CLIMATIC AND ENVIRONMENTAL CHANGE: MONITORING, ADAPTATION, ACTION. THE NEW MULTI-SCALE CLIMATE AND ENVIRONMENTAL CHANGE (MUSCLE) RESEARCH CLUSTER

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Abstract
This paper presents the various research themes addressed by the members of the MUSCLE research cluster. The author attempts to explain how we can gain a better understanding of our climate system, monitor environmental changes and how these changes are linked to our society and can impact on it. Finally, it proposes a reflection on where we stand as a society in relation to climate change and presents some avenues to promote public awareness and involvement in order to be better prepared and adapt to potential future changes.

Résumé
L'auteure de cet article présente ici les différents axes de recherche abordés par les chercheurs associés au groupe de recherche MUSCLE. Les lecteurs seront ainsi amenés à mieux comprendre leur système climatique et les moyens utilisés afin de contrôler les changements environnementaux et leurs impacts sur notre société. Enfin, l'auteure propose une réflexion au sujet du rôle joué par la société dans la nouvelle réalité des changements climatiques. Elle présente certaines pistes qui appellent à une prise de conscience et à une plus grande implication sociale afin de mieux se préparer et s'adapter aux changements potentiels qui nous attendent.

The research cluster

One of the new research clusters at Bishop's University, the MUSCLE, is devoted to the monitoring of environmental and climate changes and to researching their impacts on ecosystems and society for adaptation planning purposes and public education. This cluster counts members from various departments and disciplines, from

Biology to Physics, to Computer Sciences and Geography, Chemistry and even Business. It was created in fall 2009, thanks to an initiative led by Dr. Valerio Faraoni (Physics Department) and subsequently assisted by Dr. Elisabeth Levac (Environmental Studies and Geography Department).

The MUSCLE cluster was awarded a Canada Research Chair with the goal of boosting research in this field. Dr. Matthew Peros, who holds the Tier II Canada Research Chair in Climate and Environmental Change, joined us at Bishop's this summer and will now coordinate the cluster. A strong researcher in his field, Dr. Peros is conducting research in the Canadian Arctic and Cuba, leading projects in paleoclimatology and in archeology. As such, his work corresponds to the idea of the research cluster: to combine the social aspects and scientific knowledge of environmental change. He will be the missing link between the widely different research programs of our cluster members which focus either on human, physical or technical aspects of climate and environmental research.

Introduction: Climate change and us

The "Environment" with a big E is on everyone's mind these days. Canadians perceive climate change as a bigger threat for the "vital interests" of our country than international terrorism, according to a recent survey commissioned by the Canadian Defence and Foreign Affairs Institute (Innovative Research Group, Inc. conducted the research between Dec. 22, 2009 and Jan. 4, 2010) (Stone, 2010). Back in 2004, a similar poll showed that Canadians' fear of these two threats was equal (52% for climate change versus 49% for terrorism). In 2010, the fears related to climate change remained relatively stable (falling only 3% to 49%) while fears about terrorism fell to 28% (Stone, 2010).

While only half of Canadians expressed fears about climate change, an even greater proportion (80%) believes there is solid evidence for global warming (Borick et al., 2011). South of the border, this proportion drops to 58% (Borick et al., 2011), which is a higher number than we ought to expect given the relentless efforts made to emphasize the "uncertainties" inherent to the scientific method (Oreskes and Conway, 2010).

Environment Canada reports that Canada experienced its warmest year on record in 2010 (Environment Canada, 2010). However, 2010 will not be remembered solely for its crippling periods of excessive heat; smog was also an issue of major concern in several parts of the country. It has been noted that air quality has in fact declined dramatically over the last few years, not only in the summer months but during the winter months as well (Environment Canada, 2008).

