent research, students will produce a short piece of persuasive writing either arguing for or against Canada's support of REDD+.

Specific Curriculum Outcomes:

Students will be expected to…

- identify, investigate, and defend a course of action on a multi-perspective social issue (Science, 118-9, 215-4, 118-5)
- use library and electronic research tools to collect information on a given topic (Science, 213-6)
- select and integrate information from various print and electronic sources or from several parts of same source (Science, 213-7)
- develop, present, and defend a position or course of action, based on finding (Science, 215-5)

Materials:

- Teaching Resources 3.1-3.
- Calculators

- Tape measures
- Access to local trees in or around schoolyard
- Access to computers

Time Frame:

- 1-2 hours

Activities:

10. Have students brainstorm ways that forests in Nova Scotia may be affected by climate change. Prompt students as necessary.

11. Explain that forests are especially important to include as part of a unit on climate change as not only can trees be affected by climate change in many ways, they can be planted as part of adaptation measures, and the loss of trees also contributes to climate change.

12. Use Teaching Resource 4.1 to review the carbon cycle and discuss with students the roles that trees play in storing carbon.

13. Introduce the Calculating Carbon activity, Teaching Resource 4.2. Explain to students that they will be working with a partner to complete an activity involving estimating the amount of carbon stored, and CO_2 sequestered, by two different species of trees in or around their schoolyard.

14. Explain to students that the activity will only provide a rough estimate of the actual values. Explain that many different formulas and methods of calculating the amounts exist, and so their results would vary depending on what methods they used. Also, encourage students to locate two species of trees that are included in Table 1; however, if they are unable to find one of these, encourage them to substitute the values for the trees provided in Table 1 that most closely resemble the trees they have located.

15. After students have completed the activity, discuss their results as a class, including their answers to the accompanying questions.

16. Explain to students that given the potential for forests to act as large carbon sinks, deforestation is a particular concern as deforestation results in CO_2 emissions – the trees go from acting as carbon sinks to carbon sources – and a loss of biomass that can store carbon in the future.

17. Ask students to suggest places in the world where they would expect rates of deforestation to be high. Have students suggest reasons for the high rates of deforestation in developing countries.

18. (*Remainder of lesson is optional*): Introduce the students to Reducing Emissions from Deforestation and Forest Degradation (REDD+), a United Nations program that is meant to promote sustainable forest management and contribute to an overall reduction in atmospheric CO_2.

19. Explain that while REDD+ sounds good in theory, a number of concerns have also been raised about it. Explain to students that questions such as the following have been raised:
    - Does a lack of definition of what constitutes a forest leave room for healthy, natural forests to be replaced by plantations and still qualify under REDD+?
    - Will industrialized countries, such as Canada, feel less pressure to reduce their own CO_2 emissions if they participate in REDD+?
    - Will the commodification of forests have negative consequences for indigenous peoples who have historically depended on the forests?

20. Tell students that they will each be responsible for carrying out their own investigation into potential benefits and problems with REDD+ and will be required to write a short piece of persuasive writing either arguing for or against Canada's support of REDD+.

21. Provide students with Teaching Resource 4.3 which includes a list of recommended reading to get them started.

22. Discuss students' findings. Give students time to discuss the benefits and potential limitations of REDD+. Have students suggest other ways that governments might be able to discourage deforestation and reduce greenhouse gas emissions.

Assessment:

Students' contributions to classroom discussions and their completion of the calculating Carbon exercise can be used to assess their understanding of the connection between forests, carbon storage, and climate change. Students' pieces of persuasive writing can be used to assess their ability to convincingly argue why REDD+ should/shouldn't be part of Canada's sustainable plan related to forests and climate change.

Enrichment Opportunities:

Interested students can be encouraged to research other topics of interest and controversy, e.g., carbon capture and storage, use of genetically modified (GMO) trees to sequester more carbon, (un)sustainability of deforestation practices in the Amazon, Africa, etc. Findings can be presented in writing, visual formats, digital presentations, etc.

Students can prepare and hold an in-class debate as a way of presenting some of their findings relating to Canada's support of the United Nations' REDD+ program.

