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THE AMERICAS:
BUILDING THE ADAPTIVE CAPACITY TO GLOBAL ENVIRONMENTAL CHANGE

By:
Adam Fenech, Mary Murphy, Don MacIver,
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Adam Fenech[1]*, Mary Murphy[2], Don MacIver[1], Heather Auld[1] and Robin Bing Bong[1]

[1] Environment Canada, 4905 Dufferin Street, Toronto, Ontario, Canada
[2] Calendrium, Ottawa, Ontario, Canada
(*author for correspondence: Tel. +1 416 739-4267; email: adam.fenech@ec.gc.ca)

1. Introduction

Global environmental change can be described as a transformation in the earth's natural and anthropogenic processes that occurs on a worldwide scale (for example, an increase in carbon dioxide in the atmosphere) or that accumulates to have a worldwide impact (for example, local species extinction resulting in global loss of biodiversity). Sometimes, the term "climate change" – a designation with its own functional ambiguity as it is used to describe any climate inconsistencies, past present and future is often used synonymously with global change. The scope of global environmental change is, however, much broader than the climate system and includes global environmental systems such as the atmosphere, oceans (hydrosphere), biosphere, and geosphere and their interactions and associations with each other. Human activities play a large role in influencing global environmental change primarily through human population growth, changes in economic activities, socio-political factors, cultural factors and technological change (Millennium Ecosystem Assessment, 2005).

Our understanding of global environmental systems and the ways in which human actions are perturbing it, has advanced remarkably since 1990 (Steffen et al., 2004). Scientists are now able to predict with quantifiable skill some global processes such as atmospheric weather patterns (MSC, 2005a), changing ocean currents like El Nino (NOAA, 2005), and tectonic events like earthquakes and volcanism (Luongo et al, 1996). Scientists are also able to accurately monitor global systems given the efforts in developing global monitoring programs such as the Global Climate Observing System, the Global Terrestrial Observing System and the Global Earth Observing System. The challenge remains, however, to determine how to appropriate this emerging knowledge into our decision-making processes and policy formation, whether this is at the national, regional or global level (Adger et al, 2005).

2. Global Environmental Changes Affecting the Americas

The literature is quite clear about the global environmental challenges facing the Americas – specifically climate change; acid deposition; extreme weather events; human population growth; land cover changes; loss of biodiversity; invasive species; environmental threats to human health; and environmental threats to water.

2.1 Climate Change

The Earth's climate system has changed since the pre-industrial era, in part due to human activities, and it is projected to continue to change throughout the twenty-first century. According to the Intergovernmental Panel on Climate Change (2001), the global mean surface temperature has increased by about 0.6 degrees Celsius during the past 100 years. During the same time, precipitation patterns have changed spatially and temporally, and global average sea level has risen by 0.1 to 0.2 meters.