Environmental change is now almost irrefutable. Such change not only affects temperatures but can have numerous other impacts as well. Hence the name of the research cluster: climate and environmental change is complex, it involves numerous interactions between the atmosphere, lands, living organisms (including humans), and it operates on different time and geographic scales. We live (and think) in the present, but it is important to step back to be able to see how much, and how fast, our natural world has changed. The name MUSCLE thus stands for MUlti Scale CLimate and Environmental change.

This article divides into three sections: *ready!, set!* and *go!* The section titled *ready!* focuses on the monitoring aspect: how, how much and how fast is our environment changing? We will explore how researchers within our clusters are monitoring various aspects of environmental and climate change and their impacts. And if we talk about impacts, we have to realize that we, as humans, will also be affected. The section on adaptations (*set!*) will present the actions being planned by our governments in response to climate change. Although we share a certain responsibility in our present climatic and environmental situation, this section asks, are we ready to do anything about it? This is where our community can play the biggest role: action. That last section (*go!*) will be short, as it is a work in progress, constantly evolving. We are hoping to raise people's awareness about climatic change and to promote and support community-based research or action plans.

Ready! Monitoring climate and environmental change

Monitoring climate and environmental change is an important aspect of this research cluster because it will help scientists anticipate their effects on society and on ecosystems. Monitoring will also provide the necessary tools to determine how key natural resources would be the most affected (hence affecting communities and the economy), and to identify what ecosystems would be especially sensitive to changes. Future actions and adaptation plans should be based on knowledge.

Climate in itself is a broad field. The field of environmental studies is broader still: it includes almost every aspect of our natural world, and it touches many parts of our society, especially if we consider that humans are also part of the natural world. This is why the members of the research cluster have defined a series of four research themes, each addressing a set of questions/problems. These are: Mechanisms of climate change; Impact of climate change/biogeography; Adaptation measures; Monitoring and data analysis. I will now discuss these four research themes.

Research Theme 1

Mechanisms of climate change

The main objective of this research theme is to understand specific aspects of the dynamics of climatic and environmental change (in the past and at present). Basically, it is an attempt to better understand how climate works and how environmental changes take place. The second objective, which is to monitor present climatic and environmental changes at various spatial (geographic) and time scales, is one very important research priority identified by the Intergovernmental Panel on Climate Change in their 2007 report (IPCC, 2007a).

Of course, this research cluster cannot address all the questions pertaining to climate and environmental change. Researchers grouped within this theme mainly seek to document the natural variability of climates in the past, identify the impact of large meltwater discharge events on the Canadian climate and study the production and dispersal of biogenic particles (pollen, mold spores etc) to the global aerosols (e.g. dust) budget in the atmosphere (Sokolik, 2001).

We know that Canada was located under a large ice sheet some 20,000 years ago. When deglaciation started, large pools of meltwater accumulated in some areas. This meltwater was released into the Atlantic Ocean in large catastrophic events. Knowledge and understanding of these past events is essential because as we look to the future, we see that the anticipated melting of Arctic glaciers and of the Greenland ice sheet will add significant amounts of freshwater to the surface waters of the North Atlantic Ocean. This can disturb oceanic circulation, responsible for bringing warm ocean currents and heat towards the higher latitudes. At present, the warm Gulf Stream travels towards the north, carrying heat. When this current reaches the Nordic Sea, the surface water masses cool down, become denser and sink to form deep water masses that circulate around the world at the bottom of the oceans and resurface some thousand years later. This is called the thermohaline circulation. When large amounts of freshwater are added to the oceans, thermohaline circulation is slowed and the climate around the North Atlantic Ocean cools (Broecker, 1999).

Factors causing change in the climate system, such as these large meltwater releases, are called “forcing”. There are numerous climatic forcings but most of us are particularly familiar with greenhouse gases (CO_2, methane) and volcanic dust.

