paper 1

THE AMERICAS
BUILDING THE ADAPTIVE CAPACITY TO GLOBAL ENVIRONMENTAL CHANGE

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ABSTRACT: Environment Canada hosted an international science symposium under the auspices of the Inter-American Institute for Global Change Research (IAI) titled *Global Change: Building the Adaptive Capacity* in Montreal, Quebec, Canada on 15 May 2005. This paper outlines the background to the symposium, and provides brief introductions to each of the papers found in this peer-reviewed book including the keynote address from Michel Béland on the challenge of environmental prediction in addressing global change. Individual papers focused on climate and health in the Caribbean; global change and threats to communities; proxy data such as tree rings used to build histories of climate and drought throughout the Americas; regional research consortiums to address impacts of climate change in the Canadian province of Quebec, as well as in the Caribbean; the use of industrial partnerships in addressing biodiversity globally; the use of bioenergy solutions to meet Kyoto Protocol requirements in Canada; and the synergies between the three UN Rio Conventions to address biodiversity and adaptation. Two additional papers distributed at the symposium on building the adaptive capacity to global environmental change in the Americas through the establishment of a forest biodiversity research network, and climate-based predictions of forest biodiversity using the network, are also summarized, as well as another paper on planning for atmospheric hazards and disaster management presented at an IAI training session in Jamaica.

Keywords: global change, climate change, Inter-American Institute for Global Change Research, adaptation, adaptive capacity, The Americas

1. Introduction

Environment Canada hosted an international science symposium under the auspices of the Inter-American Institute for Global Change Research (IAI) titled *Global Change: Building the Adaptive Capacity* in Montreal, Quebec, Canada on 15 May 2005. About 100 people met to hear international experts share their knowledge on global environmental change and adaptation

science and management on the occasion of the 20th Meeting of the IAI Executive Council, and the 12th Meeting of the IAI Conference of the Parties.

The science symposium program included a keynote address from Michel Béland on the challenge of environmental prediction in addressing global change. Individual papers focused on climate and health in the Caribbean; global change and threats to communities; proxy data such as tree rings used to build histories of climate and drought throughout the Americas; regional research consortiums to address impacts of climate change in the Canadian province of Quebec, as well as in the Caribbean; the use of industrial partnerships in addressing biodiversity globally; the use of bioenergy solutions to meet Kyoto Protocol requirements in Canada; and the synergies between the three UN Rio Conventions to address biodiversity and adaptation. Two additional papers on building the adaptive capacity to global environmental change in the Americas through the establishment of a forest biodiversity research network, and climate-based predictions of forest biodiversity using the network, were not presented at the symposium but distributed as discussion papers. Another paper on planning for atmospheric hazards and disaster management under changing climate conditions was presented at the IAI Training Institute on Climate and Health in the Americas held at the University of the West Indies in Kingston, Jamaica on November 7 – 18, 2005, and is included as part of the overall volume.

This paper is a summary of the papers presented and distributed at the symposium – the peer-reviewed papers that make up the remainder of this book.

2. Building Adaptive Capacity to Global Change

Global change will result in a set of diverse and regionally-specific impacts on natural ecosystems and human societies. A growing literature suggests that while mitigation strategies are necessary, those alone are unlikely to be sufficient. 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 (Adger and Kelly, 1999; Burton *et al.,* 2002). To determine how countries are equipped to deal with the inevitable impacts of global change requires an understanding of each country's adaptive capacity. A country's adaptive capacity is its talent and

willingness to take the initiative in making adjustments to reduce the negative impacts of global change. Fundamentally, adaptive capacity is the ability to respond to global changes and then to initiate responses to these changes.

Adaptive capacity in ecological systems is related to genetic diversity, biological diversity, and the heterogeneity of landscape mosaics (Carpenter *et al.,* 2001; Peterson *et al.,* 1998; Bengtsson *et al.,* 2002). In social systems, the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem-solving and balance power among interest groups play an important role in adaptive capacity (Scheffer *et al.,* 2000; Berkes *et al.,* 2002). Systems with high adaptive capacity are able to re-configure themselves without significant declines in crucial functions in relation to primary productivity, hydrological cycles, social relations and economic prosperity.