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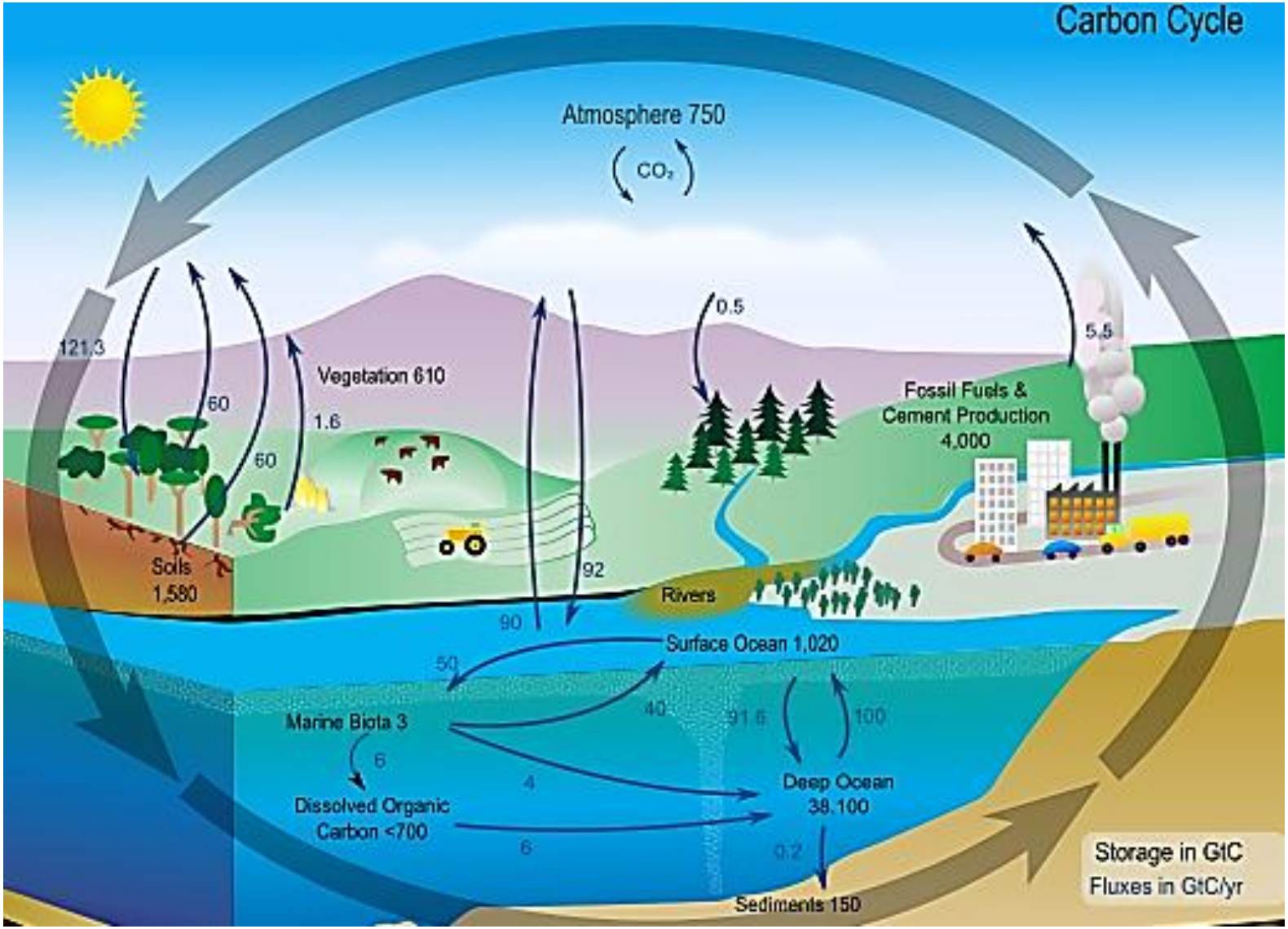

Image retrieved from Wikipedia, 2011,
http://en.wikipedia.org/wiki/File:Carbon_cycle-cute_diagram.svg

Name: _____ **Date:** _____

Carbon Calculations

Follow the directions below in order to arrive at various estimates of how much carbon is stored in trees both locally and in forests within Nova Scotia.