In this digital era, we sometimes feel that satellites, radar, and other sophisticated detection equipments can provide us with all the data we need, and that computer models will be able to simulate how our climate system will react to various “forcings”. This is something of a misconception. If we want to use climate models to simulate future

climate changes, we first have to test the models against "real" data, or replicate past climatic events. Until we have time machines, we will need to rely on what we call "proxy" data. An example of proxy is pollen grains preserved in lake sediments. These provide an indication of the type of vegetation growing around the lake, which in turn will allow us to reconstruct the air temperature. Other proxies will be used to determine the temperature of the sea surface, or its salinity. In essence, proxies are tools that are used to indirectly determine climatic conditions in the past, long before we had thermometers and monitoring stations.

Climate modelers also need all kinds of information about the past, as inputs into their models. Basically, they need to re-create past "settings": what was the ice extent? Where were large lakes located? What type of vegetation grew in various regions? What was the extent of the ice at various times in the past? And most importantly, climate modelers need to know about past climatic events in order to test their climate models for accuracy. If a model is able to re-create a given climatic event with the set of known settings and forcings, then that model should be able to predict future climate changes. Modelers can also use past climatic events as analogues for future climatic impacts of the present global warming trend (IPCC, 2007a, b). An example of analogue would be the large inputs of freshwater (meltwater) to the Atlantic Ocean during the deglaciation. These affected the thermohaline circulation and the climate, and as such could be used to estimate the impact of a melting Greenland ice sheet on the sea surface conditions in the North Atlantic. Would the melting of the Greenland ice sheet result in large changes in oceanic circulation and even in abrupt climate changes? Estimating the impact of meltwater on the ocean is one of the projects to be carried out by this cluster (Levac et al., 2011).

We sometimes feel that we know everything about the last ice age and the deglaciation period (the last 15,000 years) that followed. Actually, more research is needed about these time periods. We need to know more about the drainage of meltwater to the oceans. We need to know what major episodes of meltwater drainage occurred along the Eastern Canadian Seaboard during the last deglaciation, and when they precisely occurred (Alley and Agustdottir, 2005; IPCC, 2007a). We need to identify the sources and the oceanic paths of these large meltwater discharge events, and determine if these large releases of freshwater corresponded with (or caused) major climatic events in the past (IPCC, 2007a). One important cooling episode occurred some 8200 years ago (Alley and Agustdottir, 2005) and recently published data shows evidence for a large meltwater drainage event occurring

right before the start of the climatic cooling (Levac et al., 2011). Earlier, another event called the Younger Dryas caused a large cooling and resulted in the return of tundra-like vegetation and the growth of glaciers in many places. Some data about the impact of the Younger Dryas event on sea surface water conditions in the North Atlantic will be published soon (Levac et al., in preparation).

We also need to know more about the continental climate (air temperature) and ice extent during the last ice age and deglaciation. This is where Dr. Peros' expertise will be valuable. Dr. Peros has done extensive field work in the Canadian Arctic. Using a variety of proxy indicators, and especially pollen, he has studied the evolution of the Holocene (the period covering the last 10,000 years) climate and reconstructed air temperature for that region (Peros and Gajewski, 2008; 2009). Some of this work falls within our second theme: the impact of climate change (next section).

Dr. Peros is proposing to pursue his research on Arctic paleoclimatology and paleoecology by examining areas that might have been ice-free during the last glaciation. Pollen records from northern Yukon Territory would provide climatic information going back tens of thousands of years. This is precious because most paleoclimatic records in Canada only go back some 8000–10,000 years. The Canadian Arctic is a key area in terms of climate because it will be the most affected by global warming (IPCC, 2007a).

Dr. Peros is not only seeking to identify what forces are influencing climatic and environmental change (using various proxies), his research programme also addresses the constraints these environmental changes impose on human societies and the opportunities they provide for cultural change. Thanks to his background in archaeology, he is also assessing how humans have impacted the natural environment in the past. More will be said about this in the discussion of our third theme: adaptations measures to climate change.

Research Theme 2

Impact of climate change: biogeography and hydrology

If the climate and the environment are to change, we ought to expect that our ecosystems will be affected as a result. The objectives of this research theme are to study the present day biogeography (the distribution of organisms and ecosystems), to determine its links with various environmental factors (such as temperature, precipitation, soil types etc.), and to track modifications of ecosystems and of their evolution following environmental changes (IPCC, 2007a).

