Adapting *to* Climate Change *in* Ontario

Report of the Expert Panel on Climate Change Adaptation

November 2009

PIBS 7300e

This report has been prepared by the Expert Panel on Climate Change Adaptation at the request of the Minister of the Environment. The views expressed are those of the Expert Panel on Climate Change Adaptation and are not intended to indicate endorsement by the Ministry of the Environment of the contents of this report.

Adapting *to* Climate Change *in* Ontario:

Towards the Design and Implementation of a Strategy and Action Plan

The Expert Panel on Climate Change Adaptation

Report to The Minister of The Environment

November 2009

For more information visit www.ontario.ca/environment

Table of Contents

List of Figures

Letter from the Co-Chairs

The Honourable John Gerretsen
Minister of the Environment
77 Wellesley Street West, 11th Floor
Toronto, ON
M7A 2T5

Dear Minister,

We have great pleasure in submitting the report of the Ontario Expert Panel on Climate Change Adaptation, which you established in December 2007 "to help the Ontario government, municipalities and Ontarians prepare and plan for the impact of climate change in areas such as public health, environment, infrastructure, and economy".

The Panel's work has been intensive and highly revealing. We have learned a great deal from the opportunity to meet with Deputy Ministers, Assistant Deputy Ministers, Directors, and their staff from many ministries and agencies across the Government of Ontario. Without their help and willingness to engage in exchanges of ideas and documents, which have been searching, open and frank, our work would have been much less fruitful.

These discussions have led us to one overriding conclusion. The issue of climate change impacts and adaptation is of such fundamental importance to the Province now and into the long-term future that nothing less than a broadly conceived, across the board strategy and action plan for climate resilience will suffice. The report we now present provides a strong basis for the development and implementation of such a strategic plan. We urge that you and your fellow Ministers take steps to formulate and implement such a plan with all deliberate speed. Members of the Panel stand ready to help in this process as and when needed.

The Panel has not attempted to make a comprehensive assessment of the impacts of climate change on Ontario or on the wide range of possible responses. In the course of our work, however, we have identified many areas where adaptive measures and policies are already underway or are under consideration. We have used many of these to formulate 59 specific recommendations, which can be used to make a fast start on building a more climate-resilient province.

The effects of climate change are already being felt, and are set to become so pervasive that all levels of government and all sections of society have a responsibility to become informed and to take appropriate action within their mandates.

Having urged prompt and vigorous action, the Panel also wishes to state that Ontario is in a fortunate position compared with some other jurisdictions in Canada and especially in the less developed and poorer parts of the world. Ontario is well positioned to adapt to the impacts of climate change by virtue of its well developed economy, a highly educated and capable workforce, sound government and other institutions, and a strong social safety net. The Panel also believes that the government's early actions and leadership on both mitigation and adaptation are already putting the Province on the road to a sound and effective approach. While there will be some significant and essential new costs, it has not been possible for the Panel to assess these in any detail. We are convinced, however, that in some areas much can be done by reorienting and refocusing existing activities without the requirement of major new funds.

As Co-chairs we would like to extend our great appreciation for the dedication and constructive approach of our fellow Panel members.

On behalf of the whole Panel we would like to thank all the provincial ministries and agencies that have helped to make our work exciting and rewarding through their presentations to the Panel. Finally we would like to thank the Ministry of the Environment and its staff in the Strategic Policy Branch, especially the small team that made our ambitious work program possible, for their unwavering support.

In embarking upon the development of a strategy and in implementing early measures that will facilitate adaptation to climate change, we are conscious of the fact that we are in an early stage of what will necessarily be a long and continuing process. We can foresee this future but dimly, and we know that our ideas and recommendations will need to be frequently revisited if a sustained and effective response is to be maintained.

We look forward with confidence bolstered by the belief that you, other Ministers, and the Premier have already shown your understanding of the problem and your determination to act.

Sincerely,

David Pearson **Ian Burton**

Co-Chairs, Expert Panel on Climate Change Adaptation

Preface

As part of the government's Climate Change Action Plan, the Expert Panel on Climate Change Adaptation was appointed by the Minister of the Environment in December 2007. The Panel's mandate was "to help the Ontario government, municipalities and Ontarians prepare and plan for the impact of climate change in areas such as public health, environment, infrastructure, and economy".

Composition

The Panel has been co-chaired by Dr. David Pearson, Professor of Earth Sciences at Laurentian University, and Dr. Ian Burton, Emeritus Professor at the University of Toronto. Nine additional Panel members from a diverse variety of backgrounds and expertise were appointed:

- Grand Council Chief John Beaucage, Anishinabek Nation
- Alain Bourque, Ouranos
- Dr. Quentin Chiotti, Pollution Probe
- Dr. Judith Guernsey, Dalhousie University
- David Lapp, Engineers Canada
- Eva Ligeti, Clean Air Partnership
- Dr. Gordon McBean, University of Western Ontario
- Jo-Ellen Parry, International Institute for Sustainable Development
- Dr. Barry Smit, University of Guelph

Process

In order to assess climate change adaptation needs and potential implementation strategies and actions in the province, the Panel met systematically with senior level government managers from the following provincial ministries and government agencies:

- Ministry of Aboriginal Affairs
- Ministry of Agriculture, Food and Rural Affairs
- Cabinet Office
- Climate Change Secretariat
- Emergency Management Ontario
- Ministry of Economic Development and Trade
- Ministry of Education
- Ministry of Energy and Infrastructure
- Ministry of the Environment
- Ministry of Finance
- Ministry of Health and Long-Term Care
- Ministry of Municipal Affairs and Housing
- Ministry of Natural Resources
- Ministry of Northern Development, Mines and Forestry
- Ministry of Research and Innovation
- Ministry of Tourism
- Ministry of Transportation

The Panel Co-Chairs also invited Mr. Don Pearson, the General Manager of Conservation Ontario; Mr. Gord Miller, the Environmental Commissioner of Ontario, Ms. Libby Little, of the Eden Mills "Going Carbon Neutral Project", and representatives from the Family Physicians of Ontario to meet and discuss their views of adaptation issues.

During these meetings, the ministries and agencies outlined:

- The ways in which they saw their sector's activities, policies and programs being vulnerable to climate change;
- How they saw their existing management methods, adaptive strategies, policies or programs dealing with, or how they could deal with, climatic variations and change; and
- Their evaluation of their capacity to adapt, and what might improve that adaptive ability in the face of changing climatic conditions and their effects.

The process was, in essence, an exercise in using the vulnerability approach to understand the potential for adaptation and the changes needed to facilitate more effective and accelerated adaptation. Representatives from ministries hold responsibility for making decisions related to adaptation. Risks and beneficial opportunities were identified in the discussion from the point of view of: people in the sectors; how people in the sectors are being or could be engaged; how they currently experience climate-related conditions;

and how they manage or deal with them. It was recognized that there are few policies specifically or solely targeted to adaptation to climate change, but there are many policies, programs and other initiatives that do, or could, address issues related to climate change risks.

The discussion of existing vulnerability and adaptive strategies provided a basis to consider how climate-related exposures might change in the future, and how management strategies, programs and policies might be altered to better deal with future risks and opportunities.

This process was entirely consistent with the widely employed approach to identifying adaptation needs and getting adaptation implemented in programs and policies. It has been recognized in the publications of the Intergovernmental Panel on Climate Change (IPCC) as well as in Natural Resources Canada's report, *From Impacts to Adaptation: Canada in a Changing Climate 2007*. It is also the core framework for Health Canada's report, *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*.

A vulnerability and risk assessment approach forms the foundation for the Panel's report and many of its recommendations. Vulnerabilities and opportunities to benefit from climate change are best identified with the active engagement of stakeholders. Adaptation strategies are considered in light of existing management processes and policies, and adaptations to future changes in climate are explored through integration or mainstreaming (or climate proofing) in policies, programs, management strategies, and other operational decisions. Adaptive capacity is created by experience. Application of this approach requires the use of the best scientific information about climate trends, projections, and scenarios derived from climate modelling. It also requires the analysis of risks, and consideration of acceptable levels or standards of safety on a case-by-case basis.

Acknowledgements

All members of the Panel, and especially the Co-Chairs, are extremely grateful for the unwavering support, patience and highly professional commitment we have received from all the people in the staff team at the Strategic Policy Branch of the Ministry of the Environment. They provided the Panel with strategic analysis and perspective, in addition to undertaking jurisdictional scans, coordinating meetings, gathering information, proposing and preparing agendas, distributing information and presentation materials to Panel members, and seeking answers to innumerable follow-up questions. Our thanks also go to Al Douglas and his team at the Ontario Centre for Climate Impacts and Adaptation Resources for their background research and generous assistance.

We are also very grateful to the Minister, Mr. John Gerretsen, who showed personal interest in our work. Without his Deputy Minister, Ms. Gail Beggs, who encouraged her colleagues in other ministries to accept our invitations to make presentations, we simply would not have been able to even begin the dialogue that led to the substance of our recommendations. John Lieou, Assistant Deputy Minister, in the Integrated Environmental Policy Division, was also very supportive and constantly helpful.

Our appreciation of the highly cooperative and constructive approach taken by all of the ministries we invited to be part of our meetings is only matched by the confidence they gave us in their commitment and ability to take the leadership we hope we have fuelled with our recommendations.

Glossary of Adaptation Terms

Based on definitions from the Intergovernmental Panel on Climate Change's Fourth Assessment Report, 2007.

Adaptation – Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

> **Anticipatory Adaptation** – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
>
> **Autonomous Adaptation** – Adaptation that does not constitute a conscious response to climate stimuli but is triggered by ecological changes in natural systems and by markets or welfare changes in human systems. Also referred to as spontaneous adaptation.
>
> **Planned Adaptation** – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Adaptive Capacity – The ability of a system to adjust to climate change (including climate variability and extremes) in order to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Climate Change – Refers to any change in climate over time whether due to natural variability or as a result of human activity.

Mitigation – An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

Resilience – The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Vulnerability – The degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Executive Summary and Key Recommendations for Policy Makers

The necessity for adaptation to climate change is inevitably becoming a much higher priority for Ontario and other jurisdictions. There is a need to build a more climate-resilient economy and society. Climate change is not simply a future problem, rather it is happening here and now. Moreover, it is set to continue for decades at least. Even the most optimistic scenarios of the reduction of greenhouse gas (GHG) emissions, especially carbon dioxide, project the effects of warming to go beyond the end of the current century.

Ontario can play its part in the control of emissions but what actually happens to the climate depends much more on what other countries agree to do and actually are able to deliver. Adaptation, however, is much more within our own control and capacity. Adapt, we can and must. Ontarians have displayed considerable spontaneous adaptability in the past to changes of many kinds. While the Panel expects this kind of adaptation will continue, much more is now needed in the form of a concerted and organized strategy and action plan for adaptation. Adaptation requires collective action and cannot simply be left to individuals or households.

In Section 1, we elaborate upon the nature of climate change and the adaptation imperative in detail. We have listed examples of the impacts to be expected in various sectors of the economy, along with the most recent projections of climate developed from climate models by the Canadian Climate Change Scenarios Network. It is emphasized that both adaptation and mitigation are required to respond to climate change and that adaptation by itself will not suffice. Current limits and constraints on adaptation are briefly described. It is concluded that adaptation is so pervasive in scope, and affects the Ontario economy, society and environment in such diverse ways that a broad integrated approach is required. Examples of adaptation actions by other provinces and territories are contained within this section to describe how other governments are meeting the challenge.

Section 2 describes the strategic goals and specific recommendations from the Panel to inform both the development of a strategy and an action plan. On the basis of evidence from our dialogue with ministries, we have identified the main components of a potential strategy, as well as important ingredients for an action plan which can be quickly initiated. Well planned action is of the essence in adapting to climate change. In the process of preparing longer-term action plans, the government should take the opportunity to engage the private sector and citizens in dialogue about the challenges. The government must assume responsibility for leading the strategy and actions and it will be broadly inclusive of all the economic sectors and social communities and regions of the province – and we see every sign that this leadership will be forthcoming.

The overall objective for the Government of Ontario is to build a climate-resilient province which will adapt well to the impacts of climate change and its challenges. To this end, our five key recommendations to meet this objective are as follows (see Section 2 for detail):

Recommendation 1

The Minister of the Environment should take immediate steps to seek Cabinet support for launching, by Spring 2010, a province-wide climate change adaptation action plan based on the advice provided by the Panel and guided by a strategy founded on the following goals:

STRATEGIC GOAL 1: ENHANCE GOVERNMENT LEADERSHIP

Enhance provincial government capacity to take leadership in effectively assessing, reducing and managing climate change and related natural disaster risks, as well as taking advantage of beneficial opportunities.

STRATEGIC GOAL 2: INTEGRATE ADAPTATION

Integrate adaptation to climate change into the policies and programs of government ministries for the purpose of continuously reducing risks as well as taking advantage of beneficial opportunities resulting from climate change.

Theme 1: Increase the climate change resilience of physical infrastructure, agriculture, and human health.

Theme 2: Increase the climate change resilience of ground and surface water, especially the Great Lakes; the diversity of Ontario's biological heritage, including species at risk, forests; and the carbon rich wetlands of the Hudson Bay Lowlands.

STRATEGIC GOAL 3: SUPPORT COMMUNITIES

Increase efforts by communities to improve climate change resilience by providing information, training and tools to support an adaptive, risk management-based approach to the impacts of climate change.

STRATEGIC GOAL 4: DEVELOP AND DISSEMINATE KNOWLEDGE AND TOOLS TO MANAGE RISK

Develop and strengthen the continuous creation and communication of knowledge about adapting to climate change, reducing climate risks and taking advantage of beneficial opportunities through programs of research, monitoring, public awareness and education.

STRATEGIC GOAL 5: COLLABORATE WITH OTHER GOVERNMENTS

Seek opportunities to influence and collaborate with other governments in Canada and internationally for the purpose of sharing climate change adaptation experience and developing cooperative activities.

Recommendation 2

A Climate Change Adaptation Directorate should be established in the Ministry of the Environment to:

- Coordinate the completion of the provincial strategy and action plan (Recommendation 1) for adapting to climate change, building on the goals and recommendations in this report;
- Stimulate, integrate, and coordinate mainstreaming of climate change adaptation into government decision-making, policies and programs;
- Monitor and report on climate adaptation policy development, programs and adaptation actions in the province, including an adaptation section in the annual Climate Change Action Plan Report to the Legislature;
- Oversee the implementation of the anticipated Ontario Regional Adaptation Collaborative, to be implemented from 2009-2012 in collaboration with Natural Resources Canada;
- Create distributed climate change risk assessment and adaptation planning capacity in government by organizing professional development, education and training opportunities for staff in all ministries using examples of best practices from projects underway in Ontario and elsewhere;
- Work with the Ontario Centre for Climate Impacts and Adaptation Resources and its partners to ensure the delivery of workshops and training sessions to relevant government and agency staff, covering the steps and information requirements of vulnerability assessments and the use of assessments in adaptation initiatives; and
- Ensure that the information about climate impacts in the Ontario chapter of *From Impacts to Adaptation: Canada in a Changing Climate 2007* is kept up to date, expanded to include examples of adaptation underway in Ontario, and posted in a web friendly format for the benefit of policy makers and adaptation practitioners in Ontario.

Recommendation 3

The Ministry of the Environment should ensure that the Climate Change Adaptation Directorate has ongoing access to a broad range of adaptation experts to provide advice and assistance.

Recommendation 4

The Ministry of the Environment should enhance its climate change science and modelling capacity to include sufficient staff expertise to:

- Enable Ontario to be an active participant in the Canadian Climate Change Scenarios Network's national program of climate change science and modelling, including regional and downscaling activities;
- Provide advice across government regarding applications of climate change and impact modelling, including proper consideration of uncertainty;
- Analyze climate change science and conduct an ongoing review of new information concerning the implications for Ontario of climate change and climate impact projections, and communicate the results to government users; and
- Participate in the proposed Ontario Climate Change Network (see Recommendation 52).

Recommendation 5

The Province should identify dedicated funding for climate change adaptation initiatives.

the Adaptation Imperative

the Adaptation Imperative

In its fourth assessment report published in 2007, the IPCC concluded that the evidence for climate change is now "incontrovertible" and that a large part of the ongoing change can be attributed to human activities, especially the release into the atmosphere of GHGs. A range of projections of future emissions (see Section 1.1) all indicate, even with the most optimistic assumptions, that the planet's climate will continue to change well beyond the end of the 21st century. Adaptation is therefore not a choice but an imperative.

There remains some uncertainty about how much adaptation will be required in both the short- and the longer-term. This is because the rate of climate change itself is unclear. We just do not know if the major emitting countries – sources of GHGs – will be able to agree on collective action which is both strong and fast enough and then implement their agreement. What we do know is that since 2007, the conclusions of the IPCC's fourth assessment report have been widely criticized as being too conservative and that more recent scientific evidence points to even greater and more rapid change.

There can no longer be any doubt that climate change constitutes a major threat to future generations and that the sustainable and orderly development of global society and economy is at risk. It is in this context that we spell out in this report the urgent need for Ontario to develop its own strategy for climate-resilient development and to prepare and implement an action plan for ongoing adaptation. The pervasive nature of climate change is such that it is not an issue which can be isolated and dealt with by one authority or agency.

Responding to climate change is a common concern for all Ontarians, for all Canadians, and indeed for all people on Earth. Beginning at home and conscious of the global context, Ontario has to ensure that climate change is integrated into and made a central concern in plans for sustainable development.

To state the implications as simply as possible, it means that every policy and practice of government, the private sector and civil society must be examined and, where possible and appropriate, reshaped and redesigned to achieve three objectives:

1. The maximum reduction in GHG emissions;
2. The greatest possible reduction in vulnerability through adaptation and climate-resilient development; and
3. The integration and harmonization of these first two objectives with each other and with other policies such that the joint benefits or co-benefits of actions are maximized.