Part A: Calculating carbon storage in local trees

1. Locate two trees of different species in or around your schoolyard.
2. Complete the following table, based on the two trees you have chosen (show work).

Species	Circumference (in cm, at chest height)	Diamater (diameter= circumference X pi)	Biomass (kg)	Amount of stored carbon (kg)
Tree 1:				
Tree 2:				

Formula for calculating the biomass (in kg) of trees and shrubs:

$$M=aD^b$$

M = biomass
D = diameter of tree (in cm, measured at chest height)
a & b = species coefficients (provided in Table 1)

Formula for calculating the amount of carbon (kg) stored in trees:

Biomass (M) X 0.521 for hardwoods
Biomass (M) X 0.498 for softwoods

TREE SPECIES	a	b
Ash	.1063	2.4798
Basswood	.0617	2.5328
Beech	.0842	2.5715
Birch	.0629	2.6606
Cedar*	.1019	2.3000
Elm	.0629	2.6606
Hickory	.0792	2.6349
Hornbeam	.0792	2.6349
Maple (Red)	.0910	2.5080
Maple (Sugar)	.2064	2.5300
Oak (black)	.0904	2.5143
Oak (red)	.1130	2.4572
Oak (white)	.0579	2.6887
Pine*	.1617	2.1420
Sumac*	.0825	2.4680

Table 1. Species coefficients are selected North American trees (data is from a paper by Ter-Mikaelian and Korzukhin, 1997). * Indicates softwoods

Answer the following questions in the spaces provided.

1. To convert the amount of stored carbon into the amount of CO_2 sequestered by the two trees, multiply the carbon values by 3.67.

CO_2 sequestered tree 1: _____

CO_2 sequestered tree 2: _____

2. The average carbon footprint for Canadians in 2001 was approximately 19 tonnes of CO_2. Using this information, choose one of your tree species and use the value you arrived at for the amount of CO_2 sequestered to determine how many similar trees it would it take to sequester 19 tonnes CO_2 emissions.

3. According to report from Nova Scotia's Department of Natural Resources in 2008, the average biomass per hectare of trees in Central Nova Scotia was the following: Softwood trees contribute an average of 39.9 tonnes and hardwood trees contribute an average of 30.5 tonnes. Imagine that a new development project is being planned for Central Nova Scotia that will require the removal of 1.5 hectares of forested land. How much CO_2 sequestration potential will be lost if this proposed area is deforested? Does knowing this affect your opinion of deforesting areas for new developments? Explain.

4. Can you see any potential problems that might arise if Nova Scotia were to restrict forestry practices in the province in order to ensure that forests can exist as carbon sinks? (Think about why the forestry industry exists and what substitutes there are for local timer).

5. Identify and explain one ways that forests can be involved in climate change mitigation efforts, and one possible adaptation to climate change that involves trees and/or forests.

Name: _____ Date: _____

Reducing Emissions from Deforestation and Forest Degradation (REDD+)

Check out some of the following sources to help kick-start your investigation into REDD+:

- Reducing Emissions From Deforestation and Forest Degradation (REDD+) – Canada's Action on Climate Change – Government of Canada website
- Understanding REDD+: The Role of Governance, Enforcement and Safeguards in Reducing Emissions from Deforestation and Forest Degradation – Global Witness publication, Nov./10
- Green Banks: Paying Countries to Keep Their Trees – Article in TIME Magazine, Dec. 4/08 by Brian Walsh
- Protecting Jungles: One Way to Combat Global Warming – Article in TIME Magazine, Nov.30/09 by Andrew Marshall and Ula Masen
- Climate Debate Focuses on Deforestation – Article in Worldwatch Institute, Nov. 16/11 by Ben Block

SUSTAINABLE AGRICULTURE

LESSON 5

Introduction:

Climate change has a dual connection to agricultural practices in Nova Scotia: agricultural practices both contribute to the enhanced greenhouse effect and therefore are involved in the acceleration of climate change, and climate change results in new opportunities and constraints for agricultural production. While it has long been recognized that weather and climate play critical roles in the success of agricultural systems, the effects that climate change will have on production are poorly understood. Although most scientists agree that climate change is having, and will continue to have, a variety of effects on agriculture, including changing growing seasons, precipitation levels, temperatures, and timing of frosts, there is less certainty as to the overall net effects. Like many regions of the world, Nova Scotia is expected to experience a mix of positive and negative effects on its agricultural systems. Adaptation to climate change is important as a way of both minimizing the potential risks of climate change and taking advantage of new opportunities. Agricultural adaptations to climate change can take many forms and may be carried out at different levels (e.g., by producers, agribusiness, and governments); however, what many of these adaptations have in common is their incorporation of principles of sustainable agriculture into current practices.

Objectives:

Students will brainstorm different agricultural practices in Nova Scotia and discuss how these may be affected (positively and negatively) by climate change. Students will discuss how different approaches to farming, including large scale industrial farming, may contribute to and be affected by climate change. Students will also be introduced to some more sustainable alternatives to conventional farming. Through a group role play activity, students will have an opportunity to discuss some of the pros and cons of developing a new industrial scale poultry farm in Nova Scotia. An online low carbon diet exercise will help students begin to think about how different food choices can have different impacts on the environment.

Specific Curriculum Outcomes:

Students will be expected to…

- identify, investigate, and defend a course of action on a multi-perspective social issue (Science, 118-9, 215-4, 118-5)

Materials:

- Teaching Resources 5.1 and 5.2
- Access to laptop/computer

Time Frame:

- 1 hour

Activities:

1. Have students brainstorm as many different types of agriculture that take place in Nova Scotia as they can (e.g., corn, beef, eggs, wheat, tomatoes, etc.). Record students' ideas on the board.

2. Encourage students to suggest ways that these different types of agricultural practices may either contribute to climate change (e.g., livestock production – methane gas, high energy demands of industrial-scale crop production) or be affected by climate change (e.g., increased droughts and changes in growing seasons for crops, increased temperatures may shorten maple syrup production, etc.). Help/prompt students as necessary.

3. Discuss with students different ways that climate change may impact crop production as well as climate change-related problems with industrial-scale crop production. Help students to become familiar with some more sustainable alternatives to industrial-scale and traditional farming.

4. Have students work in small groups (3-4) to discuss the development of a new industrial-scale poultry farm in Nova Scotia.

5. Assign each student in the group a unique role (Teaching Resource 5.1) and provide each group with a copy of Teaching Resource # which provides background information on the fictional poultry production company Bountiful Birds Inc.

6. Explain to groups that they should read the backgrounder together, and then take a few minutes to independently read over the information sheets provided for each role. Encourage students to use the information on the sheets to help them think about the issues, and to give them specific points to raise during discussion, but encourage them to go beyond what information is provided and ask their own questions/raise their own issues.

7. Give students time to discuss, in role, the development idea proposed by Bountiful Birds Inc. Discuss whether this could be a sustainable form of agriculture, and whether it might contribute to, or be affected by, climate change.

8. Once groups have had time to discuss the issue, bring the class back together and have a representative from each group report back on their discussion.

9. Explain to students that they will be going to a computer lab to do an online activity that calculates the level of carbon emissions associated with their various meals/food choices (make the connection to the poultry farm – introduce students to the idea that different types of food

(e.g., chicken) are associated with different environmental impacts). Encourage students to explore the program (http://www.eatlowcarbon.org/Carbon-Calculator.html.), compare different meals, and read through the section 'What do these points mean?'

10. Have students complete a short journal response after finishing the low carbon diet activity. Encourage students to comment on what they have learned about a connection between agriculture and climate change. Have students think critically about the exercise: e.g., can they think of situations in which eating vegetables might be a higher carbon choice than meat? Have students reflect on the sustainability of current agricultural practices and patterns of food consumption. Have students suggest ways that agricultural practices and personal food choices can be more sustainable.

Assessment:

Students' contributions to the role play activity and group discussion afterward can be used to assess their understanding of the complexity that is involved in making decisions that have social, environmental, and economic dimensions. The journal responses will provide insight into what students gained from the low carbon diet activity and whether or not they have a sense of how their personal actions can be important contributions to the sustainability of environments.