Consider global warming and think about living organisms. You will start wondering what species of insects, animals or plants will be

affected by climatic and environmental change and how much. We cannot tackle all of the organisms living in our ecosystems, so our researchers are targeting insects, plants and birds.

The researcher who is studying insects is Dr. Jade Savage. She notes that individual insect species distributions are heavily controlled by temperature (and thus climate changes), and that many species of flies have extended their distribution range northwards over the last seven decades. She will therefore seek to gain greater knowledge of the impact of environmental and habitat changes on diversity and species composition. We need to understand the response of whole communities, not just of single species, to climate changes (Savage et al., 2009). Since climate changes in the Arctic and in alpine habitats are generally more dramatic than in lower latitude/altitude ecosystems, we need to monitor how insect communities are affected by various climatic factors in alpine and arctic ecosystems, especially along natural transition zones. We need to do the same in relation to insects' habitat/landscape, as these might also be affected by climate change.

Plants will also be affected by global warming and its associated impacts (IPCC, 2007). Dr. Robert Van Hulst is studying the effects of climate change on Quebec plants, both at the theoretical level and in the field. Wendy King is studying the effect of fires on the vegetation of Australia. We will see in the next section that vegetation (especially forests) belongs to what the provincial government calls the *natural capital* and is identified by the federal government as one of the important natural resources in this country. Dr. Van Hulst's research will be in line with past research conducted by Dr. Peros, who has studied the way tree populations responded to rapid climate changes (Peros et al., 2008).

Global warming will not only affect plant distribution, it will also have indirect impacts on phenomena such as pollen production. Airborne pollen has been studied in Sherbrooke and a pollen calendar has been created (Levac, 2011). Airborne pollen and mold spore concentrations have also been compared with weather parameters by two former Bishop's students (Sandercombe, 2006; Stretch, 2007). Data is collected every year in order to see how pollen and spore yields are affected by climate. The goal is to anticipate how global warming will affect pollen production and hence allergy problems.

An important component of ecosystems, which is often missed, is the set of geochemical reactions occurring in soils, plants, water, etc. Dr. Elizabeth Prusak is proposing to study specific biochemical reactions made more rapid by changes in temperature and humidity.

In our climate, we are usually not too sensitive to water issues,

except for brief drought periods in the summer when we cannot make open fire due to risks of forest fires, and when floods occur. What will be the impact of global warming on river hydrology? Dr. Norman K. Jones has recently studied the recurrence of floods in the region (Jones, 2008a) and has also examined their links with climatic parameters over the years (Jones, 2008b). He has considerable experience in field studies of rivers and alpine/arctic glaciers. Three researchers (Drs Faraoni, Heidi Webber, Brad Willms) are interested in theoretical modeling of groundwater flow and glacier dynamics. Although the media is quick to report on melting glaciers and collapsing ice shelves in Antarctica, glacier dynamics are not fully understood and the role of temperature changes on bottom lubrication and ice flow in alpine glaciers is unclear but important (Paterson, 2001).

Research Theme 3

Research on adaptation measures to climate change

Research in this theme seeks to determine how we can adapt to climate and environmental change. How can the capacity of cities, rural areas, and other communities to anticipate, adapt to, and benefit from environmental change be assessed? This assessment can be done by examining the resilience, adaptability and transformability of a socio-ecological system (if we consider that humans and human societies are a component of ecosystems we can talk about socio-ecological systems).

Socio-ecological resilience is the capacity of a system to absorb disturbances and to reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. In other words, how do we keep the system functioning in a way that is as similar as possible to the past? When changes exceed our capacity to absorb them without significant modifications to our functioning, we talk about adaptability. A step further, when the existing system is made untenable by climate change, we then talk about transformability, which is the capacity to create a new stable system when ecological, economic, or social structures cannot maintain themselves (IPCC, 2007b). The goal of all this is to identify and propose societal and economic changes or adaptations in order to respond to and/or limit the impact of environmental change (IPCC, 2007b).