1.1 Understanding the Problem

The Earth's atmosphere today has 38% more carbon dioxide (one of the main GHGs) in it than 200 years ago at the beginning of the industrial era (0.039% compared with 0.028%). The warming of the oceans and melting of ice sheets lags many years behind the warming of the atmosphere. It is abundantly clear that the effects of climate change will continue to be felt for decades after effective mitigation strategies are in place. In the worst-case scenarios modelled by the IPCC, average global temperature could rise by as much as 6.4°C by the end of the century. The potential consequences of such an increase would be catastrophic and global GHG emissions are currently increasing at a faster rate than that in the IPCC's worst-case scenario, rising 3.3% a year between 2000 and 2006 (Figure 1).

The average temperature of the planet has increased by 0.74°C since 1900. That "small" increase has made the northern hemisphere warmer than at any point over the past 1,000 years. In Ontario, the increase in average temperature during the last 60 years (Figure 2) has varied from about 1.3°C in the west to very little increase in the southeast near Lake Ontario. Ocean circulation in the northwest Atlantic Ocean, including cold, fresh melt water from the Arctic, has kept eastern Canada relatively cool, while the far northwest has warmed by more than 2.5°C (over three times the global average).

Figure 1: Global CO_2 Emissions from fossil fuel use and industrial processes since 1990 and Projections. IPCC 2007; Raupach et al 2007; Global Carbon Project 2009.

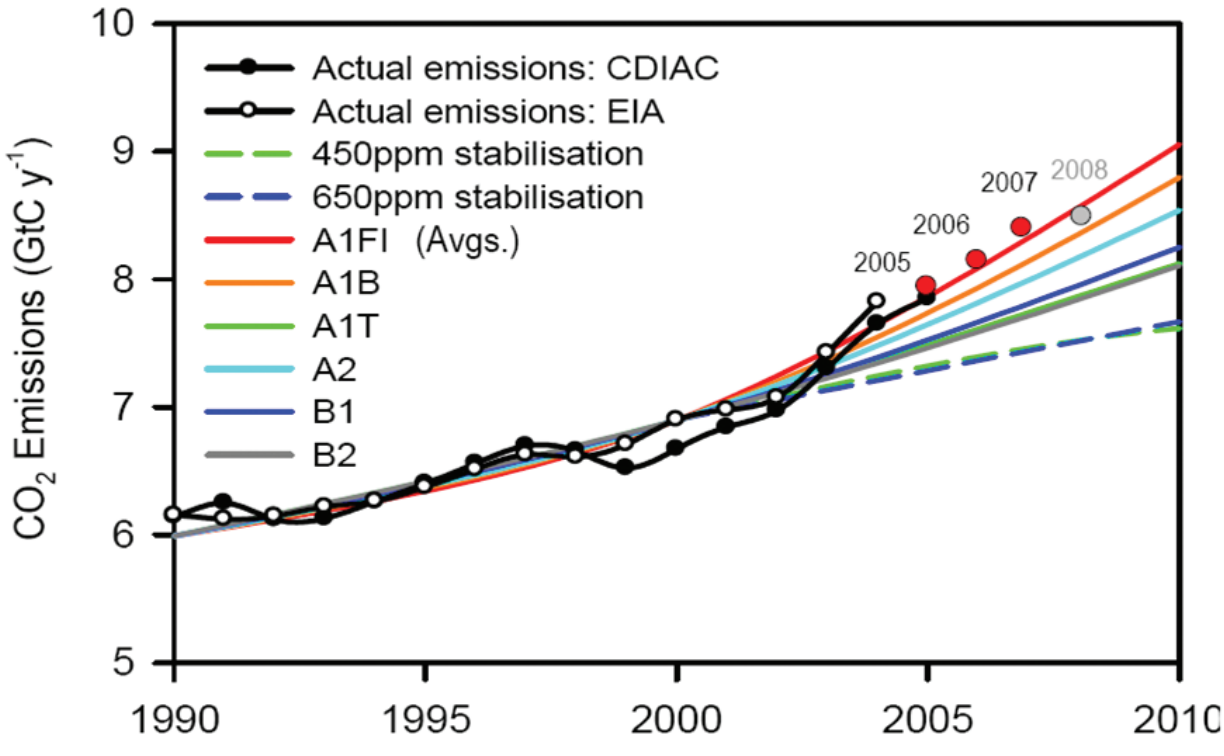
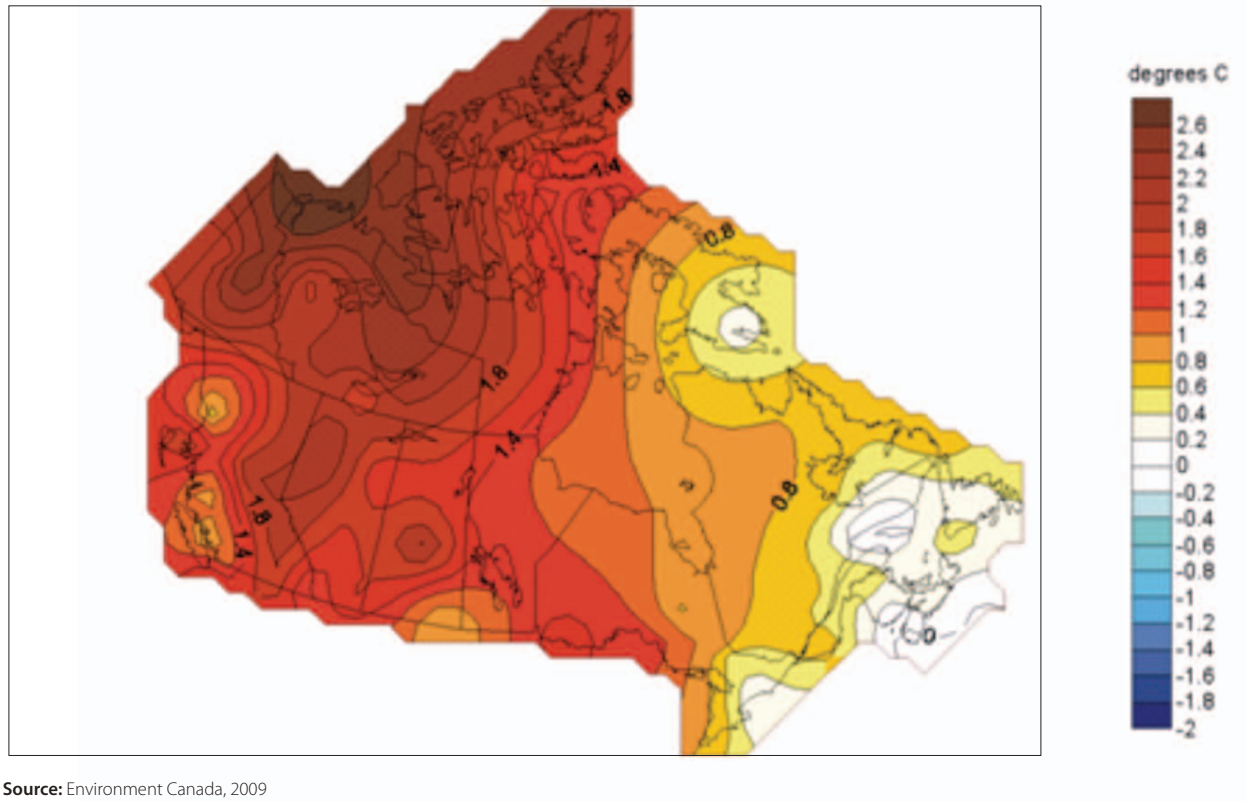


Figure 2: Annual Temperature Trend 1948-2008



Source: Environment Canada, 2009

1.1.1 Climate Projections for Ontario

We are very pleased to be able to include the latest projected climate scenarios for Ontario in 2050 (time period 2040-2070) derived from models developed by 24 international climate modelling centres (CCSN, 2009). Each of them provided their projections of future global climate to the IPCC. Environment Canada scientists, working as members of the Canadian Climate Change Scenarios Network, combined data from these 24 models to compute new projections for Ontario. Three groups of increasingly impact-laden projections, low, medium, and high, are based on different assumptions about future volumes of GHG emissions.

Research has shown that running many models, in what is known as an "ensemble" approach, is likely to provide a better overall projection of annual and seasonal temperature and precipitation than using a single model. Results between models vary widely and each model has its own built in bias. Comparison with past climate models shows that ensemble projections are usually more realistic than any single model. However, the difficulties of obtaining, storing and processing huge volumes of data make this approach extremely challenging and not often undertaken.

Computational intensity notwithstanding, the ensemble approach does not come with a guarantee. Uncertainty is still a major issue. In particular, climate models are only beginning to include feedbacks from natural systems that accelerate climate change by releasing carbon dioxide and methane from melting permafrost and warming of vast areas of northern soils and peatlands.

Observations are increasingly showing that many impacts of climate change are occurring faster and sooner than projected. The lesson for Ontario in developing adaptation policies and action plans is to lean strongly toward the use of the ensemble projections based on high emissions (the A1B emission scenario). Prudent adaptation will be best served by constant attention to observations and evaluating assumptions.

1.1.2 Annual and Seasonal Projections

The new projections for Ontario in 2050, based on middle of the road assumptions about GHG reductions, show an increase in the annual average temperature (Figure 3b) of 2.5^{0}C to 3.7^{0}C compared to 1961-1990. Higher emissions raise the annual average increase by about half a degree to 3.0^{0}C to 4.0^{0}C (Figure 3a).

The range of the projections, from minimum change to maximum change, is from 2.3^{0}C to 3.0^{0}C in the south of the province, to 3.2^{0}C to 4^{0}C in the Far North (Figure 3). If the current emission trend continues, then the higher end of the range will apply. It is worth remembering that a global average increase of more than 2.0^{0}C is now widely seen as the beginning of socio-economically "dangerous" climate change.

The winter temperature projections in the Far North are the most striking (Figure 4a) and strongly indicate a considerably shorter ice cover season on Hudson Bay and James Bay; melting of discontinuous permafrost along the coast; loss of climate-warming methane from the peat of the Lowlands; severe impacts on ecosystems and ice dependent species such as polar bears; and many impacts on First Nation communities.

Projections of total precipitation in the 2050s show little change in the south of the province but an increase of about 5-15% in the Far North (Figure 6). Most of that increase is projected for the winter with over 35% more precipitation under a moderate emission trend (Figure 6a). Winter temperatures in the Far North will cause almost all of this increase to fall as snow. Southern Ontario, like the Far North, is also projected to see the greatest seasonal increase in precipitation in winter, much of it likely to fall as rain (Figure 6a).

Spring is the other season in which precipitation increases are projected across the province. Once again the Far North is expected to see the greatest increase with 10-20%. The combination of more winter snow and more spring rain raises the prospect of more extreme spring run-off and accompanying floods in the Far North.

Summer precipitation projections show little change anywhere in the province (Figure 6b). The combination of increased evaporation with little change in precipitation raises the likelihood of more intense dry periods with low run-off water and low soil moisture.

The range of precipitation projections between models is considerable. The Canadian Model, for example, projects a decrease in summer precipitation of up to 15% in the agriculturally important southern part of the Great Lakes Basin. Plausible projections are made more difficult because of the local influence of evaporation from the Great Lakes resulting in lake effect rain and snow. The lakes are not factored into global model projections; only local scale modelling can clarify the complex local effects of the lakes, but uncertainty and variation will always be a reality.

Figure 3a: Projected increase in average annual temperature (°C) in the 2050s compared with 1961-1990 using HIGH GHG emissions (A1B emission scenario) (Environment Canada, CCCSN 2009)

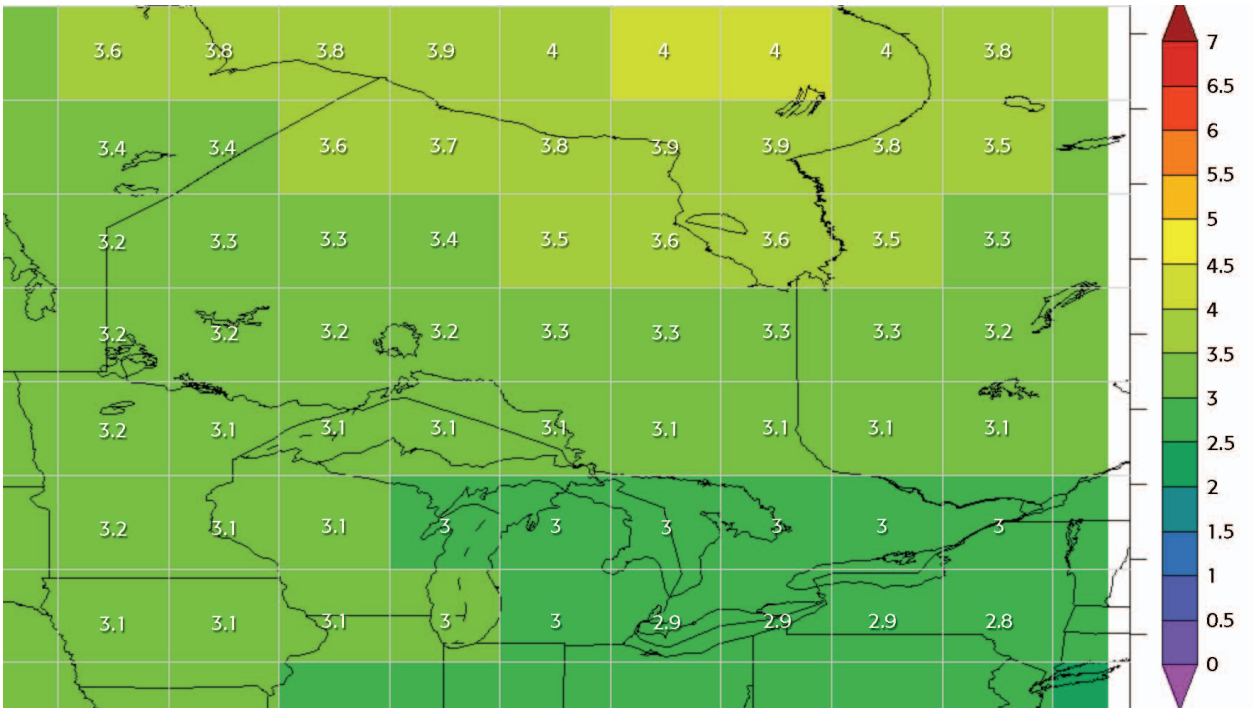


Figure 3b: Projected increase in average annual temperature (°C) in the 2050s compared with 1961-1990 under MODERATE GHG emissions (average of A1B and B2 emission scenarios) (Environment Canada, CCCSN 2009)

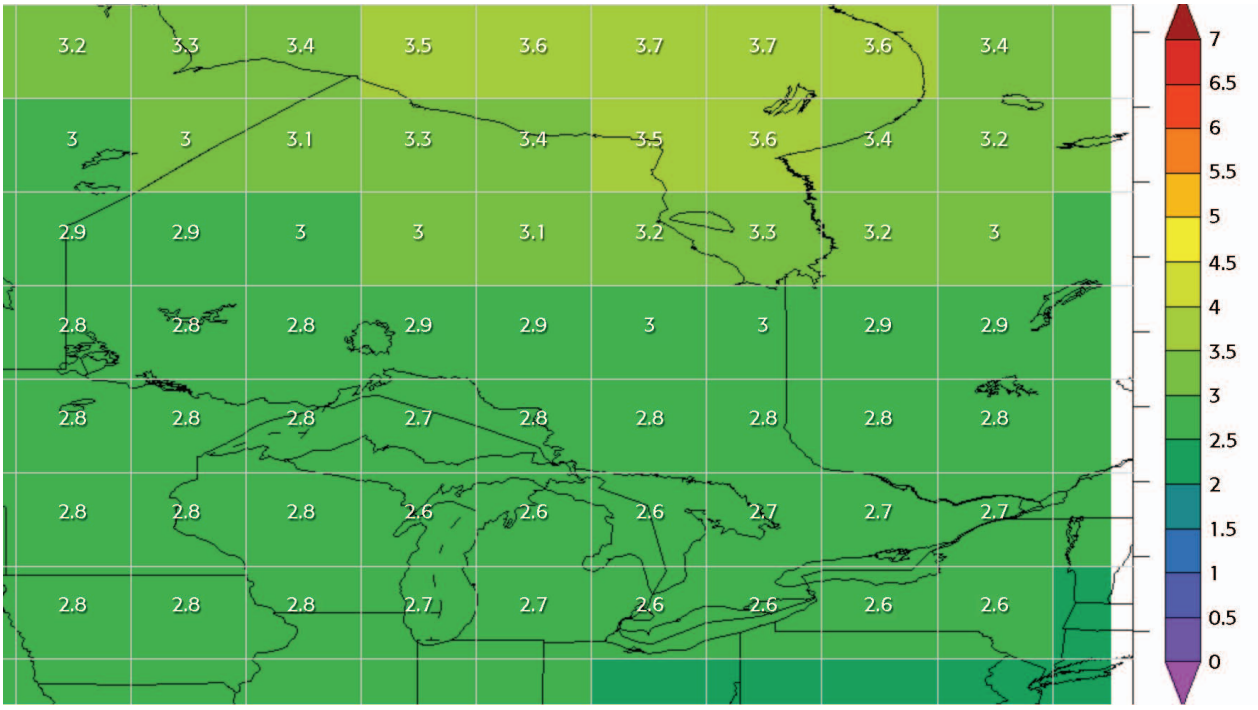


Figure 3c: Projected increase in average annual temperature (°C) in the 2050s compared with 1961-1990 under LOW GHG emissions (B2 emission scenario) (Environment Canada, CCCSN 2009)