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Poultry giant Bountiful Birds Inc. sets its sight on Nova Scotia

A European poultry company, Bountiful Birds Inc., has expressed interest in developing an industrial-scale poultry farm in Nova Scotia. Bountiful Birds Inc. is looking to replace several smaller poultry farms in the province that have been struggling to remain profitable and compete with larger facilities. This pattern is relatively common in Nova Scotian agriculture, as many smaller farms are being replaced by larger operations. Bountiful Birds Inc. plans to purchase the poultry quota that the closure of these smaller-scale facilities would free up. The initial level of production has been set at 800,000 birds a year; however, the owners of Bountiful Birds Inc. plan to increase production to over 1,000,000 birds in the future.

A variety of issues should be discussed in order to get a sense of whether this project should go ahead. For example, climate change impacts and the sustainability of large-scale, industrial farms are worth considering. Agriculture, and livestock production in particular, accounts for approximately 1/5 of global greenhouse gas emissions. In addition, researchers project that agricultural practices will experience both benefits and constraints as a result of climate change. Although climate change is likely to create certain challenges for poultry growers, e.g., birds can only tolerate narrow temperature ranges and may need better drainage systems to deal with floods and heavy rainfall, there may also be benefits such as reductions in heating costs and costs savings if more locally grown crops are used (climate change may increase yields of crops such as maize and soya in Nova Scotia).

Despite climate change uncertainties, the owners of Bountiful Birds Inc. are confident that an operation in Nova Scotia could be successful. The owners have also expressed an interest in supporting local crop growers in Nova Scotia for at least some of their feed requirements, and have also mentioned, although have not committed to, incorporating ‘green’ building principles and renewable energy sources into their production designs. Weighing the potential pros and cons of the new Bountiful Birds facility is not an easy task.

Within your group, taking on the assigned roles, discuss the proposal. Listen to different perspectives and try to reach an understanding of whether the proposal should go forward, taking into consideration the complexity of the issue.

Small-scale Poultry Farmer

- Concentration of large poultry farms can result in problems with excess manure – with smaller farms distributed around the province, manure can more easily be spread on nearby farms as fertilizer
- Small-scale operations often involve pasturing or "free range" conditions which are considered by many to be a more ethical and humane way of raising poultry – also decreases instances of disease and injury
- Raising poultry as part of a diversified farming operation (as opposed to a large facility specializing only in poultry) enhances biodiversity and improves environmental quality of the operation
- Industrial scale poultry operations are associated with increased rates of transmission of avian influenza (bird flu) – concern that more deadly forms of the virus can occur under these conditions and may be transferred to neighbouring poultry operations
- Smell, noise, increased traffic – concerns with general aesthetic of large-scale poultry operation (these may be concerns shared with many local residents)
- Loss of market share – difficult to compete with large-scale industrial operations that are able to produce more birds at lower costs than small scale operations

Nova Scotia Government

- Nova Scotia could benefit from new employment opportunities - chicken production already employees many Nova Scotians directly, e.g., in processing and hatching positions, and indirectly, e.g., work in feed mills, veterinarians, etc. (Nova Scotia's unemployment rate has risen in recent years and has been higher than the Canadian average)
- Province wants to support investment in local agriculture, e.g., a Homegrown Success plan was introduced in 2010
- Will provide funding to support agricultural practices that are innovative, environmentally friendly, and sustainable, and which will help make the province's agricultural industry more competitive
- The Environmental Farm Plan is a voluntary program that is meant to encourage farmers to be proactive on environmental issues and incorporate environmental management considerations into their operations – farms that complete an Environmental Farm Plan may be eligible for provincial funding to help cover costs of implementing environmentally friendly management decisions and best practices
- Select Nova Scotia is a provincial initiative to encourage consumers to support local food production – Farmers can register to have their products promoted by this program
- The Department of Agriculture's Marketing Services supports investment in Nova Scotia agriculture by providing services to help experienced farmers from outside of Canada relocate to Nova Scotia

Representative from Bountiful Birds Inc.