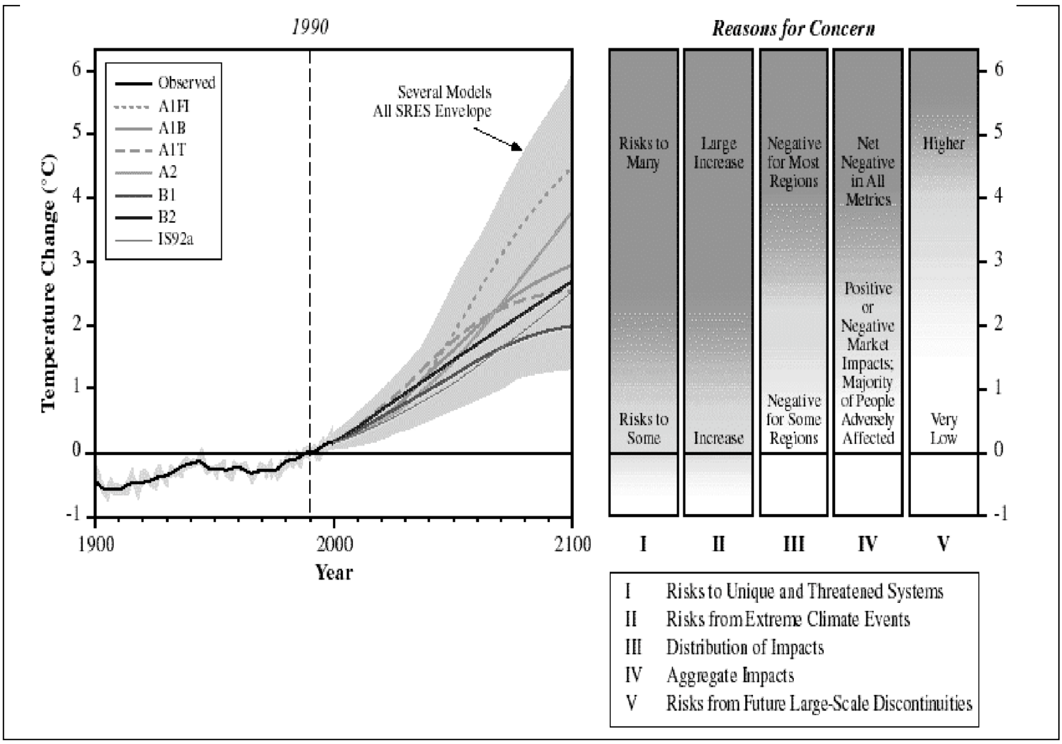

Figure 1: *Future Scenarios of Temperature Increases*

Source: IPCC, 2001.

These observed changes in climate have already affected biological systems in many parts of the world (MEA, 2005). There have been changes in species distributions (Parmesan, 2005), population sizes (H. Acevedo, 2003), and the timing of reproduction or migration events (Ahola et al, 2004), as well as an increase in the frequency of pest and disease outbreaks, especially in forested systems (Percy et al, 2002). Observation networks also show that the growing season has lengthened over the last 30 years in many parts of the world.

The IPCC (2001) concludes that human emissions of greenhouse gases and aerosols continue to alter the atmosphere in ways that are expected to affect climate. In fact, the IPCC (2001) states that “there is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities”. All models of future climate change indicate that temperatures will continue to increase regardless of greenhouse gas reductions made under the UN Framework Convention on Climate Change and its subsequent Kyoto Protocol. Figure 1 shows the range of potential temperature increases over the next 100 years under various scenarios of climate change and future human population growth and economic development.

2.2 Acid Deposition

During much of the 1900s, acid deposition, acidification of soils and surface waters, and damage to forests and fish affected large regions of Europe and North America. Emissions of acidifying sulphur and nitrogen have been reduced in North America since the 1990s and in Europe since the late 1970s and will be further reduced when the Gothenburg protocol is fully implemented by 2010. The rate of recovery of acidified terrestrial ecosystems remains small in both North America and Europe (MSC, 2004), and future modeling indicates that base saturation in Europe will increase less than 5 percent over the next 30 years (Beier et al, 2003). A climate-induced increase in storm severity (IPCC, 2001) will increase the sea-salt input to coastal and inland ecosystems. This will provide additional base cations to the soils and more than double the rate of the recovery, but also lead to strong acid pulses following high sea-salt inputs as the deposited base cations exchange with the acidity stored in the soil (Beier et al, 2003). The future recovery of soils and runoff at acidified catchments will thus depend on the amount and rate of reduction of acid deposition, and in the case of systems near the coast, the frequency and intensity of sea-salt episodes as well.

2.3 Extreme Weather Events

One of the most threatening aspects of global environmental changes is the likelihood that extreme weather events will become more variable, more intense and more frequent. International concern over extreme weather events has grown as the economic damages and human tolls from these events have increased. Since the 1950s, the annual direct losses from natural catastrophes have increased from US$3.9 billion to US$40 billion a year in 1999 dollars, as shown in Figure 2 (Munich Re, 2004; IPCC, 2001). Bogardi (2004) states that it seems to be quite realistic to assume that the average annual physical exposure to floods in all 191 countries of the world cannot affect less than about 800 million people. He concludes that the aggregate effect of higher frequency and intensity of rain, snow and ice melting affecting more denuded slopes and high runoff urban areas together with the projected population growth and displacement tendencies could easily catapult the number of people susceptible to experiencing and suffering from floods to reach or even surpass 2 billion people by the year 2050.