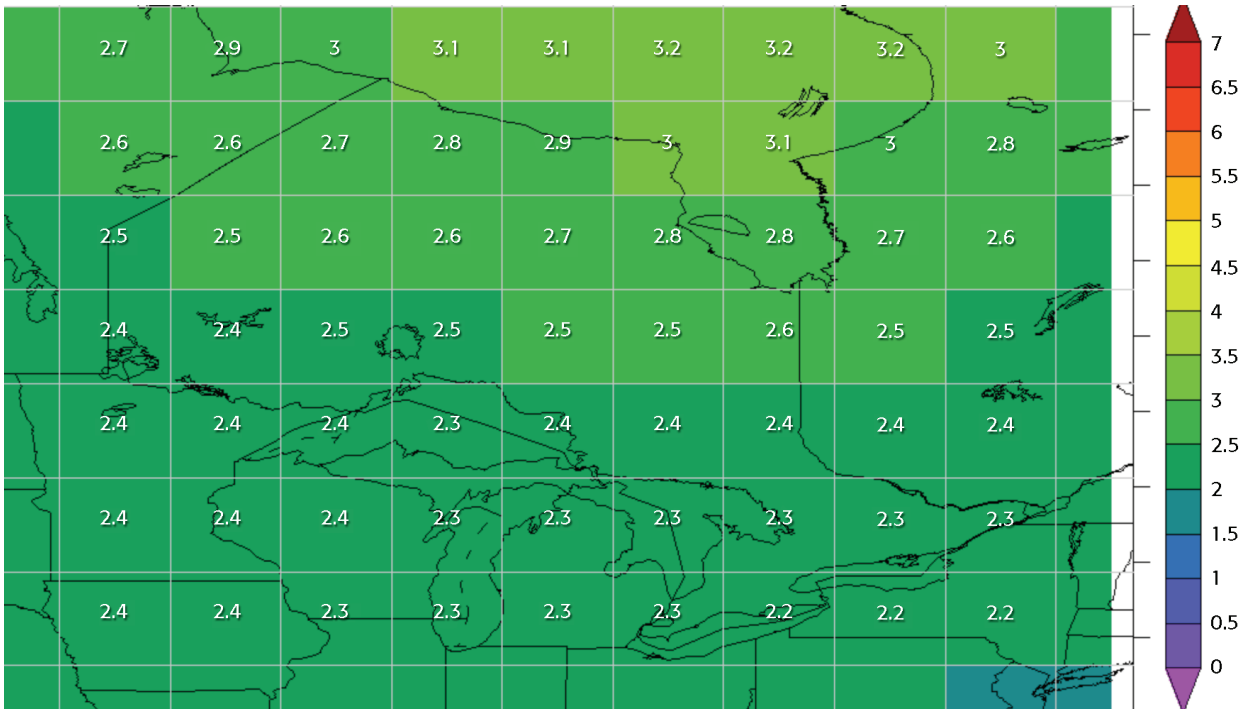


Figure 4a: Projected change in average WINTER air temperature (°C) over Ontario for 2050s compared with 1961-1990 under MODERATE GHG emissions (average of A1B [high] and B2 [low] emission scenarios) (Environment Canada, CCCSN 2009)

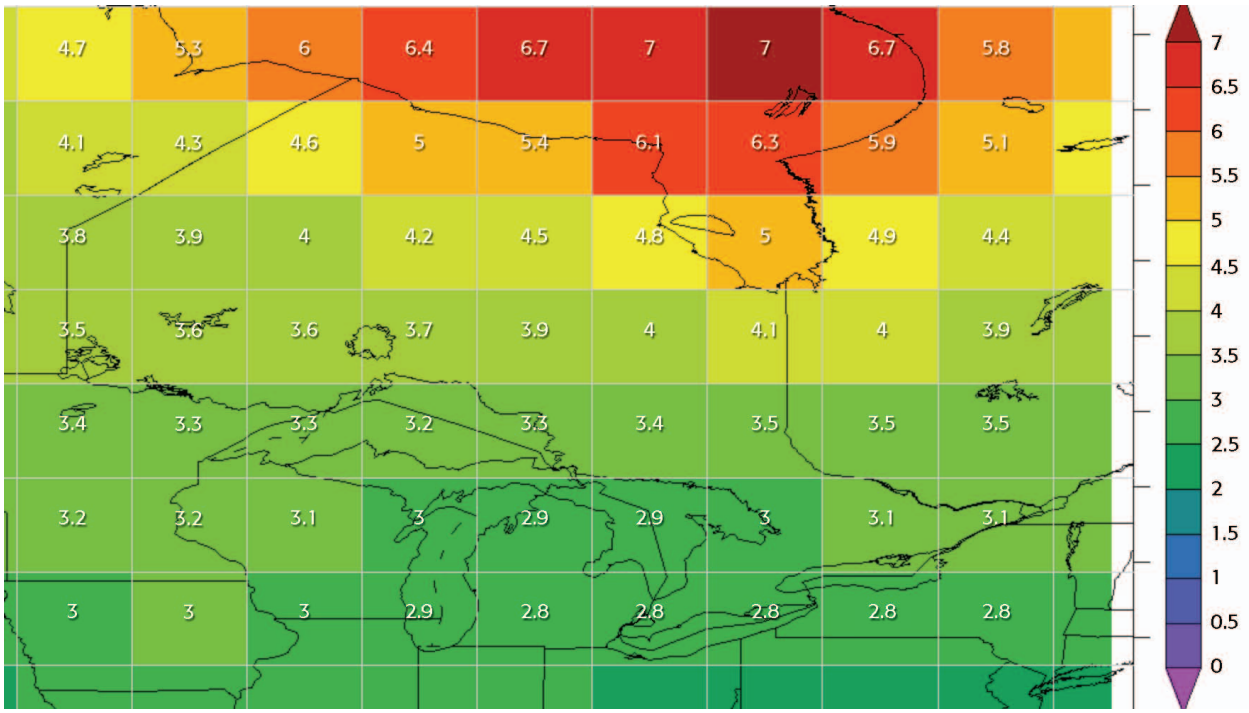


Figure 4b: Projected change in average SUMMER air temperature (°C) over Ontario for 2050s compared with 1961-1990 under MODERATE GHG emissions (average of A1B [high] and B2 [low] emission scenarios) (Environment Canada, CCCSN 2009)

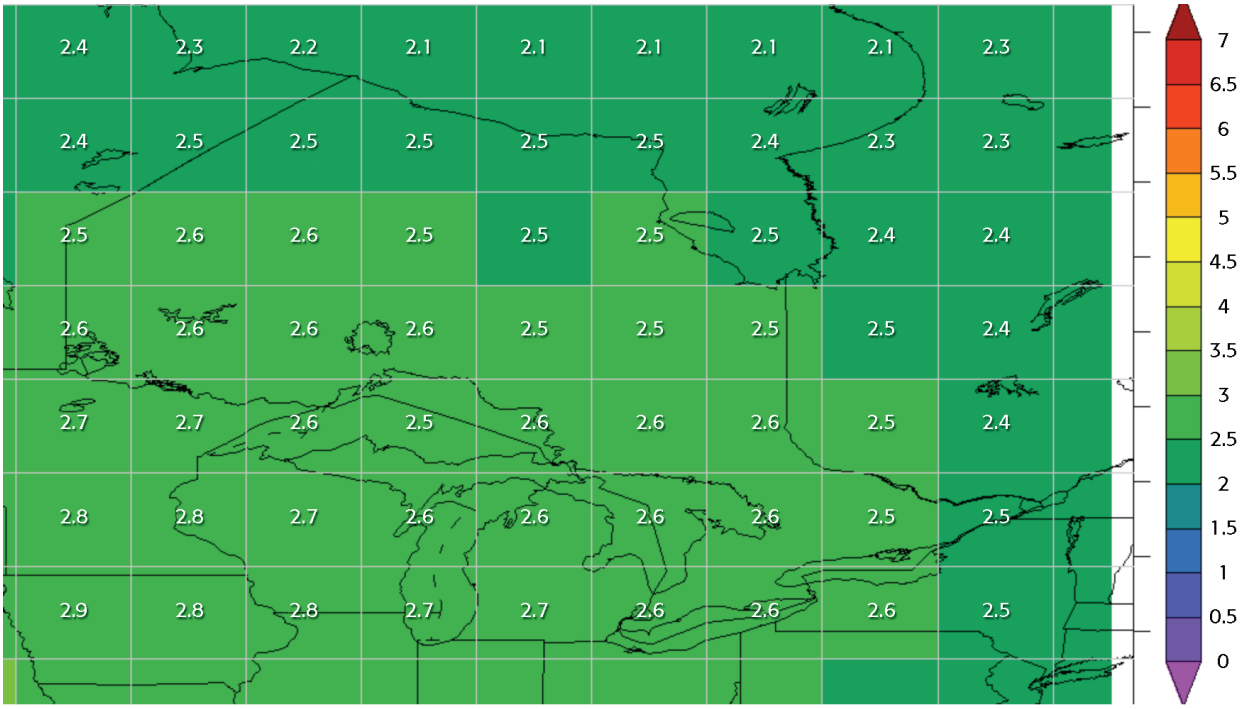


Figure 5a: Projected change in annual average precipitation (%) over Ontario for 2050s compared with 1961-1990 under HIGH GHG emissions (A1B emission scenario) (Environment Canada, CCCSN 2009)

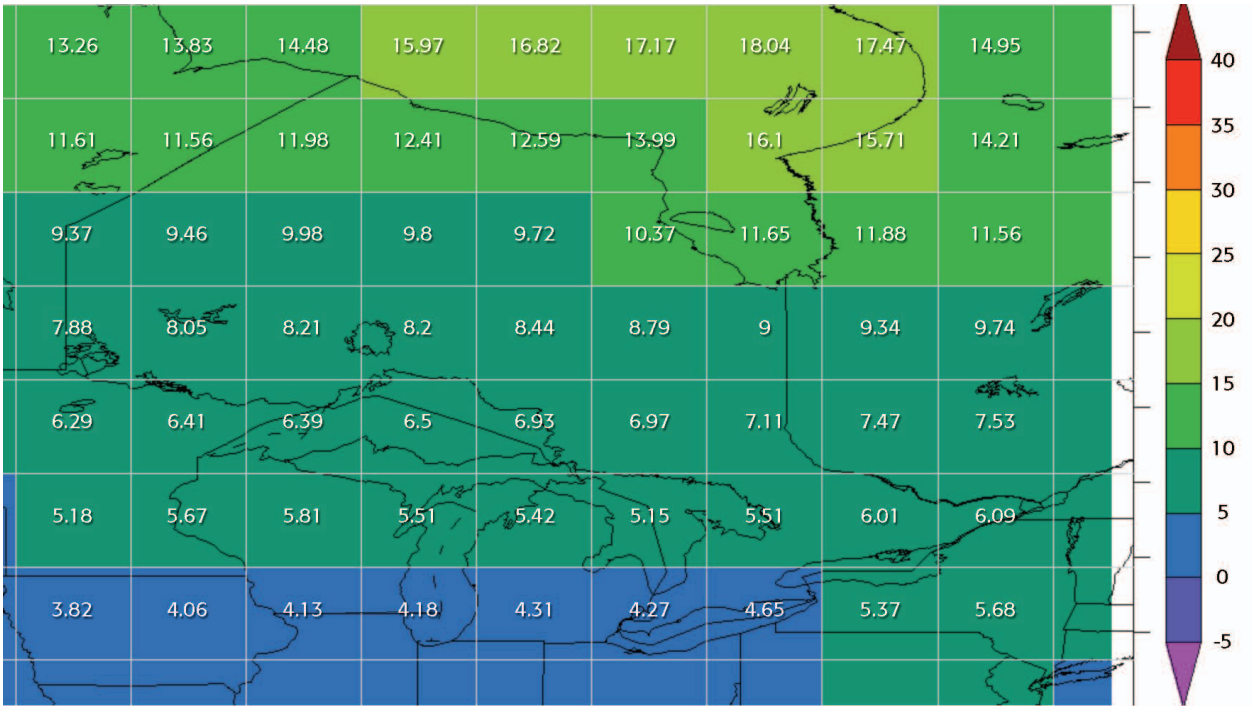


Figure 5b: Projected change in annual average precipitation (%) over Ontario for 2050s compared with 1961-1990 under MODERATE GHG emissions (average of A1B and B2 emission scenarios) (Environment Canada, CCCSN 2009)

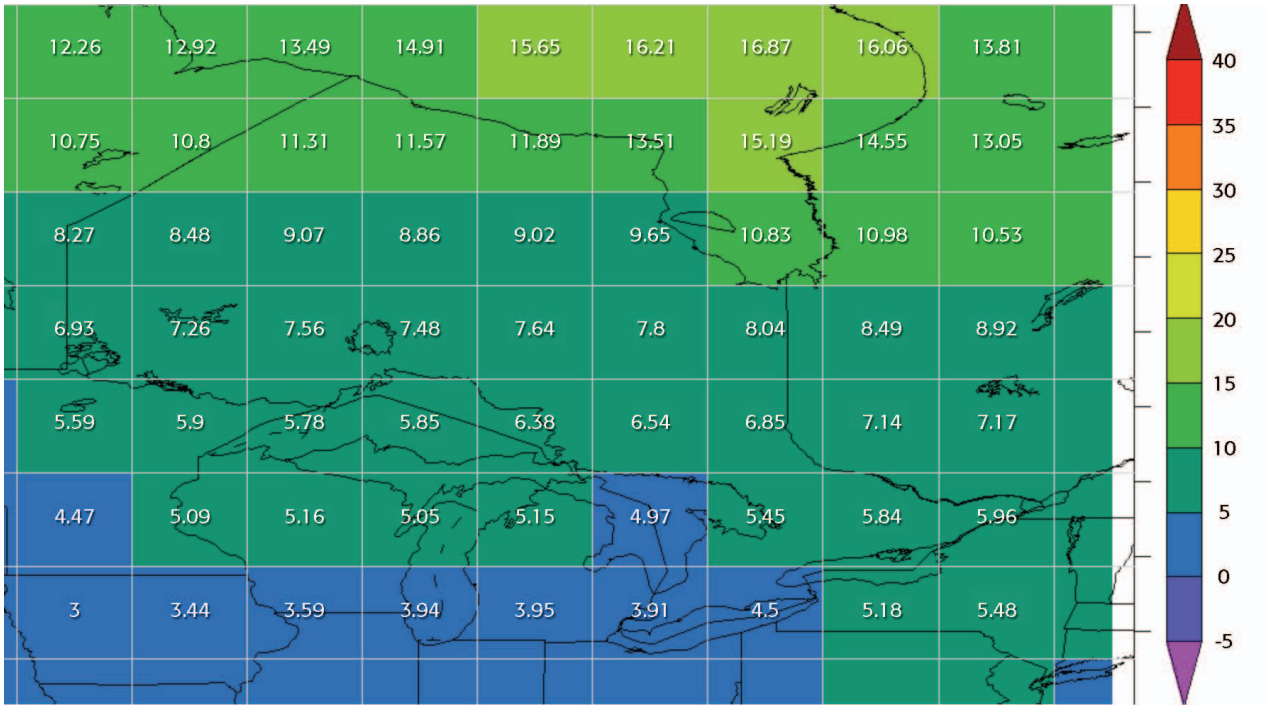


Figure 5c: Projected change in annual average precipitation (%) over Ontario for 2050s compared with 1961-1990 under LOW GHG emissions (B2 emission scenario) (Environment Canada, CCCSN 2009)

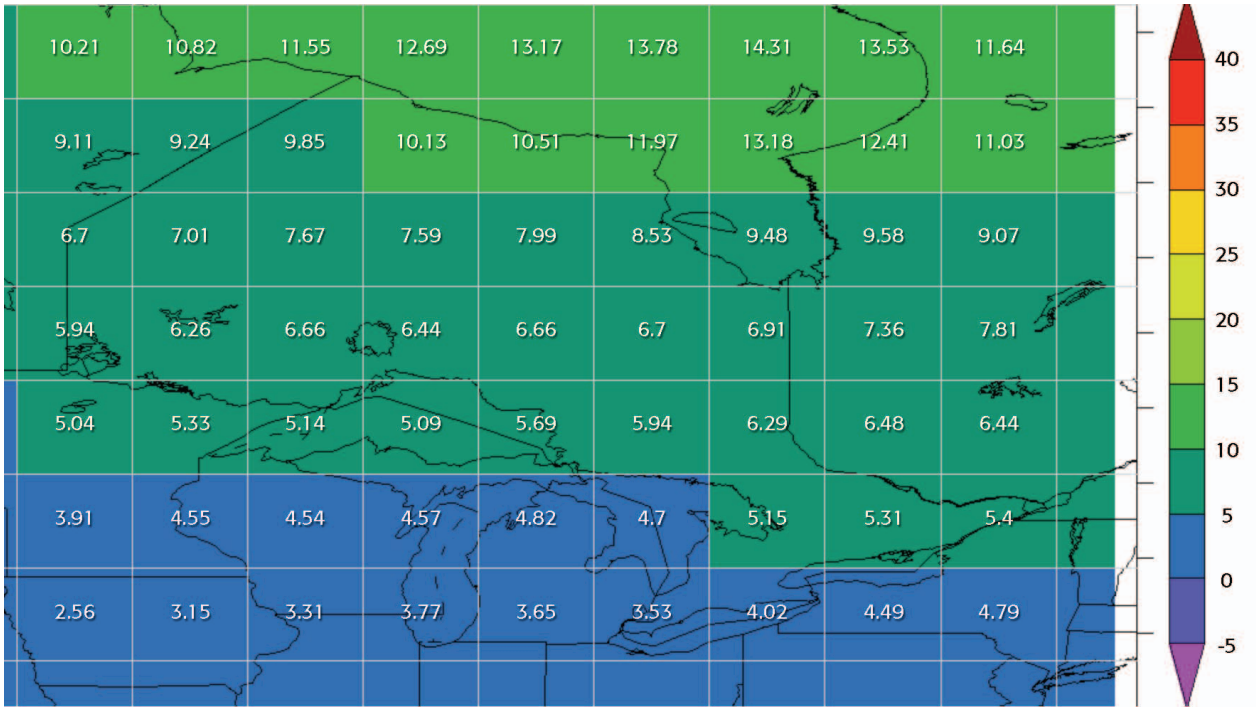


Figure 6a: Projected change in average WINTER precipitation over Ontario for 2050s compared with1961-1990 under MODERATE GHG emissions (average of A1B [high] and B2 [low] emission scenarios) (Environment Canada, CCCSN 2009)