- Poultry production results in less methane gas emissions than other types of livestock production (e.g., cattle, pigs, etc.)
- Overall CO_2 emissions for poultry production are also less than other types of meat (e.g., while a study has revealed that 1 pound of chicken meat results in the emission of 3.2 kilograms of CO_2, 1 pound of pork results in 4 kilograms of CO_2 emissions
- Plan to incorporate a number of energy saving techniques into the buildings – e.g., use of fluorescent instead of incandescent lighting, use radiant heaters instead of gas heaters in the brooding areas, use at least some solar energy to reduce heating costs
- Plan to turn the waste from the chickens into a product that is called biochar; this is a charcoal-like substance that is being experimented with in the United States as a fertilizer; biochar also has the added benefit of keeping CO_2 in the ground, instead of allowing it to be released into the atmosphere
- Biochar can be sold to local farmers as an organic fertilizer that can reduce dependence on more environmentally damaging synthetic fertilizers
- Use broiler chickens that have been selectively bred to increase growth rates, which cuts down on energy costs associated with production
- Plan to use at least some locally sourced chicken feed (made from locally grown soya and/or maize) which will reduce poultry 'food miles' (i.e., less energy intensive production)

Environmental Non-Governmental Organization (NGO)

- An operation the size of the initial 800,000 birds will likely produce around 600 tonnes of waste a year, and this will only increase with the size of the production
- Studies have shown that chickens that have been genetically selected to increase growth rates can suffer from high incidents (over 25%) of poor locomotion when intensively-reared (i.e., raised in densely packed, closed captivity environments)
- Runoff a waste from industrial-scale chicken farms has been linked to contamination of waterways and disease outbreaks
- Many large-scale poultry production facilities have little or no associated cropland, only buildings and roads – this can lead to problems with waste management and pollution
- Chicken manure is high in both phosphorous and nitrogen and while these nutrients are important in fertilizers, the ratio of phosphorous to nitrogen in chicken manure is higher than plants require –excessive phosphorous can build up in the soil and eventually be released into water
- The profitability of industrial scale poultry production relies on the availability of cheap grain – while chicken production diverts these grains from other uses, studies have also indicated that the production of these feed crops are responsible for much of the energy usage (~80 percent) and greenhouse gas emissions (over 80%) associated with chicken production

CITIES, CLIMATE CHANGE, AND THE IMPORTANCE OF PUBLIC EDUCATION

LESSON 6

Introduction:

Cities are significant contributors to global climate change, and also sources of response, making them an important part of the solution to climate change. As areas of dense population and high levels of industrial activity, cities are responsible for high levels of energy consumption and greenhouse gas emissions. However, it is important to not only be aware of the ways that cities contribute to climate change, it is also necessary to consider how cities can also be uniquely vulnerable to climate change impacts. For example, complex urban infrastructure can be particularly vulnerable to flooding and extreme weather events and the urban heat island effect can exacerbate extreme heat and put urban populations at risk of heat-related illnesses.

Objectives:

Students will think about ways that urban areas are, and will continue to be, affected by global climate change. Students will brainstorm ways that cities are responding to climate change. In addition to learning about adaptations that may be appropriate for urban areas, students will begin to think about the importance of public education as a way of raising awareness about climate change and encouraging people to take appropriate measures to prepare themselves for a changing climate. Students will work collaboratively to prepare an educational poster or pamphlet designed to teach the public in an urban area of Atlantic Canada about climate change.

Specific Curriculum Outcomes:

Students will be expected to…

- predict and analyse the impact of external factors on the sustainability of an ecosystem, using a variety of formats (Science, 212-4, 214-3, 331-6)
- diagnose and report the ecosystem's response to short-term stress and long-term change (Science, 213-7, 215-1, 318-4)
- use note-making, illustrations, and other ways of representing to reconstruct knowledge (English Language Arts, 8.2)

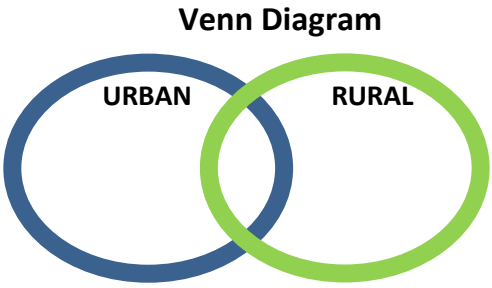
Materials Required:

- Teaching Resource 6.1
- Access to computers
- Paper and pencil crayons (optional – can create pamphlets using computers)

Time Frame:

- 1-2 hours

Activities:



1. Prepare a Venn diagram on the board. Have one circle labelled as urban, the other as rural. With the help of students, fill out the diagram with information that describes urban and rural environments.