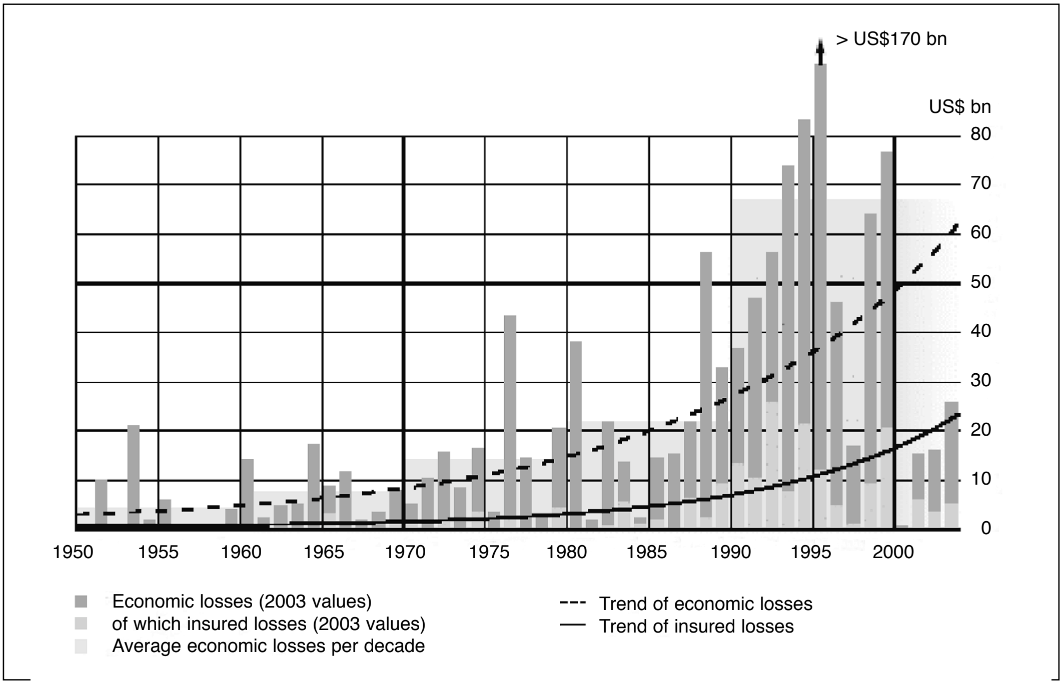

Figure 2: *Insured Economic Losses 1950 to 2004*

Source: Munich Re, 2004

2.4 Human Population Growth

The global population of humans has doubled in the past 40 years and increased by 2 billion people in the last 25 years, reaching 6 billion in 2000 (MEA, 2005). Countries such as the USA are experiencing high rates of population growth through high levels of immigration. About half of the people in the world now live in urban areas (although urban areas cover less than 3 percent of the land surface) with Latin America's urban population as high as 75 percent. Over the past 50 years, the world's urban population (~2.7 percent per year) has grown faster than the total population (~1.8 percent per year (Gurjar and Lelieveld, 2004). The world urban population is expected to rise to 5 billion by 2030. Lelieveld and Dentener (2000) have predicted that the emerging emissions in developing countries will increasingly affect hemispheric background ozone in the future, to the extent that regional control measures in Europe and USA can be overpowered. As not much is known about atmospheric chemistry in the tropics and subtropics, where much of the world population growth occurs, the study of atmospheric emissions from tropical megacities will have special significance (Crutzen and Lelieveld, 2001). The increase in human population leads to the push for additional resources and settlement areas from our natural ecosystems, especially brought about by forestry and agricultural activities.

2.5 Land Cover Change for Agriculture and Forestry

The Millennium Ecosystem Assessment (2005) focuses on land cover change as the most important direct driver of change in ecosystem services in the past 50 years. In 9 of the 14 terrestrial biomes examined in the MEA (2005), between one half and one fifth of the area has been transformed already, largely to croplands. Only biomes relatively unsuited to crop plants, such as deserts and tundra, have remained largely untransformed by human action. In coming years, the enormous human population increases, combined with growing per capita consumption, will continue to result in agricultural expansion on new lands, mostly through deforestation (FAO, 2003). Agricultural land is expanding in about 70 percent of countries, declining in 25 percent and roughly static in 5 percent. In two-thirds of the countries where agricultural land is expanding, forest area is decreasing, but in the other one-third, forests are expanding. These expansions are called forest transitions (Rudel et al, 2005). In some places economic development has created enough non-farm jobs to reduce farming activities, thereby inducing the spontaneous regeneration of forests in old fields. In other places a scarcity of forest products has prompted governments and landowners to plant trees in some fields. The transitions do little to conserve biodiversity, but they do sequester carbon and conserve soil, and so should be encouraged.

2.6 Loss of Biodiversity

Extinction is a natural event and, from a geological perspective, routine. The average duration of a species is 1-10 million years (based on the last 200 million years). There have been several episodes of mass extinction, when many taxa representing a wide array of life forms have gone extinct in the same short geological time. In the modern era, due to human actions, species and ecosystems have been threatened with destruction to an extent rarely seen in Earth's history. Probably only during the handful of mass extinction events have so many species been threatened, in so short a time. The broad category that most threatens biodiversity is global change.

2.7 Invasive Species

Non-indigenous invasive species may pose the single most formidable threat of natural disaster of the 21st century (Schnase et al, 2002). According to NASA scientists, the threat of invasive species is perhaps our most urgent economic and conservation challenge (Schnase, 2004) placing the economic cost of alien species between $100 billion and $200 billion per year. The renowned Harvard biologist

Edward O. Wilson (2002) has claimed that the introduction of alien species is second only to habitat destruction as the leading cause of extinctions worldwide. When an alien species enters a new ecosystem, it can alter the environment in a number of ways: by consuming native species; by spreading disease among them; or by altering the environment in such a way that favours themselves.