A good understanding of the interrelationships between the changes in natural environment and the changes in society is also needed. We need to analyze the link between the environment and aspects of society such as institutions, governance and policy-making, the economy and public education. Locally, this translates into efforts to increase awareness and involve the public, the students and larger institutions (e.g., Bishop's University) into habitat or energy

conservation efforts. How can we do this? This will be examined in the third section (*Go*!).

Many of our members are doing research in this theme (Drs. Darren Bardati and Tom Fletcher) or are active either in outreach and conservation projects locally (Dr. Fletcher, Jeffrey MacDonald) or on the Bishop's campus (Keith Baxter, Michel Caron). Examples of implications in local outreach and conservation projects include the Société de conservation du corridor naturel de la rivière au Saumon (MacDonald), Memphremagog Conservation Inc. (Fletcher) and the Sierra Club (Fletcher).

The best example of a link between environmental change and society are the research projects our colleague Darren Bardati is conducting on community involvement in conservation projects (Bardati 2006; Bardati and Bourgeois, 2008). Dr. Bardati is now involved in a vast project, "Challenges of Coastal Communities in the Face of Climate Change," funded by a $1 million grant over 5 years (2010–2015) awarded by the Social Sciences and Humanities Research Council of Canada (SSHRCC), through the Community-University Research Alliance (CURA). The goal of this project is to foster the development of resilience in communities lying along the coasts of the St. Lawrence River, estuary and watershed. This will be done by sharing knowledge about environmental changes and by helping communities to develop strategies to cope with the environmental and political impacts of climate change. Numerous community groups as well as government agencies are involved in this project, the following among them: Southern Gulf of St. Lawrence coalition on sustainability, Stratégies Saint-Laurent, Conseil du bassin versant de la rivière Bonaventure, Observatoire global du Saint-Laurent, Agence de santé publique de la Côte Nord, and the Mikmaq of Prince Edward Island. For more details please see the web link in Appendix 1.

At this point, it is necessary to examine how people have reacted to climate and environmental changes in the past. Dr. Peros has studied coastal archaeological sites located near mangroves in Cuba and reconstructed the local paleoenvironments in which these people lived (Peros et al., 2007; Cooper and Peros, 2010). In the future, Dr. Peros intends to study the prehistoric environmental-human interactions in the Caribbean. Among other things, he will document the hurricane activity during the Holocene, using storm-surge overwash deposits from lagoon sediments that indicate past hurricane strikes. Paleo-storm records are needed to assess the hurricane return period in the context of global warming, and to plan for future events in coastal communities. Closer to us, Dr. Peros wants to examine the effects of the Younger Dryas Cold Period on Paleo-Indian populations.

Research Theme 4

Monitoring and Data Analysis

Environment and climate change studies with the goal of environmental monitoring are primarily based on the analysis of data collected from different sources. New tools and techniques must therefore be developed or adapted (IPCC, 2007a). The principal automatic sources of data collection are measurements provided by satellites, aerial, or ground sensors. On their own, these bits of data can appear meaningless. The data must be analyzed by using key techniques such as image processing methods in remote sensing, photogrammetry, and Geographic Information Systems.

Two of our researchers, Dr. Madjid Allili and Dr. Layachi Bentabet, have a rich mathematical background in computational topology, differential geometry and statistical mathematics, and use this to design reliable techniques and powerful algorithms for image data analysis and GIS (Bentabet et al., 2003; Rana, 2004; Allili et al., 2007; Bonk, 2007).