2. Looking at the Venn diagram as a class, have students suggest some of the ways that rural areas may contribute to, and be affected by, climate change (this should be a review of some of the information covered in previous lessons).

3. Now, looking at the characteristics that students identified that are unique to cities, have students suggest some ways that urban areas are likely to contribute to, and be impacted by, climate change. Prompt students as necessary.

4. Have students identify commonalities between the way that urban and rural areas will experience climate change.

5. Focusing on the urban circle, look at the impacts that you and the students have come up with, and have students think of some ways of mitigating climate change and adapting to a changing climate that might be appropriate for urban areas. If students are having trouble, encourage students to think back to the article *Halifax Harbour faces rising waters* for some ideas.

6. Introduce the fact that increasing public education is an important part of how urban areas are responding to climate change. Explain that as one of their culminating tasks as part of their short study on climate change, students will be working with a partner to create an educational poster or pamphlet specifically tailored for an urban area in Atlantic Canada.

7. Go over Teaching Resource 6.1 with the students to help them understand what is expected of them during this activity.

8. Allow students to conduct online research and access library materials in order to find information that can be included in their poster or pamphlet. Remind students of the importance of reading material critically and relying as much as possible on good quality sources. Review with students what would be considered a reliable source.

9. Students may share their posters or pamphlets with the class and discuss challenges they encountered with their research and how they overcame these.

Assessment:

Using the rubric provided, students' posters/pamphlets can be evaluated. Students should demonstrate an understanding of how urban areas can be affected by climate change, and also an awareness of ways that urban areas can mitigate and adapt to climate change.

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Public Education Poster/Pamphlets

Working with a partner, your job is to create an educational poster or pamphlet that an urban area in Atlantic Canada could distribute to the public to raise awareness about climate change and provide information on mitigation and adaptation strategies. While you should briefly explain what climate change is and list some general impacts of climate change, you should tailor your work to a specific urban area (city, town, etc.) by discussing particular ways that climate change might affect the area (e.g., is it a coastal area? likely to be experience the urban heat island effect? etc.). Your poster or pamphlet should also include information about ways that individuals as well as the larger community can both reduce emissions and adapt to climate change. Finally, you should also provide information on where the public can go to learn more about climate change. Remember that you want the public to actually read what you have written, so presentation is important. Think of how you can use colours, images, layout, etc., to make your product visually appealing.

The following rubric will be used to evaluate your finished product. You may want to become familiar with it in order to ensure that you meet all of the requirements of this assignment.

	Level 1	Level 2	Level 3	Level 4
Content	3 or more of the required sections are missing. Information is inaccurate and/or poorly written.	2 or more required sections are missing or incomplete. There are inaccuracies and/or multiple writing errors.	The majority of the required information is included. Information is mostly accurate and there are only 1-2 writing errors.	All required information is included, with the possibility of additional material as well. Information is accurate and well written.
Layout	Pamphlet/poster is disorganized. Little or no evidence of headings or sections.	Pamphlet/poster is somewhat organized. There is evidence of some structure but it is difficult to follow.	Pamphlet/poster is organized. Information is easy to locate. Order of sections is logical.	Pamphlet/poster is well organized. The layout is pleasing to look and makes it easy to locate information.
Creativity	Lack of creativity. Little or no effort to make it visually appealing (e.g., use of images, graphs, etc.)	Some effort to make pamphlet visually appealing but lacks creativity.	Pamphlet /poster is visually appealing (good use of images, colours, formatting, etc.). Creative design.	Pamphlet/poster is visually appealing, shows careful attention to detail, and is highly creative.
Quality of Research	Little or no evidence of research. No use of reliable sources.	Evidence of some research. 1-2 reliable sources are used.	Evidence of quality research. 2 or more reliable sources are used.	High quality research. Use of 3 or more reliable sources.