2.8 Environmental Threats to Human Health

Trends in illnesses and deaths associated with air pollution, extreme weather events, allergies, respiratory diseases, and vector-, food- and water-borne diseases all illustrate that weather and climatic factors influence human health and well-being (Riedel, 2004). Therefore, there is concern that climate change of the magnitude projected for the present century by the IPCC (2001) may have significant consequences for human health and the health care sector throughout the Americas. The greater the potential for disastrous, large-scale, or catastrophic impacts on human health, the greater the case for precaution (Soskolne, 2004).

2.9 Environmental Threats to Water

The Earth has 1,386,000,000 cubic kilometers of water total but only 2.5 percent of that is fresh water. Less than 1 percent of the world's fresh water (or 0.01 percent of all water) is usable in a renewable fashion. The average person needs a minimum of 5 liters of water per day to survive in a moderate climate at an average activity level. The minimum amount of water needed for drinking, cooking, bathing, and sanitation is 50 liters. Global environmental changes will likely change rainfall and runoff patterns and seriously impact global water supplies while 1.2 billion people in the developing world still do not have access to clean drinking water. Pressure from pollution, wetland destruction, and climate change is threatening to make this situation worse (Diaz and Morehouse, 2003).

3. The Inter-American Institute for Global Change Research (IAI)

Recognizing the enormous scope of global change issues, eleven countries of the American region signed an agreement in Montevideo, Uruguay on May 13, 1992 to establish the Inter-American Institute for Global Change Research (IAI). Now, supported by 19 member countries in the Americas - Argentina, Bolivia, Brazil, Canada, United States of America, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela – the IAI is dedicated to augmenting the scientific capacity of the region through international cooperation and the open exchange of scientific information to increase the understanding of global environmental change phenomena and their socio-economic implications.

The IAI´s mission is to develop the capacity to understand the integrated impact of present and future global changes on regional and continental environments in the Americas and to promote collaborative research and informed actions at all levels. The IAI was conceived as a network of collaborating

research institutions working together to implement the Institute's Science Agenda. It functions as a regional entity and conducts research that no one nation can undertake on its own.
The IAI encourages interactive exchanges between scientists and policy makers and recognizes the need to better understand the natural and social processes that drive large scale environmental change. It serves as a helpful source of information for scientific research focused on the Americas' most pressing environmental issues.

A Scientific Advisory Committee provides the overall scientific guidance for the development, implementation and maintenance of the Institute's Science Agenda and research programs. The IAI Secretariat, the administrative arm that manages the day-to-day operations of the Institute, has been located on the campus of Instituo Nacional de Pesquisas Espaciais (INPE) in São José dos Campos, Brazil since 1996.

The scientific community and national representatives that make up the IAI have worked together to identify the most pressing scientific issues relevant to the Americas and to the scientific community that are linked to global change. Following a recent review, these four themes were adopted for the IAI's Science Agenda:

1. *Understanding Climate Change and Variability in the Americas*
   - to observe, document and predict climate change and variability in the Americas and its links to changes in natural systems and societal impacts

2. *Comparative Studies of Ecosystem, Biodiversity, Land Use and Cover, and Water Resources in the Americas*
   - to increase the knowledge of the drivers and dynamics of variability, and the impacts of such variability on food security, biodiversity and the provision of ecological goods and services

3. *Understanding Global Change Modulations of the Composition of the Atmosphere, Oceans and Fresh Waters*
   - to observe, document and understand processes that modify the chemical composition of the atmosphere, inland waters and oceans in a manner that affects productivity and human welfare

4. *Understanding the Human Dimensions and Policy Implications of Global Change, Climate Variability and Land Use*
   - to research the dynamic interaction of global change, climate variability, land use and human beings – their health, welfare and activities which depend on the productivity, diversity and functioning of ecosystems.

Examples of IAI projects underway include:

- Biogeochemical Cycles under Land Use Change in the Semiarid Americas
- The Assessment of Present, Past, and Future Climate Variability in the Americas from Treeline Environments
- Cattle Ranching, Land Use and Deforestation in Brazil, Peru, and Ecuador
- The Role of Biodiversity and Climate in the Functioning of Ecosystems: A Comparative Study of Grasslands, Savannas, and Forests
- Enhanced Ultraviolet-B Radiation in Natural Ecosystems as an Added Perturbation due to Ozone Depletion
- ENSO Disaster Risk Management in Latin America: A Proposal for the Consolidation of a Regional Network for Comparative Research, Information, and Training from a Social Perspective
- Multi-Objective Study of Climate Variability for Impact Mitigation in the Trade Convergence Climate Complex Region
- Estudio Comparativo de los Efectos de Cambios Globales sobre la Vegetación de Dos Ecosistemas: Alta Montaña y Sabana Tropical
- Andean Amazon Rivers Analysis and Monitoring (AARAM) Project
- Diagnostics and Prediction of Climate Variability and Human Health Impacts in the Tropical Americas
- Development of a Collaborative Research Network for the Study of Regional Climate Variability and Changes, their Prediction and Impact in the MERCOSUR Area
- South Atlantic Climate Changes (SACC): An International Consortium for the Study of Global and Climate Changes in the Western South Atlantic
- An Eastern Pacific Consortium for Research on Global Change in Coastal and Oceanic Regions Climate Variability and its Impacts in the Mexican, Central American, and Caribbean Region