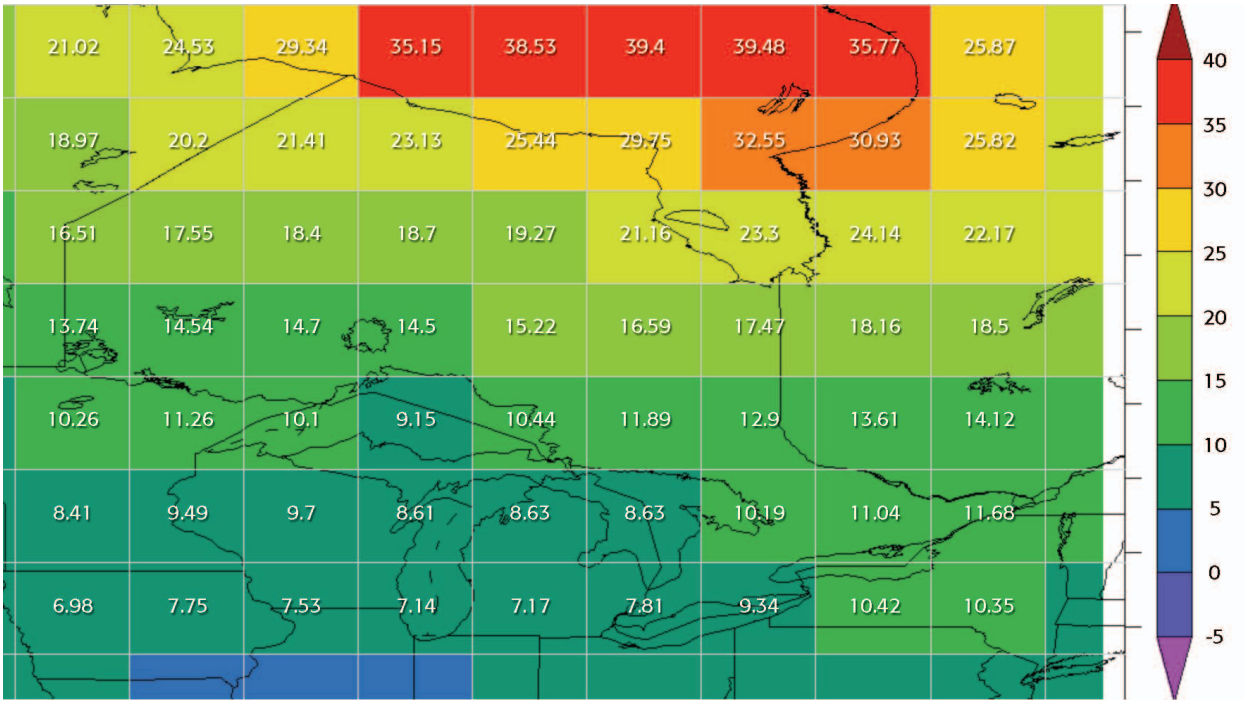
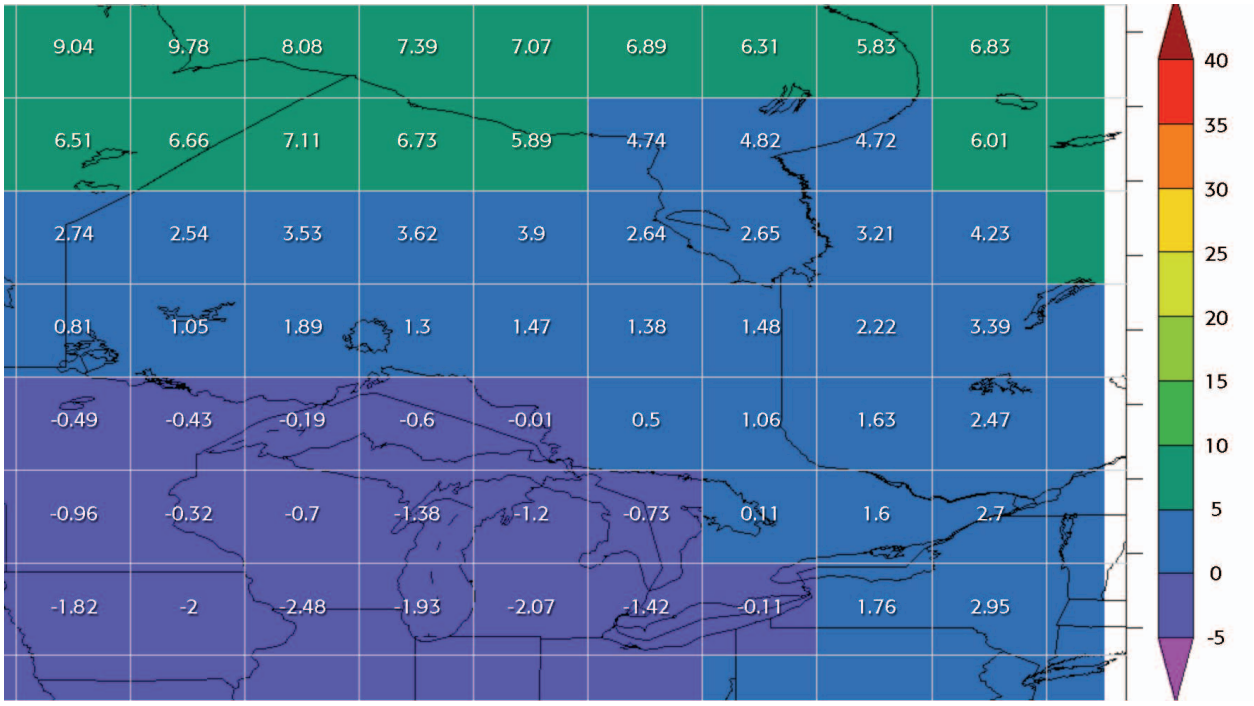


Figure 6b: Projected change in average SUMMER precipitation over Ontario for 2050s compared with 1961-1990 under MODERATE GHG emissions (average of A1B [high] and B2 [low] emission scenarios) (Environment Canada, CCCSN 2009)



1.1.3 Projections of Extreme Events

Long-term changes in annual average temperatures or rainfall are a consequence of shifts in the overall variability of weather and frequency of events that may be far from average. Droughts, heat waves, severe rainstorms, tornadoes and windstorms all contribute to calculation of averages. Projections of changes in average temperature and precipitation almost inevitably imply more frequent and possibly more intense extreme events that are outside the range within which, for example a community, or ecosystem, or planted crops, can cope. Adaptation enlarges the coping range (Figure 9).

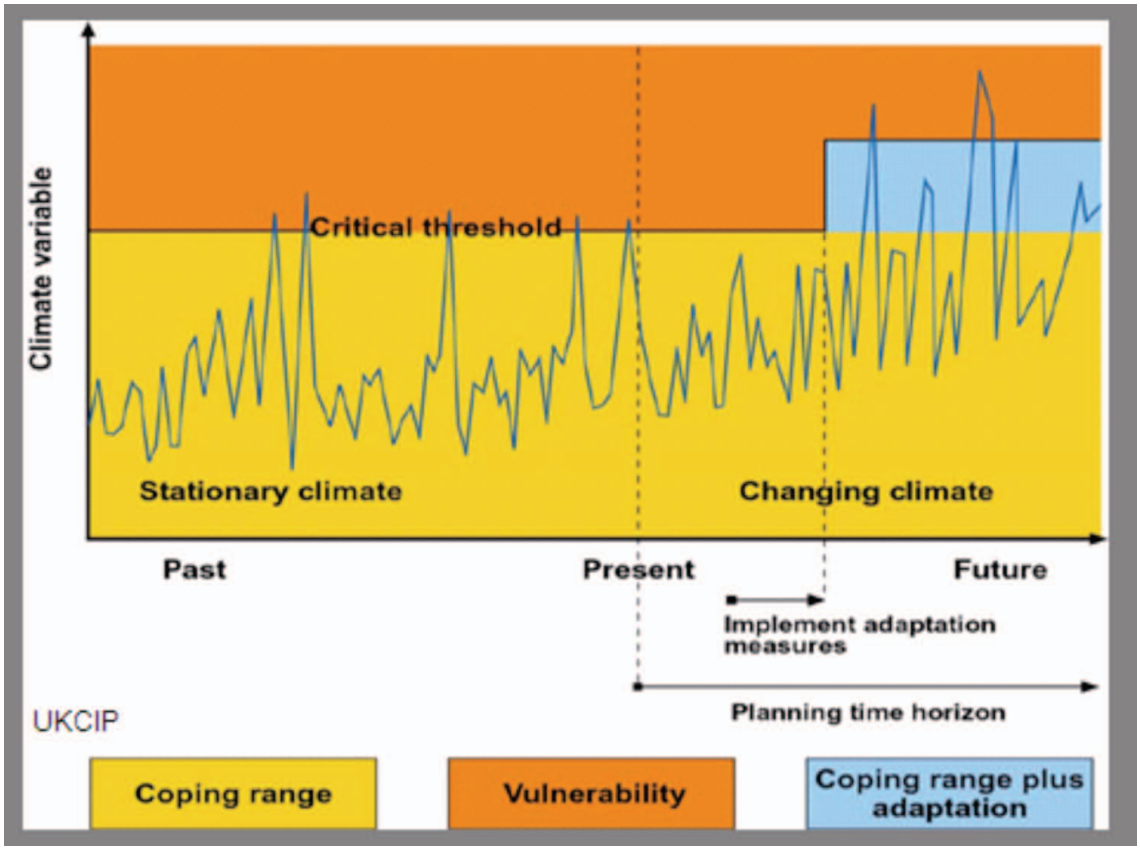
Observations have not yet clearly shown that the frequency of extreme events is increasing in Ontario, but it has been found in other places and can be expected in Ontario.

Climatic conditions that go beyond the coping range of a community or some other natural or human-based system are evidence of climate vulnerability. Assessing climate vulnerability can be based on the examination of records of past episodes that caused or came near to causing damage. Measures to reduce vulnerability might be aimed at reducing the exposure and sensitivity of the system as well as increasing the "adaptive capacity" to deal with the risks arising from threatening climatic conditions.

1.2 Impacts in Ontario

A systematic national assessment of the potential impacts of climate change across Canada, region by region, was published in 2008, just after the Panel began its work (Natural Resources Canada's report, *From Impacts to Adaptation: Canada in a Changing Climate 2007*). One chapter of this

Figure 7: Coping Range



Source: Willows, R. and Connell, R. (eds.), 2003.

report was devoted to Ontario and reviewed the current knowledge of climate impacts in the province and suggested likely future impacts. The review of this document provided the Panel with a valuable foundation upon which to build its discussion of adaptation options. Given the rapidly changing level of scientific understanding of climate change and the evolving patterns of impacts and adaptation, it is important that the knowledge in the Ontario assessment be kept up to date by conducting a comprehensive review on a five-year cycle.

A SUMMARY OF ANTICIPATED CLIMATE CHANGE IMPACTS IN ONTARIO

From Natural Resources Canada's report, *From Impacts to Adaptation: Canada in a Changing Climate 2007*.

Since 1948, average annual temperatures in Ontario have increased by as much as 1.3°C in the west of the province, but very little in the east. (Figure 2; Environment Canada 2009). Warming is projected to accelerate, with the most pronounced temperature increase occurring in winter, especially in the Far North (Fig. 4a).

More moisture in a warmer atmosphere is expected to cause an increase in extreme weather events – rain, snow, drought, heat waves, wind, and ice storms. There are indications that this trend has also begun. Weather is also likely to be more variable and less predictable from year to year.

Infrastructure

Disruptions to critical community infrastructure, including water treatment and distribution systems, energy generation and transmission, transportation and residential damage have occurred recently because of severe storm events across the province. The risk of such impacts in the future is expected to rise.

Flooding associated with an intense storm system moving across southwestern Ontario in August 2005 caused extensive flood and infrastructure damage resulting in $500 million in homeowner and insured losses. Multi-million dollar storms caused flooding in northwestern Ontario (Rainy River) in 2002, and in Peterborough in 2004.

Projected decreases in Great Lakes water levels could reduce the loads carried by Great Lakes freighters and reduce hydroelectricity output by more than 1,100 megawatts by lowering the head driving turbine generators.

Water

Water shortages have been documented in southern regions of the province and are projected to become more frequent as summer temperatures and evaporation rates increase. Sections of Durham County, Waterloo and Wellington Counties as well as the shoreline of southern Georgian Bay, where population growth is expected to increase significantly, will become more subject to shortages in the next 20 years.

Agriculture

A wide range of climate parameters influence crop and livestock production including maximum and minimum temperatures, growing degree days, length of growing season, amount and timing of rainfall, extreme weather events, drought, snow cover, and frost periods. Climate change also indirectly impacts agricultural productivity by affecting the viability of pests, invasive species, weeds and disease, and through interactions with other air issues such as acid rain and smog.

Availability of water through rain or irrigation is likely to become an even more critical issue in future, not only the total amount but also the timing of rainfall during the growing season.

Projected changes in agri-climate conditions could be beneficial for the production of some crops, and could lead to a northward extension of crop production where soil and soil moisture are suitable.

Health

Increased risk of illness and premature death is likely to result from heat waves, smog episodes and ecological changes that support the spread of mosquito and tick borne diseases such as West Nile Virus, Lyme Disease, and even malaria.

(cont'd) ▶

◀ (cont'd)

Heat-related mortality could double in southern and central Ontario by the 2050s, while air pollution mortality, compounded by warmer summer temperatures could increase about 15-25% during the same interval.

Communities at Risk

Some isolated First Nations, northern and forest-based communities have been, and will continue to be, vulnerable to earlier spring melt, ice-jam flooding, more frequent forest fires and warmer winter temperatures. The temperature would allow forest insect pests to spread, including the mountain pine beetle from British Columbia, and would shorten the season for frozen winter roads in the Far North. More urban communities will be affected by impacts on the volume and quality of drinking water, changes in winter tourism because of less reliable snow cover, as well as more frequent extreme temperature and rain events with consequences for social and physical infrastructure.

Forests

The growth rate of some tree species will increase where other conditions such as soil moisture and absence of fire, are favourable. However, higher temperatures decrease the growth rate of commercially important black spruce and white spruce. Combinations of impacts may result, for example, in black spruce and balsam fir being replaced by more drought tolerant jack pine and aspen in increasingly dry areas, but the spread of mountain pine beetle may, in turn, threaten jack pine in those same locations. Fire and blowdown windstorms are likely to become greater threats.

Ecosystems

Observations in the relative abundance of fish species in southern Ontario show a shift from cold- and cool-water species and, in turn, to more warm-water species.

Changes in the composition of aquatic and terrestrial ecosystems in the Hudson Bay region and reduced numbers and health of polar bears is an example of current impacts. Lower water levels in the Great Lakes projected for the future, will damage the wetlands that presently maintain shoreline integrity, reduce erosion, filter contaminants, absorb excess stormwater, and provide important habitat for fish and wildlife. Invasive species in the Great Lakes are likely to increase, requiring modification to infrastructure and/or management activities.

1.3 Limiting and Coping with Climate Change: Mitigation and Adaptation

Climate change mitigation measures are designed to reduce the emission of GHGs that contribute to climate change, and also include measures that enhance carbon sinks. Mitigation offers long-term benefits, but as we noted earlier, the GHGs that are already in the Earth's atmosphere will continue to influence our climate for many decades. Recognizing that the GHG concentrations in our atmosphere are already having an impact, climate change adaptation is adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

Neither mitigation nor adaptation alone can help us avoid all the impacts of climate change. Mitigation is necessary because the unchecked impacts of climate change would likely overwhelm our efforts to adapt. Adaptation is also necessary to address the impacts of climate change that are no longer avoidable, and that will continue until well beyond the date at which atmospheric concentrations of carbon dioxide are stabilized.

Mitigation and adaptation measures might conflict with one another. For example, using air conditioning systems to protect urban populations against extreme heat waves will also contribute to increased power usage and thus more GHG emissions. However, mitigation and adaptation measures can have co-benefits. For example, forests act as carbon sinks, absorbing and storing carbon dioxide

(a kind of mitigation), but they also reduce flood levels, control soil erosion (adaptation in response to increased precipitation). Moreover, urban forests reduce the heat island effect (adaptation in response to increased temperatures).

1.3.1 Recognizing the Limits to Adaptation

It is clear that anthropogenic climate change and the associated destabilization of the weather, and impacts such as sea-level rise, changes in lake levels, and drought will continue well beyond the end of the 21st century.

Undertaking adaptation measures in the short-term can do a great deal to reduce the impacts of these changes. However, it is also true that the longer it takes to control GHG emissions and stabilize atmospheric concentrations of GHGs, the more difficult and costly it will be to adapt. Furthermore, there is a risk of the rapidity and extent of climatic change overwhelming our ability to engage in planned adaptation. While much of Ontario might be able to adapt for decades, global projections based on the current emission trends indicate that present day livelihoods in substantial areas of the planet will become unsustainable. This applies especially to low lying coastal areas that will be flooded by sea level rise and continental interiors where desertification is changing grasslands into arid deserts. There is a daunting threat of international socio-economic disruption as many millions of people become environmental refugees. The focus of this report is Ontario, but no single country or province will be immune to the changes occurring elsewhere on earth.

In the immediate term, the "limits" to adaptation are perhaps best described as "constraints" upon our current capacity to effectively prepare for and respond to on-going climatic changes. Three major categories of constraints – economic, social/legal and technological – need to be addressed if we are to reduce our vulnerability to climate change.

Little is known about the potential costs of adaptation. Recent estimates of adaptation costs on a global scale suggest amounts in the order of tens to hundreds of billions of dollars per annum. These are acknowledged to be very rough estimates. Any future estimates made for Ontario would also be highly uncertain. On the other hand, it is important to know the cost of adaptation measures in specific cases in order to make comparisons with the expected reduction in damage or vulnerability. The design standards for infrastructure, for example, involve a choice between the incremental or marginal cost of additional safety and the level of risk of failure which is considered to be acceptable or tolerable. As adaptation to climate change is implemented in Ontario there will be an evident need for more economic analysis, sector by sector, region by region, and project by project.

The second set of constraints is social/legal, since many possible adaptation actions may be socially unacceptable or not permitted under the law (e.g. the allocation of water among competing uses in areas affected by reduced availability).

The final set of constraints involves technological limits and specifically the availability of technology, its costs and/or the unknown risk involved in its deployment. The Panel draws attention to this context not to detract from the importance of adaptation, but simply to underline our message that adaptation by itself is not sufficient to manage and resolve the climate crisis.