Good luck, and have fun!

PHOTOGRAPHY CHALLENGE

LESSON 7

Introduction:

Images are powerful; there is certainly some truth to the popular saying that 'a picture is worth a thousand words.' There is also evidence to suggest that photographs influence memory more than words and can be more effective at helping people visualize events and ideas. Photographs are also multifunctional, being used for a variety of purposes, including swaying public opinion, highlighting issues, document evidence, and entertaining. Given the global importance of climate change, it should also come as little surprise that photographic imagery is widely used as a way of helping the public visualize climate change realities (e.g., impacts, adaptations, causes, etc.). While climate change pictures are displayed on billboards, television, and webpages, and in reports, news articles, and galleries, a number of contests have also been created in order to further elicit and eventually display photographs that capture the many 'faces' of climate change. For example, the Global Adaptation Fund created a contest in 2011 inviting submissions of photographs depicting climate change adaptations, and the World Bank also sponsored a photography and video competition in 2011 to raise awareness of climate change, with a particular focus on impacts on youth in Africa.

Objectives:

Students will review what they have learned over the course of the module by revisiting and completing the climate change concept map. Students will be introduced to ways that photographs can spread information, messages, and ideas related to climate change. Students will be introduced to the fact that photography contests are a popular way of raising awareness about issues related to climate change. Students will be asked to use a photograph to capture their understanding of how they may be impacted by climate change.

Specific Curriculum Outcomes:

Students will be expected to…

- question and analyse how a paradigm shift in sustainability can change society's views (Science, 114-1)
- demonstrate an understanding of how meaning is embedded in works of art (Visual Arts, PR 6.5)
- use writing and other ways of representing to: – extend ideas and experiences, – reflect on their feelings, values, and attitudes, – describe and evaluate their learning processes and strategies (English Language Arts, 8.1)
- use note-making, illustrations, and other ways of representing to reconstruct knowledge (English Language Arts, 8.2)

Materials Required:

- Access to computers

Time Frame:

- 1-2 hours

Activities:

1. Revisit the climate change concept map activity used to get students thinking about climate change at the beginning of the unit. Encourage students to reflect back on what they have learned and add to the map.

2. Explain to students that as a way of reflecting back on what they have learned about climate change, they will be visiting some websites to look at photographs of climate change from a global perspective. Encourage students to think about what they have learned about how climate change may affect Nova Scotia, and consider how climate change may affect regions differently while they are viewing different images.

3. Have students visit the following websites:
    - Climate Change - http://www.rockefellerfoundation.org/impacts-adaptations/
    - Click About It - http://clickaboutit.net/click-aboutit-2/
    - Connect 4 Climate - http://www.connect4climate.org/

4. Explain to students that as a culminating activity they are to present to the class a photograph that depicts their understanding of how they and/or their community or region of Nova Scotia might be affected by climate change. You can decide whether students will be required to take their own picture (this may be limited by a lack of digital cameras) or whether they will be permitted to find a photograph online that best meets the criteria.

5. Tell students that in addition to their photograph, they will also need to prepare a short (maximum of one paragraph) written statement that explains their photograph. This may be especially important as students should be encouraged to be creative and the link between their photo and climate change can be subtle, more abstract, etc.

6. Once students have had time to prepare this assignment (use your discretion – it can be a homework activity if students are taking their own pictures, or can be done in a computer lab if students are finding existing pictures), students should have an opportunity to either present their pictures to the class, or have their pictures displayed somewhere to be viewed by their peers.

Assessment:

Use students' choice of photographs and their accompanying written explanations to assess whether they are able to identify climate change impacts that may affect them or their part of Nova Scotia.

Enrichment Opportunities:

Have students organize and carry out their own school-wide climate change photography competition. Encourage students to create rules (e.g., only original photographs can be submitted), establish categories (e.g., climate change impacts, adaptations, causes, etc.), and prepare advertisements to display around the school. The class, possibly with the help of school administration and/or teachers, can determine winners for each category and submissions can be posted in the school to further raise awareness of climate change. You may decide to encourage students in the class to create short write-ups on different climate change issues that have emerged over the course of the unit to post as part of the display.

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