Adaptive capacity can be best understood with reference to vulnerability and resilience (Dayton-Johnson, 2004). Vulnerability is the tendency for people, ecosystems, communities, etc. to be damaged; while resilience is the opposite of vulnerability, and refers to the ability of people, ecosystems, communities, etc. to resist or recover from damage. Vulnerability and resilience are two sides of the same coin (SOPAC, 2004). Something is vulnerable to the extent that it is not resilient.

This international science symposium examined the building of adaptive capacity in the Americas to global change. One important aspect of building that capacity is the information provided in this book.

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.

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

4. The Collection of Peer-Reviewed Papers in this Book

The primary role of the symposium held in May 2005, and the title of the symposium itself, is building the adaptive capacity to global change. One major initiative to build capacity is providing knowledge. This peer-reviewed collection of papers from the symposium presents information, concepts and ideas for assisting countries across the Americas in adapting to the impacts of global change. The papers in this book are organized under four themes – Environmental Prediction; Climate Change and Biodiversity; Scientific Partnership Approaches; and Mainstreaming Adaptation Science for Decision-Making.

4.1 Environmental Prediction

The first paper under this theme is provided by McNair and Béland (2006). They provide a brief overview of environmental prediction capabilities within Environment Canada with the express purpose of providing the background and context useful in considering future directions and priorities for

environmental prediction initiatives within the department. Environmental prediction is, in the simplest sense, the application of knowledge to predict environmental responses, although currently in Environment Canada, it represents the coupling of the weather prediction computer model to other environmental computer models. A brief historical perspective of environmental prediction is followed by descriptions of existing (storm surge, ice breaker energy consumption, wind energy, and the Toronto Heat Health Alert System) and potential environmental prediction programs. The examples are chosen to illustrate important features of such systems and to set the stage for potential environmental prediction applications that Environment Canada would consider as prime candidates for future, or continued development to help Canada's economy, its environment, human health and domestic security.

The paper closes with supporting information on the science and technology underpinning of environmental prediction within Environment Canada including numerical modelling, coupled modelling, data, data ingest and assimilation, high performance computing, and high speed data networks. This information provides a structure on which a cursory assessment of Canada's capabilities for environmental prediction is based. The paper ends with the challenge: "While well-primed with a history steeped in environmental prediction, and a world-class level of expertise in the scientific and technological fields that support it, Environment Canada must seize the moment by ensuring that resources are available to continue to support the necessary foundation of environmental prediction that starts and ends with science and technology."

The second paper under this theme by Taylor *et al.*(2006) examines the occurrence of Dengue fever cases in the Caribbean that has been increasing since about 1990, and shows very clearly some of the complexities of linking the incidence of diseases like dengue to climatic or weather factors. Being seasonal in occurrence, the dengue outbreaks throughout the Caribbean are linked to temperature but not to rainfall through intra and inter annual variations in the timing of the outbreaks. The projected 2 degree Celsius increase in temperature due to climate change poses a real concern to the Caribbean as it implies further increases in Dengue cases. Each year, Dengue outbreaks occur four to six weeks after the initial peak in temperature. This fact has been used to develop an early warning indicator of the occurrence of an outbreak, based on a 'moving average temperature', now being tested in

a pilot project in the Caribbean. As the authors conclude: "The advantages of an early warning system would be to decrease the uncertainty about the onset of a Dengue epidemic. The system would be cost effective by helping to pinpoint when to increase surveillance of the epidemiological index. Its value can be enhanced by adding climate forecasts - using the output of models - to predict future Dengue conditions."