1.3.2 Formulating an Approach to Adaptation

Adaptation requires an integrated approach as it is a long-term, continual process which will touch all sectors of society. This characteristic means that adaptation efforts cannot be effectively undertaken in silos; integrating consideration of climate change impacts into every day decision-making processes is more efficient and effective than addressing adaptation as a stand-alone issue. An integrated approach is also considered to be the most economically efficient way to address the consequences of climate change. By integrating consideration of the implications of climate change into financial and investments decisions, exposure to unacceptable risk can be reduced.

1.3.3 Meeting the Challenge

Like Ontario, other provinces and territories are working to mitigate their GHG contributions to climate change through policy frameworks which mandate GHG reductions. At the same time, provinces and territories are making plans to adapt to its impacts. Some provincial and territorial climate change plans, such as those in Quebec, British Columbia and Nova Scotia include adaptation actions, while other jurisdictions, such as Alberta and the Northwest Territories, are currently preparing specific adaptation strategies.

For example, Quebec's Climate Change Action Plan 2006-2012 identifies 26 measures intended to address both climate change mitigation and adaptation. Specific adaptation measures include:

- Establishing mechanisms to prevent and mitigate the impact of climate change on health and public security;
- Consolidating climate, water resources and air quality monitoring networks;
- Determining the vulnerability of Quebec forests and the forest sector to climate change; and
- Reinforcing water and air quality management procedures.

An annual duty on gasoline and fossil fuels (carbon tax) ensures the greater part of financing for the Action Plan and by 2012, more that $1.55 billion is expected to be spent on implementation.

British Columbia's *Climate Change Action Plan* includes the following adaptation actions:

- Endowment of $90 million to the Pacific Institute for Climate Solutions for climate change research;
- Continued implementation of a Pine Beetle Action Plan and implementing *Forests for Tomorrow* which is designed to adapt forest and range management for a changing climate;
- Introduced *Living Water Smart: British Columbia's Water Plan* for water conservation and efficiency (measures include funding for flood prevention and water conservation targets); and
- Building Carbon Smart Communities (measures include ensuring all new developments on flood plains will be flood-proofed to provincial standards and recognizing climate change impacts are considered when awarding infrastructure grants through the Ministry of Community Services).

Towards a Greener Future: Nova Scotia's Climate Change Action Plan includes a number of specific adaptation actions including but not limited to:

- Creating an Adaptation Fund to encourage research and development on adaptation;
- Incorporating climate change impacts and adaptation response plans into the strategies and initiatives of all provincial departments;
- Launching a web-base clearinghouse of information and tools to support adaptation;
- Beginning work on a provincial vulnerability assessment and progress report on adaptation to be updated bi-annually;
- Creating an interdepartmental steering committee and external advisory committee responsible for the coordination of adaptation efforts and provision of adaptation policy advice;
- Ensuring design standards and plans for new provincial construction and for the renewal of existing provincial infrastructure reflect projected climate trends;
- Releasing a Sustainable Coastal Development Strategy to strengthen the resiliency to climate change impacts along the coast; and
- Amending funding agreements with municipalities to require climate change strategies in municipal Integrated Community Sustainability Plans.

As part of *Alberta's 2008 Climate Change Strategy*, the province is developing a provincial Climate Change Adaptation Strategy to identify measures and indicators of climate change to provide a source of information about the impacts and to identify risks and vulnerabilities. The Strategy will focus on water, biodiversity, energy, municipal infrastructure, agriculture and forestry.

A number of adaptation actions are currently being undertaken in the Northwest Territories to address the impacts of climate change. For example, the government is using ground-penetrating radar to assess ice thickness on winter roads and has expanded weather-monitoring networks to include additional sites and more frequent recording of observations. The Department of Environment and Natural Resources is currently developing a Northwest Territories Climate Change Adaptation Plan to support continued action on adaptation.

In Ontario, the provincial government is pursuing strategies for both mitigation and adaptation. In 2007, the Government of Ontario released its Climate Change Action Plan, which set GHG emission reduction targets. At the same time, the Plan identified the need for climate change adaptation actions and identified the appointment of the Panel as an essential first step.

Preparing *for* Climate Change *and* Adapting Well:

Goals for Government

Preparing *for* Climate Change *and* Adapting Well: Goals for Government

From all the accumulating evidence, it is clear that Ontario needs a comprehensive strategy to reduce the present and future impacts of climate change to which we are already committed. The development and security of the Ontario economy and society, and protection of the environment demand no less. Piecemeal, uncoordinated actions will be insufficient and costly. A carefully considered, evidence-based strategy with goals, timelines and clear responsibilities is required.

We believe our recommendations provide an effective start for both a strategic framework and an action plan focused on the highest priorities. However, we are also very aware that our process only gave us a broad overview and in some places only skims the surface. Under those circumstances it is extremely important to build capacity in centres of expertise within key ministries, as well as distributed adaptation planning capacity throughout the government, so that the momentum of the Panel's work will continue. Our recommendations address those needs as well.

Just as the impacts of climate change will be environmental, economic, social, and cultural, affecting individuals, communities and all the life in the landscapes of our environment, so must the strategy be comprehensive and woven into many kinds of decisions at all levels.

Furthermore, the rapidly unfolding nature of climate risks and the uncertainties about the rate of reduction of GHG emissions necessitate a flexible approach that can be adjusted as we gain new knowledge and experience. Managing climate change risks and recognizing potential opportunities are essential elements in the future strength of the Ontario economy and the well-being of everyone in the province.

Strong leadership is required from the government and the strategy has to be large enough in scope and vision to embrace all elements of provincial life. We consider that the five Strategic Goals listed under Recommendation 1 can serve as a framework for Ontario's strategy well into the future.

Recommendation 1

The Minister of the Environment should take immediate steps to seek Cabinet support for launching, by Spring 2010, a province-wide climate change adaptation action plan based on the advice provided by the Panel and guided by a strategy founded on the following goals:

STRATEGIC GOAL 1: ENHANCE GOVERNMENT LEADERSHIP

Enhance provincial government capacity to take leadership in effectively assessing, reducing and managing climate change and related natural disaster risks, as well as taking advantage of beneficial opportunities.

STRATEGIC GOAL 2: INTEGRATE ADAPTATION

Integrate adaptation to climate change into the policies and programs of government ministries for the purpose of continuously reducing risks as well as taking advantage of beneficial opportunities resulting from climate change.

Theme 1: Increase the climate change resilience of physical infrastructure, agriculture, and human health.

Theme 2: Increase the climate change resilience of ground and surface water, especially the Great Lakes; the diversity of Ontario's biological heritage, including species at risk, forests; and the carbon rich wetlands of the Hudson Bay Lowlands.

STRATEGIC GOAL 3: SUPPORT COMMUNITIES

Increase efforts by communities to improve climate change resilience by providing information, training and tools to support an adaptive, risk management-based approach to the impacts of climate change.

STRATEGIC GOAL 4: DEVELOP AND DISSEMINATE KNOWLEDGE AND TOOLS TO MANAGE RISK

Develop and strengthen the continuous creation and communication of knowledge about adapting to climate change, reducing climate risks and taking advantage of beneficial opportunities through programs of research, monitoring, public awareness and education.

STRATEGIC GOAL 5: COLLABORATE WITH OTHER GOVERNMENTS

Seek opportunities to influence and collaborate with other governments in Canada and internationally for the purpose of sharing climate change adaptation experience and developing cooperative activities.

The cost of action today is an investment in the stability of the future. Choosing to deal with climate change by paying the price of reacting to emergencies will be more expensive as well as socially and economically disruptive. Ontario has an opportunity for both economic and moral leadership by connecting its investment in reducing GHG emissions with investment in limiting the impacts of climate change that are now inevitable.

2.1 Enhance Government Leadership

STRATEGIC GOAL 1:

Enhance provincial government capacity to take leadership in effectively assessing, reducing and managing climate change risks, as well as taking advantage of beneficial opportunities.

Assessing and managing future climate risks requires a high level of technical and scientific capacity, otherwise adaptation actions may be out of proportion to the risks – either too little, too late, or over designed and too expensive.

Developing social, institutional and communication capacity, and sound policy making are equally necessary in applying and transferring knowledge into action at a local level.

Taken together they are the foundation for creating a provincial culture of climate change adaptation that should be led by government. We believe that the most effective strategy for exercising that leadership begins with strengthening government capacity and integrating or "mainstreaming" climate change adaptation into current policies and programs across the full span of government.

As ministries and many others in the wider community become engaged with adaptation, the list of needed actions can be expected to grow and spread. Part of the expansion will arise as more people become aware of the potential future impacts of climate change, and the other part will result from advances in the science of climate change. If the increase of GHGs in the atmosphere continues beyond the next 20 or 30 years at anywhere near the same rate as today, then the adaptation agenda at all levels, including Ontario, will be subject to both expansion and intensification as change threatens to become destabilizing.

2.1.1 Coordinating Adaptation Policy

In order to coordinate, facilitate and inform the development of provincial climate change adaptation policy we believe a Climate Change Adaptation Directorate should be established.

The Directorate should report annually on progress in pursuing the strategic goals, objectives and action plans. It should also have sufficient authority to suggest and recommend new policy initiatives and related legislation to all ministries.

The Strategic Policy Branch of the Ministry of the Environment is not the only place that such a unit could be located. However, considering the experience and knowledge that has been built up in the Branch during the work of the Panel, the rapid rate of change in so many aspects of adaptation issues, as well as the nature of the work to be done in the short-term, it is certainly appropriate for at least three years. During this period adaptation should become firmly mainstreamed and the anticipated Regional Adaptation Collaborative Agreement with Natural Resources Canada will be completed. At the end of three years the role of the Directorate should be reassessed.

An important early task for the Directorate should be to coordinate the development of a more detailed government-wide strategy and action plan built around the recommendations in this report and the current actions and commitments of other ministries and agencies. This will require a more comprehensive and systematic analysis than has been possible during the work of the Panel.

Recommendation 2

A Climate Change Adaptation Directorate should be established in the Ministry of the Environment to:

- Coordinate the completion of the provincial strategy and action plan (Recommendation 1) for adapting to climate change, building on the goals and recommendations in this report;
- Stimulate, integrate, and coordinate mainstreaming of climate change adaptation into government decision-making, policies and programs;
- Monitor and report on climate adaptation policy development, programs and adaptation actions in the province, including an adaptation section in the annual Climate Change Action Plan report to the Legislature;
- Oversee the implementation of the anticipated Ontario Regional Adaptation Collaborative, to be implemented from 2009-2012 in collaboration with Natural Resources Canada;
- Create distributed climate change risk assessment and adaptation planning capacity in government by organizing professional development, education and training opportunities for staff in all ministries using examples of best practices from projects underway in Ontario and elsewhere;
- Work with the Ontario Centre for Climate Impacts and Adaptation Resources and its partners to ensure the delivery of workshops and training sessions to relevant government and agency staff, covering the steps and information requirements of vulnerability assessments and the use of assessments in adaptation initiatives; and
- Ensure that the information about climate impacts in the Ontario chapter of *From Impacts to Adaptation: Canada in a Changing Climate 2007* is kept up to date, expanded to include examples of adaptation underway in Ontario, and posted in a web friendly format for the benefit of policy makers and adaptation practitioners in Ontario.

It is expected that many adaptation measures and policies will be feasible within existing capacity because they will not be entirely new activities, but only adjustments to existing practice. There will clearly be some cases, however, where completely new activities are needed, such as in the development and application of risk assessment methods and tools, which will require additional funding. Action plans themselves will, of course, need to be reviewed and revised on a regular basis to allow for new knowledge and developments.

Such a plan of action and inter-ministry cooperation will require more than the leadership and coordination of an adaptation unit in one ministry. There will need to be staff in all other relevant ministries who can work together in a concerted, inter-ministerial way, as well as higher level support and direction, possibly in the shape of an Inter-Ministerial Climate Change Adaptation Committee.

The challenge of adapting well to climate change needs all the benefits from sharing experience among practitioners as well as tapping the growing knowledge of researchers. We suggest that the involvement of the expert community outside government will continue to be very worthwhile and, quite simply, an irreplaceable way of bringing research results to bear on policy development. However, future contributions could well follow a different model from that of the Panel with a varying small number of individuals contributing to focused tasks on a project-related basis.

Natural Resources Canada's report, *From Impacts to Adaptation: Canada in a Changing Climate 2007* is a valuable assessment of the scope and scale of adaptation required in Canada. The review presented in the Ontario chapter of present and likely future climate impacts across the province and in various economic and civic sectors was very helpful to the Panel. The information should

be periodically updated, sector by sector, in a rolling fashion, and it should be expanded to include examples of adaptation underway in the province. It would be much more valuable if it were made more accessible through posting in a web friendly format.

The involvement of adaptation experts will be especially valuable during the November 2009-2012 life of the proposed Ontario Regional Adaptation Collaborative, to be supported jointly by the Government of Ontario and Natural Resources Canada.

Recommendation 3

The Ministry of the Environment should ensure that the Climate Change Adaptation Directorate has ongoing access to a broad range of adaptation experts to provide advice and assistance.

IMPLEMENTATION OF VULNERABILITY ASSESSMENTS

Government and community capacity should be enhanced in the implementation and application of vulnerability assessment, including adaptive capacity assessment. Outreach activities currently in the hands of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR), and planned as an important element of the proposed Regional Adaptation Collaborative, will take the vulnerability assessment process into communities. However, it is also important that ministries and agencies understand the "Vulnerability Approach" and the methods and tools it employs in initiating "no regrets" actions and engaging stakeholders.

Vulnerability assessments are based on understanding:

- How the agency or the sector or related stakeholders are exposed to climatic conditions and climate change;
- How they are sensitive to particular conditions;
- How climatic influences are experienced in the context of other forces and stresses;
- How (and how well) they currently cope with climatic variations;
- What the constraints are on adaptation;
- How are risks and beneficial opportunities likely to be altered in the future with climate change; and
- What is needed to improve adaptive capacity.

The process of vulnerability assessment is essentially a risk management process that directly involves those affected by changing conditions and those with responsibility for dealing with risks. It documents the exposures and sensitivities of the sector to climate change, and considers ways to incorporate or modify programs and policies to better adapt to changing climate.

Vulnerability assessments can bring about rapid consideration of climate change into existing policies and planning processes bearing in mind that decisions regarding adaptation require dealing with uncertainty. There are uncertainties about future climate, uncertainties about the sensitivity of systems to changes, uncertainties about the future of social, political, economic, public perceptions and technological conditions, all of which influence capacity to adapt.

2.1.2 Climate Science and Modelling Future Climate

The IPCC listed 23 well respected global climate models in its 2007 report. These models, including a Canadian Model developed in collaboration with Environment Canada and run at the Canadian Centre for Climate Modeling and Analysis (CCCma) at the University of Victoria, simulate future global climate based on a variety of potential future global GHG emissions. They require a great deal of computing time and are constantly modified as climate trends emerge and understanding of climate science improves.

While plausible and based on the best research from around the world, simulations of future climate are inherently uncertain because of the immense complexity of the climate system. Imperfect understanding is compounded by not knowing how much the composition of the atmosphere will change through the addition of GHGs emitted in the next few decades. Those emissions will be partly industrial and therefore theoretically controllable, but some will be natural from sources such as melting permafrost and warming of northern peatlands.

Testing models by using them to "predict" the climate of the recent past shows that projections are more accurate when they reflect the results of several models based on slightly different interpretations of the behaviour of the atmosphere. Environment Canada is currently working to identify those that are most suitable for use in various regions of Canada, including Ontario.

The projections of climate in 2050 used in this report (Figures 3-6) were provided by the Canadian Climate Change Scenarios Network (CCCSN) through Environment Canada in Toronto. The CCCSN is based on Environment Canada's Adaptation and Impacts Research Division national network and includes several universities. As well as providing on-line access to global scale climate change scenarios, the CCCSN can provide high level technical support for downscaling climate models to a regional scale, as well as access to adaptation research.

Global models, like those used for the simulations in this report, project future climate for areas within a global system of cells usually measuring about 300km x 200km. While providing a global picture, a grid system of that scale does not consider the effects of the regional landscape and therefore does not project the detail usually desirable for projecting local climate. For that purpose, regional climate models are produced by integrating regional geography with a global model.

IMPACT AND ADAPTATION MODELLING

Computer modelling is also used to project the scale of the impacts that changing climate can be expected to have in a region on such characteristics as seasonal soil moisture, growing degree days, spread of insect vectors, frequency of ice storms and forest fires, flooding and droughts, energy and water use, and the quality and quantity of drinking water supplies. Regional and downscaled models serve as the foundation for projections of future local climate impacts. Such modelling links a system such as the hydrology of a watershed with a projection of future climate.

Adaptation modelling, in which different ways of adapting can be projected and compared, also uses regional scale climate modelling as a starting point. Monitoring information related to the adaptation approach under consideration is then integrated into the impact or adaptation model. Economic and social data, such as the cost of crop failure compared with implications of alternative crop choices or the human cost of alternative heat wave adaptation choices, can also be integrated into impact and adaptation models.

Downscaling scenarios of probable future climate to community scale can also be accomplished using statistical methods. Statistical downscaling techniques are based on determining a statistical relationship between years of weather monitoring data in the local area of interest and the projections for the cell within which the area lies. It requires

much less computing time than integrating the physical features of the regional landscape into the production of a regional model.

Government capacity should be enhanced in the areas of climate science and computer simulations of future climate and its impacts. While recognizing that a good deal of worthwhile adaptation can be based on assessing vulnerability to past climate, plausible scenarios of probable future climate, although uncertain, must be accessible for risk assessment and management purposes across the province. They will always, however, have to be used with at least as much caution as any other projections of future conditions. For that reason alone it is important that government ministries are consistent and fully informed in their choice and application of climate modelling.

The use of a common, basic set of best available regional climate projections by government ministries, agencies, municipalities, and non-government stakeholders should serve to reduce confusion about choices among models and projections.

The most cost effective use of modelling in Ontario will occur if the government takes the lead in making downscaled, regional climate models available along with tools that enable those models to be used in planned adaptation. At the moment it is not clear what new regional modelling capacity might be needed and what can be provided with existing capacity through, for example, the CCCSN and Environment Canada. The computing power of SciNet at the University of Toronto is another potential contributor and there may be more. The Panel has not considered the options and only suggests that they be clarified and considered at a series of working meetings in which collaboration is paramount, that existing capacities are fully explored, and that clearly articulated user needs drive the discussion.