Nowadays, research on climate and environmental change involves huge amounts of data from numerous locations. Large scale trends are impossible to see with statistical tools. It is also difficult to visualize spatial relationships that exist within the digitally stored data. This is why mathematical tools are needed. They are also needed to model groundwater flow, glacier dynamics, aerosol dispersion, animal and plant populations, and their response to multi-scale climate change. Other potential applications include land-use planning, natural resource management, wildlife habitat analysis, and natural hazard assessment, all applications of major importance at local, national, and international levels.

Other researchers in the MUSCLE cluster propose to develop theoretical and mathematical models of alpine and arctic glaciers as indicators of climate change and of changes in groundwater flow (Dr. Faraoni and Dr. Willms). Dr. Webber works at modelling soil water and crop water use in order to identify agricultural systems vulnerable to water deficit and soil salinization and to propose possible adaptations (Webber et al. 2006; 2009).

Sometimes, large-scale or long-term trends are only visible when large datasets are analysed and signals are extracted (Peros et al., 2010). Dr. Peros will continue to use this type of analysis to extract information from large paleoenvironmental and archaeological database. The goal is to examine interactions between climate, vegetation, and people over large spatial scales. Right now, his regional foci are northern Canada and the Caribbean, but Dr. Peros' work should include the Eastern Townships in the coming years.

Set! Planning Adaptation Measures to Climate Change and Identifying Research Priorities

Our governments, at the national, provincial and even at the municipal levels, believe in climate change and have plans to address various impacts climate change will have on society. Preparedness requires knowledge and involves a great deal of research. Some of our cluster's research goals clearly match some of the governments' research priorities.

Federal research priorities

At the national level, we will examine the research priorities of three major federal agencies: Canada Environmental Assessment Agency, Natural Resources Canada, and the Meteorological Service of Canada. Their current priorities relate to climate change, its impact on ecosystems and society, and to the anticipation/adaptation to climate change, including sustainable development (NRCAN, 2009; CEAA, 2009). I will briefly mention which members are involved in each topic.

The Canadian Environmental Assessment Agency identifies shifting climatic conditions and associated social changes as major challenges (CEAA, 2009), as does the Social Sciences and Humanities Research Council of Canada (SSHRCC), which finances the large research project Challenges of Coastal Communities in the Face of Climate Change in which our colleague Darren Bardati is actively involved. They have invested $1 million to study climate change adaptation and to foster academic-community partnerships.

Natural Resources Canada (NRCAN, 2009) acknowledges that natural resources are directly affected by climate change, for example forests, fire, and insects (Savage), biodiversity (King, Levac, Peros, Savage, Prusak, Dr. Stephen Yezerinac), conservation (MacDonald, Baxter, Fletcher), and groundwater (climate change affects precipitation and storage in glaciers) (Bardati, Jones, Faraoni, Willms).

Natural Resources Canada (NRCAN, 2009) also underlines that the study of paleo-environmental records of climate change is essential for policy-making, to create realistic scenarios of potential impact, and to verify climate models. Paleoclimatic records are used to assess the natural variability and thresholds of climatic systems (Allili, Bentabet, Jones, Levac, Peros), and these subjects have been identified as priorities also by the Meteorological Service of Canada. Finally, the role of clouds and biogenic aerosols (Levac) needs to be incorporated in climate models.

The provincial government is clearly showing a desire to act on climate change, at least on paper. The *Plan d'action 2006–2012 sur les*

changements climatiques of the ministère du Développement durable, de l'Environnement et des Parcs du Québec states that « La lutte contre les changements climatiques exige des actions immédiates et concertées » (the fight against climate change demands immediate and concerted actions) (MDDEP, 2006). This action plan includes a programme for climate monitoring (Jones, Levac, Peros), as climate changes affect population security and have major economic impacts (Baxter, Fletcher, MacDonald). This plan also aims at reducing greenhouse gas emissions, and Bishop's University has made many important changes to reduce its emission among which the implementation of geothermal energy and new heating systems (Caron).