The third paper under this theme by Luckman (2006) shows how tree rings and long term data records have been used to document temperature and precipitation changes in the Americas over the past several hundred years. Climate varies in time and space over the Americas driven by many factors such as the 1976 Pacific Climate Shift and El Niño and La Niña events. Temperatures in the Arctic and Sub-Antarctic have increased over the 20th Century while the maximum summer temperatures at the Columbia Icefield in Canada show no trends over the past 1000 years. The implications of these changes for steam flow, water supply and human health effects are illustrated for the North American prairies, South American rivers and Mexico. Glaciers are important sources of water for western areas of North America, the pampas, and some urban areas, notably La Paz in South America. However, the author shows that the ice mass of glaciers in both North and South America have been decreasing since the late 1800's, raising concern for future water shortages. Periodic droughts have occurred in many areas over the length of the records. In some cases, the droughts have had disastrous consequences for human populations. It is concluded that while increasing temperatures are a concern, changes in precipitation will have far greater impacts on humans and the economy.

4.2 Climate Change and Biodiversity

The first paper under this theme by Auld and MacIver (2006) presents the Millennium Development Goals of the Rio plus 10 conference in Johannesburg, South Africa, that is, sustainable development, and the fair and equitable sharing of benefits as a way of bringing the four Agreements (Biodiversity Convention, Combating Desertification Convention, the UN Framework Convention on Climate Change, and the Forest Principles) together. The targets of the conventions are different - the Convention on Biological Diversity (CBD) is to reduce losses of species by 2010; the UN Framework Convention on Climate Change (UNFCCC) is to stabilize concentrations of greenhouse gases at a level that prevents dangerous

interference; and the climate and land-use driven action programs in all affected countries are targeted under the convention combating desertification. The authors demonstrate how the activities needed to achieve the targets of the 3 Conventions and advance the Forestry Principles are closely linked. They provide a number of examples of the linkages including: through environmental prediction; through the biogeochemical cycle; through policies related to land use and agriculture; through protected areas; through steps to reduce disaster losses; and through human health concerns for clean water and prevention of vector borne disease. The authors conclude that the key to improvements in the understanding of linkages and natural processes between climate and ecosystems will be increased collaboration, including stronger linkages and synergies between the UN Conventions, their objectives and their implementation measures.

The second paper under this theme by Fenech *et al*.(2006) describes global environmental change as a transformation in the earth's natural and anthropogenic processes that occurs on a worldwide scale or that accumulates to have a worldwide impact. The understanding of global environmental systems and the ways in which human actions are disturbing it, has advanced remarkably since 1990. The authors provide a summary of global environmental challenges facing the Americas – specifically climate change; acid deposition; ocean carbon flux; extreme weather events; human population growth; land cover changes; loss of biodiversity; invasive species; threats to human health; and threats to water. The Inter-American Institute for Global Change Research (IAI) is an important mechanism for building the capacity of the Americas to address the pressing challenges of global change. Fundamentally, adaptive capacity requires both talent and a willingness to act in response to global changes and a long-term commitment to sustain the responses. Building a willingness to act requires changes in human behaviour at both an individual and community level. Building the talents for adapting to global change is happening in Canada through the development of the Canadian Global Climate Model, the scenarios of future climate change as well as through global change impact and adaptation studies conducted on a regional basis. Canada has worked internationally to help foster a stronger adaptive capacity in other countries through initiatives such as the Canada-China Cooperation in Climate Change (C5) project. A new opportunity describes the development of a transect of biodiversity monitoring plots throughout the forests of the Americas to provide an early warning system of perturbations as a result of global change.

A proposed research project entitled *Measuring and Assessing the Impact of Global Change on Biodiversity in the Forests of the Americas* proposes to form a transect across physical, chemical and ecological gradients and allow for unique investigations into the cumulative impacts of global change on forest biodiversity that would further help to build the adaptive capacity of the Americas.