Several years ago, the Ministry of Natural Resources made initial projections of future climate in Ontario available as a decision-making tool to its managers and staff and also to the public on its web site, as well as through its Climate Change Research Reports. The modelling technique was relatively simple but served the need at the time.

More recently, nearly $4 million over four years was allocated in the 2008 budget to enhance modelling, monitoring and research capabilities in the Ministry of the Environment. The Ministry has been using a portion of these funds to explore various modelling options, including using the modelling capabilities of academia and the Ouranos climate change consortium in Quebec.

Creating good, evidence based, public policy requiring climate change risk assessments in land use planning, infrastructure proposals, source water protection and numerous other activities, implies the development of a variety of guidelines relating to the selection, use and limitations of models and projections of future conditions. Confidence in those guidelines should be based on a high standard of internal government climate change expertise and excellent knowledge sharing with other practitioners. The core of that expertise should be housed within one lead ministry – the Ministry of the Environment – with smaller nodes with excellent understanding of applications in key sectors. Other key ministries will include the Ministry of Natural Resources, Ministry of Municipal Affairs and Housing, and Ministry of Agriculture, Food and Rural Affairs.

Collaboration with other governments and the research community will contribute to informing Ontario's climate change policy and program development, risk assessment, and climate related decision-making by government and its program partners. The proposed Ontario Climate Change Network (see Recommendation 52) will assist in bringing about this collaboration.

Recommendation 4

The Ministry of the Environment should enhance its climate change science and modelling capacity to include sufficient staff expertise to:

- Enable Ontario to be an active participant in the Canadian Climate Change Scenarios Network's national program of climate change science and modelling, including regional and downscaling activities;
- Provide advice across government regarding applications of climate change and impact modelling, including proper consideration of uncertainty;
- Analyze climate change science and conduct an ongoing review of new information concerning the implications for Ontario of climate change and climate impact projections, and communicate the results to government users; and
- Participate in the proposed Ontario Climate Change Network (see Recommendation 52).

2.1.3 Funding

We have not attempted to determine the level of funding that may be necessary for implementing our recommendations. In some cases new funding will be minimal or even unnecessary because action can be taken by altering existing processes, mandates and job descriptions without any cost implications. However, in some cases there will be additional costs imposed on individual ministries. For example, funding will also be required for research and to support the operation of the Ontario Climate Change Network proposed in Recommendation 51.

Implementation of Quebec's Climate Change Action Plan 2006-2012, which includes both mitigation and adaptation measures, is funded in part by an annual duty or carbon tax on gasoline and other fossil fuels. The American Clean Energy and Security Act of 2009 (the Waxman-Markey Bill) currently before the U.S. Senate, if passed as proposed, will contain a mechanism to fund adaptation actions through the auctioning of emission allowances under a cap and trade system.

Recommendation 5

The Province should identify dedicated funding for climate change adaptation initiatives.

2.2 Integrate Adaptation

Integration or "mainstreaming" of adaptation into all aspects of government activity means changes in policies and processes, decision-making criteria, planning frameworks, legislation, regulations, and many of the ways the government shows leadership in its relationship with municipal governments and the public in general. Some of our recommendations related to specific ministries have to do with policy but many are more operational. We have not, however, attempted to prepare a comprehensive list of operational recommendations. Those we have listed are only intended to illustrate adaptation actions suitable for inclusion in a comprehensive plan.

STRATEGIC GOAL 2:

Integrate adaptation to climate change into the policies and programs of government ministries for the purpose of continuously reducing risks as well as taking advantage of beneficial opportunities resulting from climate change.

Theme 1: Human systems – Increase the climate change resilience of agriculture, physical infrastructure, and human health.

2.2.1 Agriculture

Ontario agriculture is the most rich and diversified in Canada. With over 57,000 farms, the agricultural sector is a major contributor to Ontario's economy accounting for approximately one quarter of the national total of farm cash receipts with $10.2 billion in 2008. Additionally, Ontario's food processing sector is the largest in Canada and the second largest manufacturing sector in the province, generating more than $35 billion in shipments annually.

Climate change presents significant risks and potentially beneficial opportunities in the agriculture and food sector in Ontario. Particular sensitivities are expected with respect to water supplies, heat waves, droughts and pests, with implications for producers, rural communities, processors and trade.

Warmer temperatures and longer growing seasons provide opportunities for many crops including corn, soybeans, forages and horticultural crops, but climate change also brings significant risks. Changes in drought frequency and severity, shifts in the timing of precipitation and changes in storm intensity present risks to production, income and support programs. Climate change also affects farm production and profitability through changes in agricultural pests, invasive species, weeds and disease.

Farmers in Ontario are long accustomed to making adjustments in order to adapt to variations in conditions. In the last ten years many farmers report having noticed changes in climate and have responded by growing different crops or crop varieties, changing tile drainage, utilizing conservation tillage, installing irrigation systems and adjusting the timing of planting.

A perfect example of adaptation occurred in 2002, when Ontario tomato growers used an improved irrigation system adapted from Australia. Despite the fact that it was one of the driest years in memory, the yield was the second highest on record. In response to recent drought, producers at the community level have begun to work with local water managers to create irrigation advisory committees and develop plans for sharing water fairly at the same time as ensuring flows required by ecosystems. If occurrences of drought increase as expected, such solutions will become even more important.

While a longer growing season will allow the northward expansion of the growing territory of some crops such as soybeans, sorghum and maize, suitable temperature is not the only relevant factor. Soil type and lack of reliable soil moisture in the growing season can hinder that expansion. In addition, ground level ozone concentrations in smog can damage soybeans and other crops, causing yields to decline in both quantity and quality. Ozone is the most damaging constituent of smog and is generated at street level by sunlight and warmth acting on vehicle and industrial fumes. Once produced, it can drift hundreds of kilometres from its urban origin. The City of Toronto, for example, receives ozone from the U.S. Midwest. In turn, it is thought that smog generated in Toronto drifts as far as North Bay and Sudbury, some 400 kilometres away.

Soybeans are an example of a significant crop for Ontario facing climate change risks. Asian soybean rust is an invasive fungal disease of soybeans new to North America. It was first detected in the United States in 2004, and that year's very active hurricane season is believed to have played a role in carrying spores northward from South America. Warmer winters will provide the right conditions for the spread of this disease. In anticipation of that occurrence, the Ontario Rust Coalition has used Quincy Research Centre for fungicide trials, and for variety and geoplasm development of potential Canadian rust-resistant soybean lines. Furthermore, Canada and Ontario are partners in the North American Soybean Rust Sentinel Plot Network. Soybean fields and sentinel plots are monitored for the disease, and new technologies such as computer prediction models, molecular detection and tracking of soybean rust through spore traps are used to fight the disease.

The growth, multiplication and spread of other plant diseases and pest infestations are predicted to increase with warmer conditions, thereby resulting in increased crop losses. The geographic

distribution of pests and diseases will vary depending on local conditions as climate changes. Many weed species will thrive on higher levels of CO_2 in the atmosphere, with some, such as ragweed, producing more pollen.

While there are climate change risks facing the agricultural sector, there are also opportunities. Vineyards have been established in the last two years in the more northern regions of Southern Ontario including: Ottawa, Collingwood, Owen Sound, Prince Edward County, and Manitoulin Island. Vineyards in these areas consist of hardy varieties able to withstand relatively harsh winter weather. The long-term vision for a new vineyard on Manitoulin Island includes wine production on-site.

Planned adaptation serves to effectively realize opportunities and minimize the need to adjust after climate-related losses have been incurred. Adaptation in agriculture involves producers, businesses and public agencies and can include measures involving farm production and business risk management, technology, financial and marketing strategies including income support, incentives and crop insurance all aimed at increasing the climate resilience of the agricultural sector. For example, anticipating climate change rather than reacting to it can result from offering incentives to farmers to change their practices in ways that attempt to take account of climate change risks instead of relying only on crop insurance.

AGRICULTURAL IMPACTS: DROUGHT

According to Agriculture and Agri-Food Canada, the 2001-2002 drought years are considered to be amongst the worst in Canadian history with the following results:

- Agricultural production dropped an estimated $3.6 billion;
- The Gross Domestic Product fell some $5.8 billion for 2001 and 2002;
- Employment losses exceeded 41,000 jobs;
- Crop production losses were devastating for a wide variety of crops;
- Livestock production was especially difficult due to the widespread scarcity of feed and water; and
- Water supplies that were previously reliable were negatively affected, and several failed to meet the requirements. Dry conditions in southern Ontario resulted in requests to reduce water consumption in some watersheds.

Source: Agriculture and Agri Food Canada, January 2005. Lessons Learned from the Canadian Drought Years of 2001 and 2002, SRC Publication No. 11602-46E03.

Recommendation 6

The Ministry of Agriculture, Food and Rural Affairs should complete by 2011 a systematic climate change risk and opportunity assessment for the agricultural sector throughout the province, consult with the farming community, producer associations, and the research community, and based on the assessment:

- Engage the agricultural community in dialogue concerning longer-term climate change risks and opportunities in agriculture in contrast to shorter-term weather risks using workshops and interactive communication; and
- Work with the agricultural community, producer associations, the research community and other levels of government to develop local adaptation options, engage the agricultural community in an ongoing assessment of the effectiveness of these and other adaptation options, and facilitate the sharing of best practices.

Recommendation 7

The Ministry of Agriculture, Food and Rural Affairs should review and, where appropriate, amend its policies relating to business risk management, income support, incentives and crop insurance. This will increase the climate resilience of the agricultural sector in the context of an adaptive management approach that supports farmers in changing their practices in ways that anticipate climate change rather than reacting to it.

There is already cooperation between the Ministry of Agriculture, Food and Rural Affairs, the Ministry of Natural Resources, and the Ministry of Health and Long Term Care in wildlife disease surveillance with emphasis on the preparedness for diseases of significance for agriculture.

Recommendation 8

The Ministry of Agriculture, Food and Rural Affairs, the Ministry of Natural Resources, and the Ministry of Health and Long Term Care should enhance the province's ability to anticipate, prepare for, and prevent new or expanded animal and plant diseases and pests including:

- Building on the Plant Diseases Act to improve provincial capacity to respond to plant and animal diseases;
- Improving monitoring and surveillance capacity to detect, prevent, and respond to new pests, and plant, livestock and zoonotic diseases; and
- Seeking opportunities to collaborate with the federal government.

2.2.2 Energy

The Panel recognizes the provincial government's commitment to phase out coal-fired electricity generation as a very progressive piece of its climate mitigation strategy that is expected to provide nearly half of Ontario's reductions towards its 2014 GHG reduction target. The complementary implementation of a green energy strategy through the Green Energy and Green Economy Act, 2009 places greater emphasis on energy efficiency and conservation as well as on generation from renewable power sources including biofuels, wind, and other distributed sources. These initiatives will produce new and emerging adaptation opportunities in all regions of the province.

Adaptation of the province's electricity distribution and transmission infrastructure to climate change, notably more frequent and severe windstorms and precipitation events, especially ice storms, must be a priority. Periodically assessing the risks in the light of climate projections followed by a review of the design standards for new transmission and distribution systems will be required as trends become clearer, including shifts in the track of ice storms.

The climate resilience of the provincial grid, as well as the resilience of the communities it serves, will benefit from development of local generating capacity that shares and spreads the risk of climate impacts. Reducing the vulnerability of the provincial network in this manner would help protect people, communities and the economy from the adverse consequences of a system-wide failure.

The Panel was encouraged to learn that the government is investing in research, capital and demonstration projects necessary for the development of a smart grid – a system that uses software, two-way communications and automation to manage the flow of electricity more efficiently, from power generation, through transmission and distribution lines, and into homes and businesses.

Provisions for the implementation of a smart grid in the Green Energy and Green Economy Act, 2009 will contribute to conservation, the most important component of adaptive climate resilience and sustainability.

Assessing the risks and impacts of future climate change to the provincial power generation system would include assessing the overall system and its components in terms of the potential for damage, destruction and reduced reliability below threshold levels of service. Such an assessment would help identify and establish priorities, and facilitate planning to address those parts of the network that are most vulnerable and for which the consequences of failure would have the greatest economic, social and environmental impact.

Recommendation 9

The Ministry of Energy and Infrastructure should request the Independent Electricity System Operator, in accordance with its responsibility for maintaining the reliability of the electricity grid in the province, to complete a climate change risk assessment of the Province's electricity grid and to propose adaptive actions. This should be carried out in partnership with other energy agencies in Ontario such as the Ontario Power Authority, Hydro One and local distribution companies, and should be completed by the end of 2012.

2.2.3 Infrastructure

Increased flooding, prolonged dry periods, droughts and other severe weather events will pose additional challenges for Ontario's physical infrastructure beyond the need for an aging system to respond to the increased demands and levels of service required by a growing society. Infrastructure failures, such as the culvert and road washout on Finch Avenue in the City of Toronto in August 2005, as well as the extensive flooding in Peterborough in 2004 caused by severe rain, raise concerns that stormwater infrastructure in many areas of Ontario may not be able to cope with the challenges of climate change, at least not in its existing condition. In private residences, especially in older neighbourhoods, damage from sewer back-ups is resulting in major financial implications for homeowners and the insurance industry. According to the Insurance Bureau of Canada, the Canadian insurance industry is currently paying $1.5 billion in an average year in claims due to water damage.

According to Statistics Canada, with an average age of 16.3 years, much of Canada and Ontario's physical infrastructure – roads and bridges, along with stormwater, drinking water and wastewater facilities – was built before modern design considerations for stormwater and the impacts of climate change and changes in weather trends were evident. While natural variations in climate and historic extremes would have been considered during their design and construction, the coping range built in at that time may not be adequate to handle future climate conditions, leaving some of the existing infrastructure vulnerable and with limited capacity to adapt.

Most infrastructure systems are interdependent, meaning that a failure in one system will often have an impact on other systems, expanding the adverse impacts. For example, the Finch Avenue washout resulted in the interruption of cable communications and natural gas supply as well as road traffic. A loss of electricity will result in implications for drinking water and wastewater treatment facilities.

The need to introduce climate change risk assessment into infrastructure planning and investment comes at a time when governments at all levels are facing significant challenges in meeting their existing infrastructure needs. On the other hand, recent federal investment decisions, such as the Infrastructure Stimulus Fund related to dealing with the major worldwide recession, have the potential to turn adversity into an opportunity to upgrade climate-sensitive infrastructure. Similarly, there is a need for climate change impacts such as increasing water and wind damage to be integrated into the design standards of new and retrofit home construction in Ontario.

Ontario's public infrastructure should be properly documented and information assembled on its location, age and current condition to enable proper planning of adaptive measures. To address this issue, the government has adopted asset management plans for provincially-owned infrastructure and has started to incorporate climate adaptation considerations into the capital planning process.

This information is essential for conducting risk assessments of infrastructure vulnerability to climate impacts. However, many municipalities either lack this information or have significant gaps. This lack of knowledge and documentation is itself a vulnerability to climate change. Along with the documentation of infrastructure, risk assessment should begin with a detailed assessment of the risks related to the ability of urban drainage run-off systems to accommodate major rainfall events.

Best adaptive practices have been recently illustrated through work undertaken by the Public Infrastructure Engineering Vulnerability Committee (PIEVC), a partnership between Engineers Canada and Natural Resources Canada. The PIEVC Protocol is a step by step process derived from standard risk management techniques to assess the impacts of climate change on infrastructure (building, roads and associated standards, water resources, as well as stormwater and wastewater systems).

We also note that the Canadian Water Network and the Central Mortgage and Housing Corporation sponsored a project in 2006 aimed at highlighting successful innovative approaches to stormwater management across Canada, including presentation of cases to practitioners and developers. The project focused on a multi-barrier approach to reducing flooding from heavy but not the most severe rainfall events. It responds to the increasing variability of climate that all communities and regions are beginning to experience, rather than an increase in the most severe, scattered and sporadic rainfall events.

Run-off is often regarded as waste and rapid removal in a channelized and subsurface drainage system has been the traditional approach to urban stormwater management. In the 1980s, the Province introduced an integrated approach to allow intercepting and detaining rainfall with as much infiltration and evaporation as possible rather than trying to quickly capture and convey surface run-off into pipes and streams. This approach considers surface run-off as a resource for potential re-use, and lends itself to a variety of scales from swales and pervious surfaces at lot level to an entire watershed where temporary water retention becomes a central element in integrated watershed management.

Recommendation 10

The Ministry of Energy and Infrastructure should support the development of case studies for representative asset types and geographical locations to better understand the climate change risks to physical infrastructure. Where case studies or previous assessments indicate significant risk of failure for specific types of infrastructure, then:

- More detailed site specific risk assessments should be undertaken, and potential remedial adaptation actions identified and implemented; and
- Proponents of infrastructure projects for which provincial investment is sought should be required, after January 1, 2013, as a matter of due diligence, to provide a climate change and infrastructure risk assessment. In the meantime, proponents should provide a site specific vulnerability assessment of known climate risks such as flooding.

At the same time as supporting case studies to demonstrate risk assessment, it is important to set expectations and standards by promoting the value of proven and innovative green technologies with adaptive benefits. Public buildings reflect values and priorities in a very clear way. The LEED (Leadership in Energy and Environmental Design) building rating system, administered by the Canada Green Building Council, is a well respected approach to certifying environmental building standards. While the main purpose of

the system has been to reduce GHG emissions, building design and materials chosen in light of future climate risks such as heat waves, are also adaptive. Some cities and jurisdictions have adopted LEED Silver or Gold as minimum standards for construction of publicly owned buildings.

"*The Toronto Green Standard*" approved by Toronto City Council in December 2008, for implementation in September 2009, consists of an integrated set of performance measures, principles, and practices to guide the development of city-owned facilities and to encourage sustainable development in the private sector. Many of the elements of the Standard are adaptations to climate change, often with co-benefits for reducing GHGs as well. The City of Toronto's recently approved Green Roof Bylaw, which requires a green roof on new developments over 2,000 square metres, is a specific example of leadership in urban building adaptation.