The IAI is an important mechanism for building the capacity of the Americas to address the pressing challenges of global environmental change.

4. Building a Willingness to Adapt

A growing literature suggests that while mitigation strategies are necessary to reduce global changes from anthropogenic activities, those alone are unlikely to be sufficient. As studies have shown, the impacts of global change will have to be confronted by all countries. Therefore, pursuing a complementary strategy of enabling countries to adapt to global change and negate many of the expected adverse impacts is equally, if not more, urgent. To determine how countries are equipped to deal with the inevitable impacts of global changes requires an understanding of each country's current capacity to adapt, as well as its future capacity to take actions that will reduce the negative impacts of global change. Fundamentally, adaptive capacity requires both talent and a willingness to act in response to global changes and then a long-term commitment to sustain the responses to these changes.

Much attention is being paid to mitigative solutions to global environmental change in the Americas. There are changes being experienced now in the Americas, however, that require governments, communities, businesses, and individuals to be more willing to consider both adaptation and mitigation solutions. The challenge is to build both a societal capacity to adapt to global change, and embrace mitigative actions such as those to reduce atmospheric emissions of greenhouse gases. To build such a broad adaptive capacity will involve scientific, technological, economic, political, institutional, regulatory and, of course, individual behavioural changes that impact the current norms and values, as well as decisions being made, in the Americas (MacIver, 2004).

Changing human behaviour, however, is not simple, and building a societal capacity to adapt to global change is complex. The knowledge around the changes required is available, and yet humans often resist change and embrace the status quo. When asked to introduce a new behaviour or change an old one, the first reaction is likely to be "Why do I need to do this? What is the benefit to me?" The simple answer is that making certain changes can increase the capacity to adapt, and this in turn reduces our vulnerability and builds our resiliency to future changes. However, knowledge, though necessary, is not sufficient to produce behavioural changes. Other issues such as perceptions, willingness, talent, and factors in the social environment also play important roles (US National Cancer Institute, 2003). For example, it is well known that smoking cigarettes is harmful to human health and can lead to death, yet people smoke. It is also known that wearing seat belts in automobiles saves lives, and yet it took government regulation in North America before people buckled up. It is known that driving big cars results in higher levels of greenhouse gas emissions and air pollutants that hurt the environment and humans, and yet cars are getting bigger and more are being purchased.

So how is "willingness" in individuals and communities to build an adaptive capacity and change behaviour built? What causes humans to make changes in their lives that are known to be needed and of benefit to individuals, communities and the planet? In reaction to a crisis, a catastrophe or sustained uncertainty humans are more likely to be willing to make changes. In the absence of these conditions, a proactive approach is needed. The issue must resonate "personally" so that humans can relate to it and realize the benefit of taking action. Acknowledgement and reward for taking the action is also important if the commitment to change is to be sustained. Humans look for confirmation that they are doing "the right thing".

It is also necessary to identify the internal and external barriers that are preventing action. As McKenzie-Mohr Associates (1998) state - "To build an effective program, it is critical to identify all of the barriers that inhibit the public from engaging in a desired activity and to then design a program that systematically removes them." There are numerous social marketing initiatives designed to reduce greenhouse gas emissions, but few to build an adaptive capacity to climate change. Key activities in a community-based social marketing approach, once barriers have been identified include:

- Deciding how to motivate people to start doing the activity;
- Selecting ways to remind people to undertake the action;
- Finding ways to make it easy for people to act;

- Deciding how to build motivation to continue the action and sustain the momentum; and
- Selecting communications channels and vehicles to reach the audiences.

The essential elements of local and societal programs designed to change behaviour and sustain a willingness to adapt will require, at a minimum, a catalyst for change, an understanding of the barriers to change, ongoing activities and communications to reinforce new behaviours, and recognition for taking the action. Patience, as well, is required because change takes a long time and requires continuous reinforcement.