The third paper under this theme by Karsh *et al.*(2006) focuses on the conceptual relationship between temperature and forest family diversity that has been developed by Rochefort and Woodward (1992), and is a useful concept to detect, examine and calibrate the climate-biodiversity relationship. The conceptual model assumes that the primary mechanisms that determine forest diversity include the capacity to survive the absolute minimum temperature of a site, and the ability to complete the life cycle in a given length and warmth of a growing season. This study presents the actual data, based on earth observing sites, as an effective diagnostic tool to identify areas where the biodiversity is or is not in equilibrium with the present climate, as well as developing the basis for predictions under climate change. This observing network is based on data from monitoring plots established in Canada and worldwide using protocols from the Smithsonian Institution's Measuring and Assessing Biodiversity (SI/MAB) program, as well as growing-degree data derived from climate observing sites. The authors conclude: "A capacity to make predictions can give policy makers and regional planning groups some confidence to move forward, implement or change current policy instruments, identify critical thresholds of climate for important biomes, develop and test key indicators of change, and highlight iconic species or communities or communities under immediate threat (Chilcott *et al.*, 2003)."

4.3 Scientific Partnership Approaches

The first paper under this theme by Dallmeier and Alonso (2006) focuses on the major challenge for humans in protecting biodiversity and whole ecosystems that are subjected to threats from pollution and human development. At present, 30 to 50 percent of the world's surface is under some form of human management. Many habitats are being altered and even destroyed, resulting in many species being driven to extinction. The Smithsonian Institution has established research partnerships with industry and non-government organizations (NGOs) that are proving to be very

effective in addressing biodiversity problems. While the challenges associated with dealing with large oil companies are recognized, many are including biodiversity protection into their extraction operations. A specific result of the research-industry partnerships is the process for developing Biodiversity Action Plans to put in place at construction sites. The authors also provide information on a new project of the National Science Foundation of the USA called the National Ecological Observing Network (NEON). NEON is designed for the 'Big Science' needed to address the IAI questions of 'scientific research that requires a regional network of research sites and teams of scientists'. NEON organizes the efforts of a wide range of relevant scientific studies into large teams to address the issues of biodiversity protection. The authors conclude that: "the emerging National Ecological Observatory Network (NEON) in the USA provides a means for top ecological scientists to get together to produce a new way of doing science and a new way of affecting the world."

The second paper under this theme by Bourque (2006) focuses on the inevitable impacts of climate change on the Canadian province of Quebec which will affect just about every social, environmental and industrial aspect of life in Quebec. The forest industry is already having problems in removing the wood harvest, because the winter logging roads do not freeze as needed. Northern communities have experienced an increased number of deaths because of transportation over lakes that were frozen according to traditional knowledge, but are not frozen on the same dates now, because of the warming trend. An Applied Research Consortium called 'Ouranos,' has been established to organize the major scientific efforts needed to develop ways to reduce the impacts and to adapt to the changes. Ouranos, based in Montreal, Quebec, Canada incorporates about 95 professionals with a wide variety of expertise. The issues being studied include; permafrost melting, hydro power generation, forestry, coastal erosion, water levels, human health and regional climate model development. The annual budget is CAN$6 million plus contributions from Consortium partners for a total of about CAN$15 million. As Bourque concludes: "A scientific cooperative plan has been established called Ouranos, and it is being effective in mobilizing scientific expertise to address climate change adaptation issues in Quebec. A regional approach to climate models is being used to try to link climate change to the operational needs of all stakeholders."

The third paper under this theme by Leslie (2006) focuses on the impacts of climate change on the Caribbean, an area consisting of 28 insular and coastal states and 10 territories bordering the Caribbean Sea and the Gulf of Mexico, with a combined area of over 5 million square kilometers. The estimated population of the region is about 40 million people, of which an estimated 28 million live in coastal cities, towns, and villages. The average temperature in the area has increased about 2 degrees Celsius over the past century and is projected to increase another 3.5 degrees Celsius during this century. The author states that the Caribbean is particularly vulnerable to future climate change due to its coastal human populations; its reliance on climate-sensitive human economies such as tourism; its history of severe and impactful hurricanes; and its low capacity to adapt to climate change due to dispersed governmental structures, knowledge and resources. In response to the climate change threat, the governments of the Caribbean established the Caribbean Community Climate Change Centre to focus research efforts on the problems of the region. The Centre is working closely with many countries including Italy, Japan, Canada and the United States of America in order to transfer and build some of the adaptive capacity to climate change that exists around the globe.