In meeting with the Ministry of Energy and Infrastructure, the Panel encouraged revisions to the annual infrastructure planning guidelines to enhance considerations of climate change in infrastructure investments. A component of the annual Results-based Planning process is a multi-year Infrastructure Plan with associated funding requests prepared by each ministry. This now includes a requirement for ministries to consider the impacts of climate change on their infrastructure and identify renewal/rehabilitation activities that address climate change adaptation and mitigation. It is important that this direction be continued.

Recommendation 11

The Ministry of Energy and Infrastructure should consult with the Canada Green Building Council and other relevant and experienced parties and establish a minimum climate-resilient, sustainable environmental standard for public buildings in Ontario in order to proactively demonstrate and support climate adaptive building design, materials, technology, and construction.

Recommendation 12

While participating in national reviews of infrastructure codes, the Province should actively encourage federal, provincial and territorial partners to take account of climate change impacts and in so doing the Ministry of Municipal Affairs and Housing should:

- Work with the Canadian Commission on Building and Fire Codes and the Provincial/Territorial Policy Advisory Committee of Codes to persuade Environment Canada and Natural Resources Canada to update the climatic tables used in the Building Code to design structural and building envelope elements so that they reflect advances in climate change projections. Every effort should be made to have this completed in advance of the 2010 release of the next editions of the model national codes; and
- In the interim, the Ministry of Municipal Affairs and Housing should identify opportunities within Ontario's existing Building Code to increase the resilience to climate change of structural and building envelope elements of new buildings and those undergoing renovation, including energy conservation provisions.

The Institute for Catastrophic Loss Reduction (ICLR) maintains that the increasing frequency and severity of extreme weather events due to climate change need not result in continuing increases in damage if current construction and retrofit practices integrate risk reducing adaptation considerations. Researchers at ICLR anticipate that billions of dollars of severe weather damage to homes and other buildings in Ontario could be prevented by applying emerging knowledge and risk management to residential developments, the construction of new homes and retrofits of existing homes.

The installation of backflow valves on domestic sewer lines in the basements of homes is often cited as a straightforward example of retrofitting

that would save homeowners and insurers many millions of dollars. Connections between storm and sewer drainage systems often lie at the root of basement back-ups, and the urgency of separating the two systems is underscored by the likelihood of increasingly frequent intense rain events.

Recommendation 13

The Province, working with Ontario homebuilders, designers and adaptation experts such as the Institute for Catastrophic Loss Reduction, should assess the feasibility and benefits of introducing guidelines and/or standards to address climate risks for existing residential, institutional and commercial buildings. Further, the Province should support the development of tools to help homeowners and building professionals identify retrofit measures that will increase the resiliency of existing buildings to climate change, especially extreme weather events.

Recommendation 14

Building on the current review of stormwater management, the Ministry of the Environment should complete a comprehensive review of stormwater management throughout the province by the end of 2011 to ensure that provision has or is being made to take climate change risks into account, and in that review the ministry should also:

- Assess the effectiveness of the approval process for stormwater facilities and examine the benefits of requiring municipal stormwater management master plans; and
- Update the Stormwater Management Design Manual to encourage adoption of innovative, multi-barrier stormwater management practices by municipalities.

2.2.3.1 Water Related Hazards

Under the Emergency Management and Civil Protection Act, 2006 and Ontario Regulation 380/04 (*Ministry Standards*), the Ministry of Natural Resources has the mandate to manage water related hazards such as floods, drought and low water, dam failures, erosion and bedrock instability through the development of an emergency management program.

The Ministry of Natural Resources and the Ministry of Municipal Affairs and Housing are co-chairing a multi-ministry urban flooding working group with the objective of creating a provincial adaptive strategy for addressing this hazard and filling identified management gaps for the future.

Recommendation 15

The Ministry of Natural Resources in collaboration with Conservation Authorities should:

- Review existing flood plain mapping and coordinate completion where gaps exist, and thereafter conduct a review every five years in the course of which local floodplain hazard maps should be updated to take account of climate change projections to a planning time horizon of 2050 for the purpose of informing Official Plans, municipal land use planning and development, emergency management planning, source water risk assessments, and transportation planning; and
- Update local and develop regional Intensity, Duration and Frequency Curves to ensure the best available data and projections are accessible to provincial and municipal planners and decision-makers for purposes such as land use planning, infrastructure design, and emergency management.

2.2.4 Health

According to research undertaken by Toronto Public Health, an average of 120 acute deaths every year between 1954 and 2000 were heat related. Environment Canada projections foresee a near doubling of hot days above 30°C in the City of Toronto by 2050 (Figure 10). Toronto Public Health projects a doubling of heat related mortality to about 240 persons per year in the 2050s as a consequence.

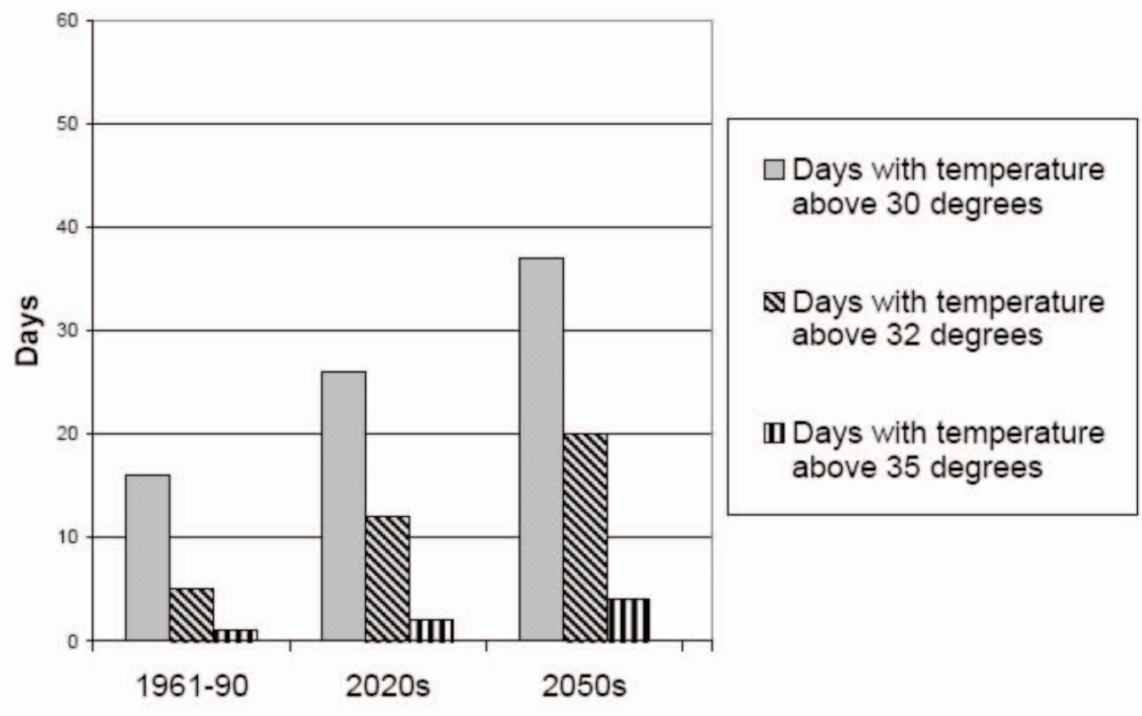
Heat waves were responsible for almost 600 deaths in Chicago during five days in July 1995 and about 37,000 deaths in Europe in August 2003. Young children and the elderly were especially vulnerable. Those casualty numbers far exceeded the total of all other weather events combined in those years in both the United States and Europe.

These numbers identify heat waves as the major potential impact of climate change on health in at least southern Ontario as extreme heat events become more intense, frequent and longer. The spectre of much higher numbers during a prolonged extreme heat wave deserves the greatest possible attention.

We are pleased to note that the proposed Ontario Regional Adaptation Collaborative (see Recommendation 59) includes a project in which Toronto Public Health will refine its prototype approach to spatially visualizing and mapping risk information related to vulnerability to heat waves. The purpose is to provide a suite of tools and information that municipalities can build on to evaluate vulnerability to heat in their own communities.

Extreme heat also contributes to the creation of smog that worsens other health conditions related to air quality, such as asthma. Smog is a complex chemical haze of microscopic particles and gases, especially ozone, produced by the action of sunlight and warmth on tailpipe and industrial fumes, as well as evaporated gasoline and solvents. The most damaging of the chemical reactions in smog is the creation of ground level ozone. Its concentration is one of the main triggers for declaring a "Smog Advisory" or smog alert.

Figure 8: Increase of Hot Days in Toronto



Source: Environment Canada, 2002

The Ontario Medical Association has estimated that in 2005, the annual illness related to air pollution resulted in 5,800 premature deaths, more than 16,000 hospital admissions, almost 60,000 emergency room visits and 29 million minor illness days. In 2008, 9,500 premature deaths in Ontario were related to air pollution, with more than 1,000 occurring during or immediately after periods of increased pollution. Heat wave temperatures add to respiratory stress and exacerbate the impacts of pollution.

There were 43 smog alert days in the City of Toronto in the seven years from 1994-2000. That number climbed to 152 days in the subsequent seven year period from 2001 to 2007. While an increase in vehicles entering and leaving Toronto every day is a relevant factor, as well as smog drifting from the U.S. Midwest, warmer summer weather as the driver of smog creating chemical reactions is also important.

In many larger communities, especially in southern Ontario, the shade of urban trees plays a useful role in helping to cool the urban environment as well as generating other co-benefits such as improving local air quality, reducing stormwater runoff, and enhancing biodiversity. Policies and programs directed at advancing the health and extent of an urban treescape have multiple roles in urban adaptation.

Northward expansion of diseases carried by blood-feeding mosquitoes and ticks is already evident and well known to the public. Lyme disease, carried by the black legged tick, has already spread from southern to northern Ontario. International travel may have been responsible for the introduction of West Nile virus, carried by mosquitoes, into North America. Since 1999 it has spread into Canada from New York City. Increased mosquito activity, the complex life cycle of the virus through birds to humans, and the geographic spread of the virus are all favoured by longer, warmer and wetter summers.

A Canadian outbreak of malaria in 1995–97 may have been brought to Canada by travelers arriving from the Punjab in India, where an epidemic had occurred. Research now suggests there is a risk of malaria being locally transmitted by mosquitoes in southern Ontario.

The appearance of exotic pathogens causing the emergence of new climate induced disease risks as well as the continuing spread of already familiar insect or rodent borne diseases into new areas must be expected. Changing risks are requiring family physicians and health care providers to be prepared for diagnoses that go beyond the conventional scope of today.

An increase in extreme weather events such as floods, violent windstorms, and ice storms during which people may be evacuated and lose basic services, will not only bring increased pressure on emergency health services but also result in stress related mental health issues.

Important aspects of health risks and health system requirements are shifting as climate is changing. Medical school students should be introduced to the health implications of climate change. The same educational material should be available as professional development opportunities for physicians, primary care professionals, and public health professionals. Climate change will only increase in importance as a factor in individual and public health in Ontario from the urban south to Hudson Bay.

Recommendation 16

The Province should assess and, where necessary, expand the capacity of the Ministry of Health and Long Term Care to respond to health related risks resulting from climate change impacts.

Some adaptive measures will build on existing policies and procedures to make them more effective, while others may require new measures to protect more vulnerable members of the population, such as children and the elderly. The incorporation of adaptation measures and proactive protocols into public health promotion and protection systems will ultimately be more effective and less costly than reacting to emergencies.

Existing local adaptation measures, such as warning of the dangers of extreme heat, opening "cooling centres" as well as the smog reduction plans in many municipalities, will complement provincial and/or urban heat and air quality advisories. These measures should be expanded to all vulnerable communities.

Health Canada has stated that periodic assessments of vulnerabilities to climate change are necessary to inform and support adaptation. For example, if the frequency of extreme weather events in Ontario increases as expected, public health officials will need to continuously assess the impact of these changes on the systems they manage, and develop adaptive measures to strengthen those systems. Where knowledge of groups and areas vulnerable to climate-related stresses is weak or missing, more detailed regional studies of needs and potential adaptive measures will be required.

Health Canada's report, *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*, demonstrates the significance of climate-related health risks in Ontario and emphasizes that these risks are expected to become even greater with climate change. It is an important analysis that should inform strategy and action plans.

Recommendation 17

The Ministry of Health and Long Term Care in collaboration with the Ontario Agency for Health Protection and Promotion should co-ordinate a review of Health Canada's report, *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity* and other studies and by the end of 2010:

- Complete an assessment of the need for detailed regional scale studies of adaptive measures for protection of health in Ontario in the light of climate change risks; and
- Consult with health partners, the academic community and key agencies to identify priority areas for action.

Recommendation 18

The Ministry of Health and Long Term Care should assess the tools and resources of Public Heath Units with respect to their capacity to respond to health risks related to climate change and, where necessary, expand that capacity by:

- Working with the public health agencies to define public health 'best practices' for addressing climate change health risks and ensuring those best practices are widely shared;
- Enhancing support for the development of tools that will enable Public Heath Units to respond as effectively as possible to the impacts of climate change and play a major role in climate change adaptation in their communities;
- Specifically addressing the health risks arising from summer heat waves, including provision of Geographic Information System tools required for mapping and assessing vulnerability to heat stress and air quality issues, as well as support for heat wave risk reduction programs; and
- Continue to distribute relevant climate change research to Public Health Units.

There will be benefit in ongoing dialogue on climate change health impacts and adaptation among health partners, including the Association of Local Public Health Authorities, Council of Ontario Medical Officers of Health, Association of Supervisors of Public Health Inspectors of Ontario, Ontario College of Family Physicians, Ontario Medical Association, the Canadian Institute of Public Health Inspectors (Ontario Branch), Ontario Public Health Association, the academic community, and other agencies.

The Ontario Public Health Standards, released in January 2009, established new minimum requirements for public health programs and services across Ontario. As a result, all Boards of Health are required to increase public awareness of health risk factors associated with climate change and

extreme weather. Public Health Units are on the front line in their communities, and along with family physicians are uniquely well placed to reduce risks through risk assessment, preparation and public communication.

Theme 2: Natural Systems – Increase the climate change resilience of ground and surface water, especially the Great Lakes; the diversity of Ontario's biological heritage, including species at risk, forests; and the carbon rich wetlands of the Hudson Bay Lowlands.

Climate has most effect on the natural systems of the landscape. No engineering can shield a forest or cover a watershed. Adapting to change in our terms has largely to do with how we manage our use of natural resources as they react to changing conditions – to temperature and rainfall, fire and insect pests, drought and flooding. Designing and redesigning with nature with as good an eye to the future as uncertain projections will allow, is the only sustainable approach. Adaptive management in the light of ongoing risk assessments means, first and foremost, understanding ecological and hydrological systems as best we can.

Ontario is enormously fortunate to be anchored in the south by nearly 20% of the world's fresh surface water in the Great Lakes; by one of the world's most important areas of Boreal Forest of the north; and in the Hudson Bay Lowlands of the Far North is the world's third largest wetland of tundra peat, storing as much carbon as we emit over the entire planet in four years.

At the same time as we benefit economically, we are also stewards of a rich part of the planet's natural heritage. Adapting to climate change involves recognizing the responsibilities of our stewardship as well as the value of our resources. That is nowhere more important than in the Far North where continuing to accumulate and store carbon in vegetation and peat will affect the atmosphere of the entire planet. Losing that carbon to the atmosphere as GHGs is a risk of global proportions.

2.2.5 Great Lakes

The Great Lakes Basin, including all the streams and rivers that flow into the lakes, is the world's largest connected system of fresh surface water. Only the frozen polar ice caps hold more. The Basin hosts more than 250 fish species and 3,500 plant species. More than 98% of the province's population, including 60 First Nation communities, live in the cities, towns and villages of the Great Lakes Basin, and the watershed of the St. Lawrence River that drains the lakes to the Atlantic Ocean. The Great Lakes Basin is also the fourth largest economic region in the world and is a key driver of the national economy. Ontario is geographically and economically anchored by the Great Lakes, and their future sustainability is essential to the province, if not the entire country.

Climate projections show average temperatures over the Basin rising between 2°C and 4°C by 2050, continuing a trend already discernible in weather records. Precipitation may increase by up to 20% by 2050 in all but the summer months, when no change is projected. Rising air and water temperatures are already shortening the ice cover season, exposing water to evaporation for more of the year.

Research in Lake Superior has shown that water temperatures may increase by as much as twice (4°C-8°C) the air temperature. Warmer water, combined with stronger winds and a longer ice-free period, is very likely to increase the volume of water evaporating from the surface of the lakes. Increased evaporation from the land surrounding the lakes, especially in summer, is likely to reduce the flow in rivers after the spring run-off. In the long-term, the most obvious combined result is likely to be a fall in the average lake levels of the four lower lakes currently projected to be between 15 and 115 cm over the next 40 years (Mortsch et al, 2006). These projected drops in lake levels are in addition to the historical fluctuations that have been documented over the past century, potentially exacerbating the impacts associated with lower lake levels, especially in connecting channels.

Warmer waters are likely to make the Great Lakes more hospitable for invasive species, nuisance algae, pathogens and waterborne diseases. Invasive species have already severely disturbed the aquatic ecosystem of all the Great Lakes, and would be expected to continue as a major issue even without the impacts of climate change. For example, spreading populations of zebra and quagga mussels are exacerbating nutrient problems in shallow water, partially nurtured by favourable water conditions associated with climate change. The mussels filter phosphorus-rich particles from the water and concentrate it in their near-shore colonies. When they die, they release phosphorus that causes nuisance algae problems, especially in Lakes Huron, Erie and Ontario.

The recent announcement of the opening of the Invasive Species Centre in the Great Lakes Forest Centre in Sault Ste. Marie is an important initiative that the Panel hopes will be complemented by effective federal and provincial Invasive Species Action Plans that take climate change into account.

Falling lake levels and rising water temperature will affect all of the interconnected coastal components of the Great Lakes ecosystem, including wetlands, shorelines, and near-shore and offshore zones. Impacts on wetlands, shorelines and near-shore zones include degraded recreational boating and community use of water for drinking, as well as wastewater and stormwater disposal.