5. Canada Building Adaptive Capacity to Global Change

Canada is building its talents for adapting to global change through modeling global systems such as the development of the Canadian Global Climate Model, the Canadian Climate Scenarios Network as well as conducting global change impact and adaptation studies on a regional basis.

5.1 Canadian Global Climate Model

Global Climate Models are the only tools available to look into the future and predict how climate patterns and ocean circulation will respond to changes in greenhouse gases and related pollutants in the atmosphere. The first climate models developed in the Meteorological Service of Canada (MSC) focussed on the atmospheric physics that determined global climate patterns. In the late 1980s and early 1990s atmospheric processes and ocean circulation were combined in the models to make them more realistic. Subsequently, MSC scientists developed a coupled atmosphere/ocean/ sea-ice model that is considered to be among the best in the world (Flato and Boer, 2001; Kim et al, 2002). MSC climate scientists are now developing the next generation of climate models that will include the key biological and chemical processes that regulate the global carbon cycle – and thus, our climate. Understanding how the biosphere will respond to higher atmospheric concentrations of greenhouse gases, and in turn, what feedbacks this will have on the atmosphere, is essential for formulating policy to respond to commitments under the Kyoto Protocol.

5.2 Canadian Climate Scenarios Network

Climate scenarios are plausible alternative futures, each an example of what might happen under particular assumptions. Scenarios are not specific predictions or forecasts, but rather provide a starting point for examining questions about an uncertain future. Scientists use scenarios to help explore vulnerability to climate change because many aspects of the future climate cannot be predicted. Canada has launched a Climate Change Scenarios Network (MSC, 2005b) to maintain a leading-edge scenarios facility that is one of the premier sources for Canadians seeking information on climate change. The network provides scientists with information on: climate change scenarios derived from all global GCM simulations, particularly the Canadian Global Climate Model; climate change scenarios derived from the Canadian Regional Climate Model simulations; bioclimate profiles for Canada;

scenarios and impact and adaptation research from regions inside and outside of Canada; on-line instruction for using scenarios and downscaling tools; links to downscaling tools; links to other tools used in impacts and adaptation research; and scenario reports.

5.3 Global Change Impact and Adaptation Studies

Numerous research projects have been undertaken in Canada in recognition of the importance of providing Canadians with the information to promote and facilitate adaptation to atmospheric change, variability and extremes and to assist in identifying the need for other response options (e.g., mitigation when impacts and adaptation response are deemed unacceptable or insufficient). Some examples of projects include:

- Development of a Universal Thermal Climate Index (Jendritzky et al, 2001)
- Impacts of Climate Change on Transportation in Canada (Mills and Andrey, 2003)
- Atmospheric Hazards in Ontario (Auld et al, 2004)
- An Assessment of Natural Hazards & Disasters in Canada (Etkin et al, 2004)
- Climate Change and Waterborne Disease in Canada (Charron et al, 2004)
- Climate Change Scenarios for Impact and Adaptation Studies in the Great Lakes – St. Lawrence Basin
- Climate Change and Water Management in the Okanagan Basin, British Columbia (Cohen et al, 2004)
- Threats to Water Availability in Canada (Environment Canada, 2004)
- Climate Change and the Great Lakes Coastal Management
- Wind Energy
- Integrating Green Roofs, Green Walls and Urban Forestry at the Community Scale
- Climate and its Impact on Energy in Canada (Mirza, 2004)
- Climate Change and Canada's National Park System (Scott and Suffling, 2000)
- Mackenzie Basin Impact Study (Cohen, 1997)

6. Canada Building the Adaptive Capacity Around the World The Canada-China Cooperation in Climate Change (C5) Experience

Canada has worked internationally to help foster a stronger adaptive capacity in other countries. In 2001, the *Canada-China Cooperation in Climate Change (C5)* project (Jasmin et al, 2004) was organized to:

1. Undertake research to identify the sensitivities of China's key sectors (agriculture and natural ecosystems) to a changing climate and extremes to provide a basis for discussions on vulnerability and adaptation;

2. Strengthen the research capacity to understand the links between climate change and natural disasters such as drought;

3. Develop the research capacity around adaptation strategies that include socio-economic level and local people's traditional habits; and

4. Strengthen the capacity to integrate climate considerations into sustainable development policies and planning.

It was recognized that Canadian experience and expertise in data analysis and extreme climate research were valuable for building and enhancing Chinese research capacity by providing access to robust Canadian models and approaches that could be adopted and adapted by Chinese scientists. A number of training activities such as workshops, study tours and practical attachments of Chinese scientists to Environment Canada were designed to enhance China's knowledge base around the use of climate scenarios and build the knowledge base for Chinese decision and policy-makers on the sensitivity of Chinese systems to a changing and variable climate.