4.4 Mainstreaming Adaptation Science for Decision-Making

The first paper under this theme by Layzell (2006) talks about two of the greatest challenges facing human society in the twenty first century - climate change and providing a supply of clean energies. The author states that the biosphere can contribute to emission reductions by sequestering carbon and nitrogen, by reducing emissions from the related industries such as agriculture and forestry, and by providing biomass alternatives to fossil fuels. Canada has a 'green advantage' in this regard because of its large areas of forests and agricultural land and relatively small human population. The author contends that there is a total biosphere contribution from the biological systems of Canada that could contribute as much as 80 million tons of carbon dioxide equivalents per year, about 28 percent of the 285 million ton reductions needed to meet Canada's Kyoto Protocol target. The BIOCAP Canada Foundation, a national non-profit, research foundation, has a mandate to harness the research capacity in Canada, to focus on particular strategic areas that are going to help find sustainable solutions to climate change and clean energy, using biological systems. BIOCAP has established 10 national research networks across Canada that have engaged about 400

researchers from university, government and industry. Research includes the areas of forestry, natural ecosystems, agriculture and bioenergy. Layzell concludes that bioenergy and the movement to a bioeconomy should be integral parts of climate change and energy strategies for the countries of the Americas.

The second paper under this theme by McBean (2006) focuses on natural hazards and communities. Communities that range from very small to mega-cities have one common characteristic in that they are all vulnerable to natural hazards (with the focus of this paper on weather-related hazards). The author, using the definition of hazard by the United Nations International Strategy for Disaster Reduction (UN ISDR) as "*a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation*", details the dramatic increase in natural hazards throughout the globe over the past decades, dominated by the dramatic rise in disasters of hydrometeorological origin. The author calls for a need to bring the focus of governments and people on reducing the impacts by investments in, among other things, infrastructure renewal and hazard warning systems. In considering global change, including climate change, and the threats to communities, the author says that it is important that there be a shift in the balance of emphasis and investments in disaster management between response-recovery and prevention (preparedness and mitigation). These do not mean failing to respond to disasters but making investments in prevention resulting in less need for expenditures in response-recovery. With the impacts of natural disasters, development cannot be sustainable. Societies need to look to the future and make investments now that will allow future generations to meet their needs consistent with those of present generations.

The final paper under this theme, and in this book, by Auld *et al.*(2006) focuses on reducing societal vulnerability to weather related disasters under current and changing climate conditions. The authors state that this will require a diverse and interconnected range of adaptive actions including hazard identification and risk assessment, comprehensive emergency and disaster management, improved predictions of high impact weather, better land use planning, strategic environmental and ecosystem protection, continuously updated and improved climatic design values and changes to infrastructure codes and standards to support disaster resistant infrastructure.

Actions will need to be undertaken by all levels of government, by individuals, planners, professional associations and investors. One critical disaster reduction response is that of emergency and disaster preparedness, which involves the development of an emergency response and management capability long before a disaster occurs. The provinces of Ontario and Quebec, in central Canada, have both passed provincial legislation requiring that all municipal and regional governments adopt emergency management planning. In support of these legislated measures in Ontario, Environment Canada along with its partner Emergency Management Ontario, have developed an atmospheric hazards publication and web site that supports municipalities in accessing climatological extreme weather and air quality information, customizing atmospheric hazards maps for their localities and in linking hazards maps. Maps can be functionally linked through cumulative co-recognition software that allows the user to select specific thresholds per hazard map and to display the cumulative result of regional combinations of hazards. Information on climate trends for the hazards variables is presently available on the site, and future plans for the site include climate change trend projections, where appropriate.

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