Along with the Action Plan for Sustainable Development (*Plan d'action de développement durable*) (MDDEP, 2008), the Quebec government presented a list of sustainable development indicators used to monitor progress made in Quebec in this field (MDDEP, 2009). One of the dimensions listed in *Natural Capital* is biodiversity, which relates to some of the objectives of our cluster (Savage, King, Yezerinac, Van Hulst, Levac). Other dimensions of *Natural Capital* addressed by our cluster are forests, surface waters (Jones, Faraoni, Willms, Webber), air quality (Levac) and climate (Jones, Willms, Levac, Peros). Water is a precious resource, lacking in certain areas, and Dr. Webber is looking for methods to use water resources more efficiently in agriculture (Webber et al., 2006; 2009).

One of the sustainable development indicators used by the Quebec government, *Human Capital*, includes education (MDDEP, 2009). Undergraduate and graduate training taking place in our cluster relates to this priority. A number of graduate students are actively involved in the research projects of many of our cluster members, as well as many undergraduate students working as summer research assistants in the laboratories. Moreover, each year, a number of undergraduate students choose to tackle a research project of their own and produce an honours thesis. This year in the Environmental Studies and Geography department, one honours student assessed the feasibility of building a self-sufficient home in the Eastern Townships (Klinck, 2011). Another student studied the effect of recent global climate change on the spring migration of some Ontario bird species (Kryczka, 2011). A different example of honours thesis is the use of historical GIS (geographic information systems) to track land-use change in downtown Sherbrooke over the last 150 years (Gkotsis, 2011).

Outreach activities and awareness efforts also fall within the scope of education (MDDEP, 2009). Many of these dimensions of society and sustainable development are also emphasized by UNESCO. Members clearly involved in such activities are Fletcher, Baxter, Kingsley and

MacDonald. Some of these members have also recently published textbooks in this field of studies (Faraoni, 2006; Fletcher, 2010).

_Go_! Are We Ready to Take Action?

As discussed earlier, climate change is perceived as a threat to our society. Is the fear serious enough to lead to action or is lethargy preventing us from doing so? It is difficult to answer that question because results of surveys have changed from year to year.

In 2007, a report from the Finance Department stated that few Canadians were ready to change their habits or to make financial sacrifices to save the environment, even if most believed in global warming (The Ottawa Citizen, May 23, 2007). The same article, however, mentions another government poll (conducted by a different firm) showing contradicting results, finding that about 60% of Canadians would be in favour of a new green tax.

In 2008, the main conclusion of a larger poll of 12,000 citizens from 11 different countries (including Canada) was a distinct lack of enthusiasm for international efforts to fight climate change: the public was becoming reluctant to make personal sacrifices (Canwest News Service, November 27, 2008). The poll also underlines a growing dissatisfaction with the government's perceived inaction resulting from its focus on indirect actions such as increasing taxes on fossil fuels, encouraging individual environmentally friendly activities and participating in international negotiations. Instead of these types of indirect actions, 55% of respondents in 11 countries think governments should take direct actions and invest in green energy sources. In 2011, this perception towards the government has not changed: 68% of Sherbrooke residents believe the government in place is taking no measures at all (or too few measures) to counter global warming (Gilbert, 2011).

Despite our discontent with the lack of concrete measures to counter climate change, we still expect others, including the government, to lead actions to protect the environment. When the Community Foundation of Canada took the "pulse" of Canadian Communities in 2010, it concluded that we believe we can make a difference but that we lack the motivation to do so. When they are aware of environmental issues affecting their community, most Canadians will expect the government or other citizens to address these local issues (*http://www.vitalsignscanada.ca/nr-2010-public-opinion-survey-e.html*). Locally, we are no different than most Canadians. One honour's student, Evelyne Gilbert, surveyed people in Sherbrooke, Quebec and Yamaguchi, Japan and found that in both countries a strong proportion (65% and 72%) of residents are expecting either their governments or Non Government

Organizations (35% and 32%) to lead the social changes necessary to counter global warming.