An international scientific conference entitled *Climate Change: Building the Adaptive Capacity* (Fenech et al, 2004), was held in Lijiang, China in May 2004, and focused on climate change adaptation science, management and policy options. The conference provided the opportunity to engage international researchers in dialogue, to share experiences on the use of vulnerability and adaptation tools, to provide input to adaptation case studies, and to publicize climate change impact and adaptation issues to a broader audience. A major result of the conference was the increased capacity of key Chinese institutions and sectors to conduct similar adaptation and impacts research in the future. In addition, the conference helped promote the integration of adaptation strategies into Chinese government development and planning initiatives.

The most significant benefits of the C5 Project are the increased ability of China to address the issue of climate change - from emissions reductions through to adaptation - and the improved abilities of Chinese organizations and individuals to make decisions and take action that include considerations of climate change.

7. Emerging Opportunities
A Proposal for a New Research Network for the Americas

As a permanent member of the Inter-American Institute for Global Change Research, Canada benefits from the enhancement of regional relationships, the establishment of new institutional arrangements among countries, an open exchange of scientific data and information generated by the Institute's research programs, and the implementation of IAI Training and Education Programs. Canada remains committed to the IAI and sees an important role in continuing to organize specialized science symposia, conduct training institutes for transferring the technological knowledge in climate models and climate scenarios development, and perhaps investigating the development of a comprehensive program fashioned after the C5 framework to help countries in the Americas build their adaptive capacity.

In addition, Canada views the opportunity to work together by developing a new initiative on *Monitoring and Assessing the Impact of Global Change on Biodiversity in the Forests of the Americas*. This project would create a transect of biodiversity monitoring plots throughout the forests of the Americas to provide an early warning system of changes as a result of global change. To this end such a project would further contribute to building the adaptive capacity of the Americas.

Forest biodiversity may be the richest of all terrestrial systems. Together, tropical, temperate and boreal forests offer diverse sets of habitats for plants, animals and micro-organisms, holding the vast majority of the world's terrestrial species. Forest biodiversity provides a wide array of goods and services, from timber and some non-timber forest resources to playing an important role in mitigating climate change as carbon sinks. Forest biological diversity also has important economic, social and cultural roles in the lives of many indigenous and local communities.

This proposed initiative would have as its Principal Investigator, Francisco Dallmeier, Director of the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program (MAB). Since 1986, Dr. Dallmeier has directed this program's evolution and tremendous growth into a network of more than 300 research plots throughout the Americas and worldwide combining research, training, and public education to forge a powerful tool for the conservation of biodiversity around the world. In significant contributions to the science of conservation biology, Dr. Dallmeier has successfully integrated conservation principles and adaptive management into resource development ventures. From a mining project in Madagascar to energy projects in Peru and Gabon, the MAB Program, its international counterparts, and companies with a commitment to resource protection are creating prototypes to reduce the development "footprint" in ecologically sensitive areas and restore landscapes scarred from past resource extraction.

For over 10 years now, the Smithsonian Institution has been training scientists throughout the Americas in establishing biodiversity monitoring plots for adaptive management. The six week training course is based on a common methodology, or monitoring protocol, for establishing permanent plots for the long-term observation of biological diversity in forested areas (Dallmeier, 1992). The plots have been used to monitor the status of forests around the world and changes in that status over time. These long-term data are helpful in detecting the magnitude and duration of changes, how related taxa are changing, and "early warning" indicators of forest health (Dallmeier and Comiskey, 1998).

The biodiversity protocols have been adopted at nearly 200 research sites in 23 countries around the world, facilitating the easy transfer of comparable data, and providing a framework for data analysis and dissemination. These biodiversity research plots are established usually with the help of local communities, and thus provide a capacity for local communities to monitor changes, and benefit from the added knowledge about global change in their community. This new project proposal for a transect throughout the Americas would connect over 12 countries in the Americas with their respective Smithsonian Institution biodiversity monitoring plots, creates a transect that runs from the single pine species plots of the Cree community of Oujebougamou, Quebec, Canada throughout North, Central and South America to the single pine species plots of Chile. The plots throughout the Americas form a transect across physical, chemical and ecological gradients that allows for unique investigations into the cumulative impacts of global change on forest biodiversity. When pulled together into a research network, this transect of biodiversity monitoring plots is able to assess some fundamental research questions throughout the forests of the Americas such as:

- the changing biological diversity of the forests throughout the Americas including causes and consequences;
- the level and future potential of carbon dioxide sequestration at forests throughout the Americas and its changing role under a changing climate;
- climate changes throughout the Americas and its impact on the changing biological diversity of the forests throughout the Americas including scenarios of future climate change;
- the spread and severity of invasive species throughout the forests of the Americas including environmental prediction;
- forest management practices, land-use changes, population changes and their success in maintaining biological diversity;
- the impact of climate on forest health throughout the Americas including scenarios of future climate change; and
- the synergistic effects of climate change and acidic deposition impacts on forest soils throughout the Americas.

In addition, this proposed forest biodiversity observation network can contribute to the international Group on Earth Observations (GEO) and its goals of providing comprehensive, integrated, sustained, timely, quality, national, regional, and global information of earth systems as a basis for sound decision-making. Key public policy issues can be addressed such as reducing the social and economic vulnerabilities from environmental hazards; promoting economic competitiveness and prosperity; and preserving and enhancing the natural environment.

Many existing biological and atmospheric monitoring systems collect systematic observations using inventory-type protocols and schedules to record, archive and detect changes. Few abiotic and biotic observations have been collected over the long-term at the same site. Even fewer databases, such as climate, have the universality to provide the connecting spatial linkages with site-based biological observations. However, the geo-referencing of these data observations allows for the spatial mapping and overlaying of different thematic surfaces. Figure 3 shows an example of southern Ontario where a transect of SI/MAB plots are layered onto the climate-based biodiversity map for southern Ontario, along with the average daily atmospheric ground-level ozone measurements. It becomes apparent from this overlay of data that human intervention and management is needed to reduce the cumulative atmospheric stressors, to rehabilitate and adapt native biodiversity and to reduce the potential for invasion of native vegetation by exotic species (MacIver, 2000).

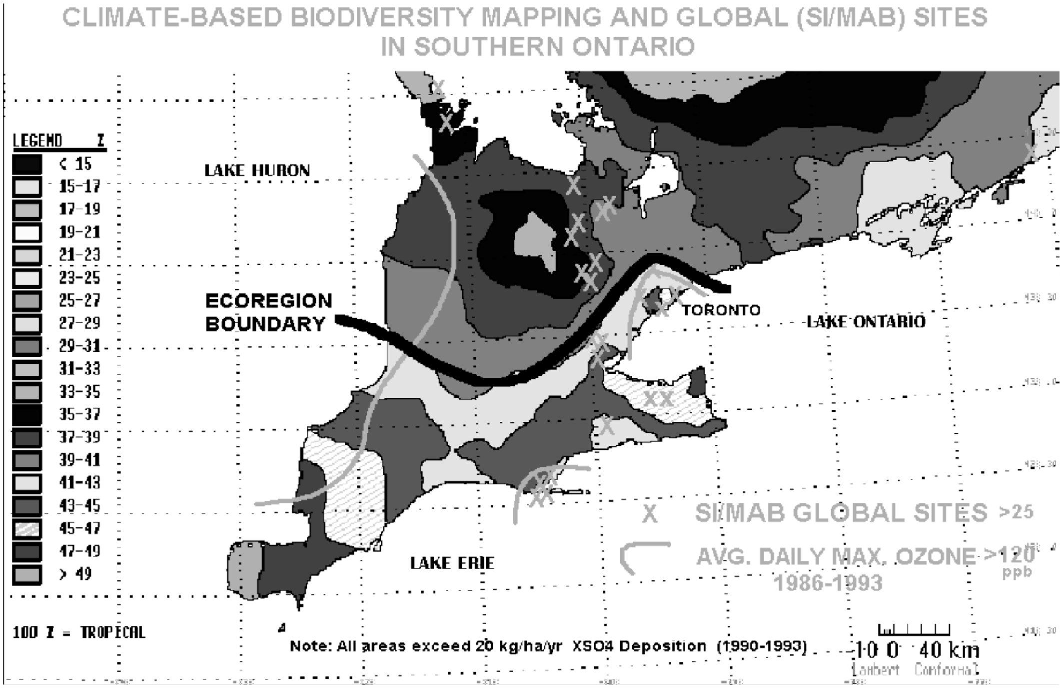

Figure 3: *Southern Ontario Example of Transect of SI/MAB Plots Across Physical, Chemical and Ecological Gradients.*

Note: Percent in the legend refers to percentage of tropical biodiversity as described by Rochefort and Woodward, 1992.

Source: MacIver, 2000.

Many SI/MAB plots have already been established throughout the forests of the Americas. This proposal recognizes the need to formalize the network of scientists who have established these plots, bring the forestry data together with other information, and begin comparable transect studies across the physical, chemical and ecological gradients of the forests of the Americas. This would allow for unique investigations into the cumulative impacts of global change on forest biodiversity and help to build the adaptive capacity of the Americas.

The Smithsonian Institution is prepared to lead this initiative in partnership with the Adaptation and Impacts Research Group of Environment Canada which is based at several universities across Canada including the University of Toronto, the University of Waterloo, The University of British Columbia, the University of New Brunswick and the University of Saskatchewan.