When we compare recent surveys with those conducted in 2007 and 2008, we do note one significant change: we are now ready to consider investing. A 2011 survey reveals that 73% of Canadians now say they would accept paying an extra $50 per year in energy costs to support the production of renewable energy (O'Neil, 2011).

While we are ready to commit monetarily, most Canadians admit to being lazy and resisting changes in lifestyles (Community Foundation of Canada, 2010). This does not mean that the situation is hopeless, but might indicate rather that the issue is perceived by many to be too vast to handle (O'Neil, 2011). Jacques Languirand, radio host for Radio-Canada, speaks of procrastination and suggests cutting large tasks into a set of smaller ones (*Par Quatre Chemins*, Radio-Canada, March 27th, 2011). This is actually a plausible course of action in this particular situation. People are more willing to act if they don't feel the task is overwhelming and if they see immediate results. 70% of Sherbrooke residents compost, 90% recycle, 82% use ecobags (Gilbert, 2011). With these three simple actions, we see the results: the amount of material ending up in the garbage bins is dramatically reduced. We are far less committed in gestures that would really reduce the amount of CO_2 produced, such as walking and biking instead of driving (40%) or using public transit (only 20%) (Gilbert, 2011).

It is obvious that we are waiting for some leaders to show us the way and set us in motion. Energetic young people with good ideas and initiative might be what we need. Even small projects can make a difference and acting locally is important.

Bishop's University students have been especially active in a number of green initiatives. Small universities are in an excellent position to raise awareness in their communities due to their small size and close connection with the community, and to initiate societal changes, promote innovation and facilitate public involvement. Student groups such as the Sustainable Development Action Group (SDAG) and the Environment Club have already had a real impact on decision-making in the campus community.

Successful initiatives were led by SDAG at Bishop's University, including the "Think Global, Drink Local" campaign in 2009. Bishop's University became the first campus in Quebec to ban sales of single-use bottled water after a student referendum in March 2010. SDAG members are working to increase the percentage of campus waste that is recycled or composted. Printing from campus computer is now recto-verso by default. To promote sustainable forms of transportation, a bike-sharing program called Gaiter Gears has been proposed. Finally,

the Lennoxville Plastic Bag Initiative seeks to have plastic bags banned from our borough.

Another student group, the Bishop's University Environmental Club, is working hard at raising student awareness about environmental issues and at promoting student initiatives on campus. Promotion activities include sustainability fairs, town clean-ups, car-free days. The club has proposed to buy a dishwasher for the Gait (on-campus bar) instead of using disposable glasses and beer mugs. Apparently small but useful and readily applied actions!

At the municipal level, not only did the city of Sherbrooke implement selective garbage collection, including the separate collection of compostable material, the city has also created "La Brigade Verte," which employs young people each summer. Among other things, they promote lawns with a greater biodiversity!

It would be unfair to take credit for the great work done by our students. You are therefore strongly encouraged to visit their web sites (Appendix 1). Similarly, since this article only summarizes the work performed by our research cluster and gives a very brief overview of my colleagues' research, its web site will give you a more detailed description of the various projects under way (Appendix 1).

This research cluster hopes to foster innovative research into the monitoring of environmental and climate change and to promote tighter links between the researchers and the general public in order to make our community more resilient to changes, maintain or even improve its quality of life.

APPENDIX 1: WEB LINKS

Challenges of coastal communities in the face of climate change *http://www.ubishops.ca/research/whats-new.html*.

Plans to implement geothermal energy at Bishop's University: *http://www.ubishops.ca/fileadmin/bishops_documents/services/SDAG/AMERESCO.pdf*

Sustainable Development Action Group and Bishop's University Environmental Club: *http://www.ubishops.ca/sustainability-and-environmental-actions-at-bishops.html*
http://www.ubishops.ca/sustainable-development-land-use/index.html

Multiscale Climate and Environmental Change research group at Bishop's University: *http://www.ubishops.ca/research/research-units/multi-scale-climate-and-environmental-change-research-group.html*

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