Contaminants discharged from sewage treatment plants or washed from fertilized and disturbed areas into increasingly shallow and warm near-shore areas are likely to lower water quality and trigger increasing algal growth, contributing to more frequent closings of public beaches. More frequent intense rainstorms can be anticipated to result in more pollution reaching the lakes through overtaxing the capacity of municipal stormwater systems, as well as through erosion. The integrity of coastal wetlands will be negatively impacted through dramatic alterations to their natural actions in filtering and storing water, and providing habitat for fish, amphibians and terrestrial species, especially water birds.

The province's $7 billion per year shipping industry will feel the economic effects of lower water levels. Although the shipping season could be extended with climate change, cargo ships will have to lighten their loads in order to navigate shallower channels, especially between lakes. This in turn may increase the pressure for dredging channels that is accompanied by a suite of environmental issues, especially those related to the impacts of sediment disturbance on water quality and habitat.

Ontario depends on the Great Lakes for more than 80% of its electricity through hydro generation, the use of water for cooling in nuclear plants and as water for steam turbines. In theory, lower volumes of water passing through turbines will lower the power produced, while higher water temperatures could cause cutbacks in power production in order to maintain an acceptable temperature for the water discharged back to the lake.

How climate change might affect the efficiency of existing coal and nuclear electricity generation plants constitutes a significant knowledge gap. However, there is stronger certainty regarding hydroelectric facilities, where lower lake water levels have been reported to potentially decrease output by up to 1,160 megawatts. At the same time, rising water temperatures will affect fish and other temperature sensitive species, altering ecosystems and their food chains. Warmer water will, for example, cause cold water fish to be replaced by warmer water species. This will impact not only the natural ecosystems within the Great Lakes, but also the recreational and commercial fisheries that have established themselves based on cold and cool water species.

Recommendation 19

The Province should develop a broad, comprehensive strategy to enhance the resilience of the Great Lakes to the impacts of climate change that includes:

- Undertaking a climate change vulnerability analysis of near-shore water quality and the status of ecosystems in areas directly influenced by high volumes of stormwater or discharges from industrial and municipal wastewater treatment plants, and combined sewer outflows, and assess risks arising out of climate change impacts in vulnerable areas;
- Giving high priority to investment in wastewater treatment infrastructure projects (especially those using innovative green technology) addressing identified water quality risks;
- Establishing targets for water quality, quantity and aquatic ecosystem health throughout the Ontario part of the Great Lakes Basin that take account of climate change projections and that will contribute to the resilience of the Great Lakes to the impacts of climate change; and
- Undertaking an analysis to assess the risks arising out of climate change projections to wetlands, navigation, power generation, shorelines subject to flooding, erosion and slope instability and to sustaining Great Lakes water levels and interconnecting channel flows.

Recommendation 20

The Ministry of Natural Resources should work with the Great Lakes Fisheries Commission to undertake a climate change vulnerability analysis of Great Lakes fisheries. Further they should ensure that policies and procedures underlying Great Lakes fisheries management are based on fisheries assessment processes, techniques, decision support tools and models that take into account the potential impacts of climate change on individual species as well as habitat and the overall food web.

The management of the Great Lakes, which are considered international bodies of water, is subject to both national and provincial jurisdiction and in many cases is shared with U.S. counterparts. A number of existing multilateral agreements provide both an opportunity and a measuring stick for developing and implementing climate change adaptation measures.

Recommendations regarding these inter-provincial, national and international agreements are included under Section 2.5 (Recommendation 55).

2.2.6 Biodiversity

The communities of organisms that make up the natural ecosystems of the landscape in Ontario are especially vulnerable to the speed at which climate change is taking place. The average annual air temperature has increased by as much as 1.3^0C in the west of the province in the last 50 years, and somewhat less in the east. With a 1^0C change being roughly equivalent to a northward shift of 200-300 kilometres in the climate of eastern North America, it is not surprising that the temperature change over the last few decades has had a noticeable effect on the distribution and health of plants and animals.

Eastern bluebirds are arriving almost two weeks earlier at their summer breeding grounds, and the body condition of polar bears on the shores of southern Hudson Bay has declined in the last 20 years as the sea ice on which they depend to hunt seals in the winter has formed later and melted about two weeks earlier. Mountain pine beetles have crossed the high ranges of the northern Rockies where winter night time temperatures until very recently were too cold for them to survive. Having devastated the lodgepole pine forests of British Columbia they are now in Alberta, killing jackpine and moving east.

Aquatic ecosystems are being impacted as well. A survey of the shallow rivers and creeks of the Upper Grand River Watershed in 1996 found warm water species like small mouth bass had increased compared to 1983, while cool water mottled sculpin had disappeared. Even a dozen years ago the signals were very clear: climate change will cause major shifts in the composition of ecosystems in the province.

The mobile members of ecosystems are moving and changing the diversity and balance in the ecosystems where they are newly arrived. On the other hand, trees and shrubs are not able to migrate further than the very few hundreds of metres over which their seeds are scattered over every year. If climate change happens too rapidly individuals become over-stressed by changing seasonal patterns of temperature and rainfall, and soon fall victim to disease or insect pests. These deaths can lead to the local extirpation of the species. Endangered and threatened species, already under stress for reasons that may have nothing to do with climate, are especially vulnerable.

Nothing can be done to prevent ecosystems from being exposed to climate change. However, some proactive adaptation strategies, as well as adaptive management measures to increase the resilience of ecosystems and threatened species will be possible.

Ontario's Biodiversity Strategy (2005) is a good starting point but, like others of its time, it did not fully embody an approach based on ecosystems being rapidly overtaken by more southern climate envelopes. A "Biodiversity Strategy for 2050" should envisage a very dynamic environment in which the province's system of parks, reserves and other types of protected areas, as well as areas under the *Niagara Escarpment Planning and Development Act*, the *Oak Ridges Moraine Conservation Act* (2001), and the *Greenbelt Act* (2005), become nodes in a system of migration paths or "Greenways" of interconnected habitat.

Recommendation 21

The Ministry of Natural Resources should strengthen its capacity to develop and plan, in collaboration with other ministries, both short- and long-term adaptation actions designed to increase the climate resilience of ecosystems and species at risk.

Recommendation 22

The Ministry of Natural Resources should establish a scientific and technical working group of government and non-government members, including the research community, Conservation Ontario, agricultural communities, and NGOs to:

- Recommend modelling, adaptation strategies and tools, adaptive management techniques, and information needs for short- and long-term adaptation options covering terrestrial and aquatic species and ecosystems in the province; and
- Provide advice concerning the likely ecosystem impacts of climate change for consideration in the 2010 review of Ontario's Biodiversity Strategy that should consider 2050 as the time horizon for policy development and planning purposes.

Recommendation 23

Policies and strategic plans should recognize that natural adaptation of species and ecosystems to climate change can be promoted by fostering healthy, resilient, unstressed populations and environments free from pollution and invasive alien species.

Recommendation 24

Organizations focused on conservation of genetic diversity in the fauna and flora of Ontario, including building seed banks to optimize conservation of germplasms, should be engaged in collaboration with the Ministry of Natural Resources in designing and implementing adaptation options and adaptive management plans for species and ecosystems.

Recommendation 25

The Ontario Invasive Species Action Plan to be completed in 2010 and co-ordinated with the federal plan, should include a framework for adaptive management and control of alien invasive species that takes account of climate change and is supported by research and by the delivery of invasive species management programs.

2.2.7 Forests

Canada is host to more than 400 million hectares of forest accounting for almost half its total landmass and almost 10% of the world's total forest cover. The Boreal Forest of spruce, pine, fir, birch, aspen and poplar, circling the Arctic Ocean, is the most northerly forest and is especially extensive in Canada and Russia. In Ontario, the Boreal Forest stretches north from Lake Superior until it blends into the tundra peat and eventually permafrost of the Hudson Bay Lowlands. To the south of the broad band of boreal species is the mixed coniferous and deciduous maple, oak and white pine forest of central Ontario and the St. Lawrence Valley. Further south, fragmented remnants of the Deciduous or Carolinean Forest occur among the farms on the north shores of Lake Ontario and Lake Erie.

People in 260 Ontario communities owe their livelihood either directly or indirectly to forests through tourism, fishing, hunting, and wood products. About 67,000 jobs and $18.3 billion annually are derived from wood products.

A recent review by Natural Resources Canada and the Sustainable Forest Management Network's report, *Climate Change and Canada's Forests: From Impacts to Adaptation*, summarizes the potential landscape scale changes in forests across the country, including Ontario. It provides a useful framework for strategic planning and action at the national as well as the provincial level. One of the authors, a senior member of the Ministry of Natural Resources, participated in a presentation to the Panel. We anticipate the conclusions of the review being readily integrated into the biology basis of Ontario's forest planning.

It seems only a question of time before the mountain pine beetle appears in jack pine stands in Ontario now that it has crossed the high ridges of the Rocky Mountains that were once too cold for it to survive the winter. Jack pine is a close enough relative of the lodge pole pine for the devastation of the pine forests in British Columbia to be a daunting spectre for Ontario. But infestation by immigrant insects is not the only imminent, climate induced risk facing the Boreal Forest.

"Climate envelopes" or climatically suitable habitats are moving northwards at several tens of kilometres a decade whereas boreal tree species can migrate only very few kilometres in the same time. An increase in the frequency of storms is expected to result in a greater risk of fires started by lightning. This trend is already apparent in Ontario along with lengthening of the fire season in both the spring and fall. Potentially longer periods of drought, causing areas of forest to become drier and more vulnerable to burning, will compound the risk, including the potential for property loss in forest-based communities. Severe storms are also likely to increase the area of blowdown.

Research has shown that the growth rate of some species will increase where other conditions, such as soil moisture and absence of fire, permit. However, studies have shown that higher temperatures decrease the growth rate of commercially important black spruce and white spruce. Climate impacts in forests will rarely be limited to a single influence. Combinations of change may result, for example, in black spruce and balsam fir being

replaced by more drought tolerant jack pine and aspen in increasingly dry areas, but the spread of mountain pine beetle may, in turn, threaten jack pine in those same locations.

Increasing carbon dioxide in the atmosphere, encouraging faster growth at the same time as rising average air temperatures, increasingly frequent and intense disturbance by fire, and wind and insect pests impose a combination of future uncertainties in the Boreal Forest that are currently very difficult to analyze. Furthermore, economic issues are understandably dominating discussion among those concerned with the viability of the forest industry. Under those circumstances climate change seems a very distant issue. However, the forests on the landscape of Ontario at the end of this century will not be the same as those of today and climate change, not the economy, will have been the cause.

2.2.7.1 The Great Lakes – St. Lawrence Forest

The Great Lakes – St. Lawrence Forest to the south of the Boreal Forest is composed of mixed deciduous and coniferous tree species including maple, basswood, oak and white pine. It is expected that these species will gradually migrate northward as the southern fringe of the Boreal Forest retreats. But just as elsewhere, the climate envelopes will move faster than trees can migrate. It will not be a simple transition as different species move at different rates and the stress of drought, insect infestations and fire varies from region to region. There is, however, clear evidence of the likelihood of such a profound shift in forest type in the pollen records preserved in peat that show Great Lakes – St. Lawrence Forest in the Timmins area during a warm period from 9,000 to 5,000 years ago.

Sugar maple in particular is likely to be the species with the greatest potential to spread north based on pollen and tree ring data. However, in areas suffering from drought dieback red maple, white pine and red oak are likely to dominate in the new forest.

2.2.7.2 The Deciduous or Carolinian Forest

The fragmented Deciduous Forest of southern Ontario, immediately north of Lakes Erie and Ontario, also known as the Carolinean Forest, is the northernmost tip of a forest type that runs down the east of the United States through the Carolinas to Georgia. Sugar maple and beech are accompanied by black walnut, tulip tree, American chestnut, hickories, oaks, and many species of very restricted range in Ontario. It is habitat for over 125 species considered vulnerable, of special concern, threatened or endangered by either the federal or provincial government. Over 400 other species in "Carolinian Canada" are considered rare.

Species from further south in the United States deliberately brought across the border or with seeds that are able to cross the Niagara and St. Clair Rivers will spread north. Species of oaks, hickories and outliers of Deciduous Forest species in the Great Lakes – St. Lawrence Forest will also slowly spread north.

The complexity and uncertainty of projecting the impacts of climate change are probably greater for forests in Ontario than for any other sector of the economy or ecosystem. Despite uncertainty, and perhaps because of it, government leadership is needed not just in the short-term but also for the long-term. Our recommendations are made with that in mind.

Recommendation 26

The Ministry of Northern Development, Mines and Forestry and the Ministry of Natural Resources in collaboration with the forest industry, the research community, and leaders of forest-based communities, should review current forest policies, management structures and regulations. The aim of this review should be to ensure they either take climate change projections into account or are sufficiently flexible to allow the integration of climate change adaptation considerations into forest management as knowledge increases and climate change trends, projections and impacts in Ontario become clearer.

Recommendation 27

The Ministry of Northern Development, Mines and Forestry and the Ministry of Natural Resources, should seek consensus in Ontario among the forest industry, governments, the research community, and leaders of forest-based communities on a suitable methodology for assessing the climate change vulnerability of the Great Lakes - St. Lawrence, Carolinian, and Boreal Forest and their associated forest-based communities, and then undertake a comprehensive regional vulnerability assessment to be completed by the end of 2011.

Recommendation 28

The Ministry of Northern Development, Mines and Forestry and the Ministry of Natural Resources should initiate the development and ongoing validation of models aimed at elucidating cumulative impacts of multiple climate change stressors on Great Lakes – St. Lawrence, Deciduous (Carolinean), and Boreal forest ecosystems and the implications for forest management practices.

2.2.8 Wetland Peats of the Far North

Like forests, the vast expanse of wetland peat on the Hudson Bay Lowlands in the Far North of Ontario is part of an immense pole-encircling carbon store, as well as a rich habitat with great natural heritage value. It is said to store about 33 billion tonnes of carbon in Ontario alone-nearly 4 years of current global carbon emissions from fossil fuels (see Figure 1).

Disturbance of the peat through climate induced changes in the water-table will release either methane or carbon dioxide, both GHGs, depending on the local circumstances. Attempting to protect the resilience of the peat can be seen as mitigation because it would limit the release of GHGs, or it can be seen as adaptation because it is aimed at proactively enabling a natural system to continue to function within the limits of a changing climate. We note that the background documents to the Far North Planning Initiative have noted the significance of these peatlands as a carbon store and we endorse that recognition of their role and importance.

NEW CLIMATE RELATED ADAPTIVE FOREST MANAGEMENT OPPORTUNITIES

Forests on the planet are an enormous store of carbon that would otherwise be in the atmosphere as climate warming carbon dioxide. The Boreal Forest is an especially important store despite having grown only since the ice of the last ice sheet melted back around 9,000 years ago because the biological decay rate is very slow in the cold circum-Arctic climate.

Managing the Boreal Forest to protect and enhance carbon storage is a new challenge and potential economic opportunity. It goes to the need for carbon budgeting and illustrates a field in which the values of the forest for wildlife habitat and biodiversity as well as a resource of timber and a carbon store, all come together and require integrated policies.

The possibility of using forest resources for producing bio-fuels is also receiving attention. Producing biochar by heating wood waste to 500-750^{0}C in an oxygen free kiln (pyrolysis) produces a highly stable form of carbon as well as biofuels as gas or oil. The solid, carbon rich biochar is highly stable and effective as a soil amendment. It might emerge as an adaptive energy generation opportunity that could increase the resilience of some Near North and Far North communities, at the same time as sequestering carbon and potentially increasing the fertility of local agricultural soils. Biochar production is also a field in which potential adaptation and mitigation measures co-exist.

2.2.9 Water

Climate change is already affecting the quality and availability of water in Ontario in many different ways. Adaptation strategies have become necessary to react to droughts, floods, falling lake levels, drinking water quality concerns, more winter rain and earlier spring run-off. The impacts from future climate change are likely to exacerbate pressures for increased use of water in growing communities, industries and agriculture. A great deal more anticipatory adaptation will be required across a broad spectrum, from land use planning to proper maintenance of on-site septic systems on lake shores, if the water quality and quantity enjoyed in most of Ontario today is to be available in the future.

Water levels in many lakes, including the Great Lakes, are projected to decline because of increased evaporation from open water swept by stronger winds during a longer ice-free season. Greater evaporation from soil and land surfaces is likely to add to the problem as well as cause soil moisture issues for agriculture, wetlands, forests and other landscape ecosystems. Urban watersheds face difficulties because of greater surface run-off and less infiltration caused by hard surfaces such as parking lots and roads. Water that is drained away immediately is not available as groundwater that slowly seeps into lakes during dry periods. Shorelines of lakes with falling water levels will retreat, damaging ecosystems and shoreline installations like marinas. The inflowing and outflowing streams of some small lakes may dry up for as long as several weeks in the summer.

Seasonal concentrations of dissolved and particulate contaminants discharged from industrial sources and municipal water treatment systems, including nutrients like phosphorus, may become a problem in lakes and rivers if discharges are not controlled and adjusted to lower flow and lower volumes of receiving water. Higher concentrations of phosphorus from human sources, such as private septic systems, lead to the growth of nuisance algae and cyanobacteria (bluegreen algae) in warmer, shallow lakes, which can cause potential health effects in humans and animals.

Changes in the seasonal patterns of snowfall and rain, especially less frequent summer showers and longer continuously dry periods, coupled with increased evaporation, may reduce the infiltration of surface water into groundwater aquifers in the summer. On the other hand, increased infiltration may occur in winter because of a shorter period of frozen ground. In combination with climate change this may lower water tables, causing low water levels toward the end of the summer. These effects point to the importance of considering hydrology and the impacts of climate change in land use planning from a community scale to individual lots. Uncertainty and variability from year to year will often be a challenge for water related adaptation.

Lakes affected by earlier spring warming and later cooling in the fall will stratify into a warm upper layer and lower cool water sooner in the year, increasing the risk of very low oxygen concentrations developing in the cool, lower water. This will affect fish and can lead to “dead zones” in the bottom of some lakes in the late summer. Water drawn from deeper lake drinking water intake pipes affected by low oxygen concentrations is likely to deteriorate in quality because of a change in the chemical processes at the surface of the lake sediment.

Future precipitation is more difficult to project than temperature. Although the annual total precipitation may not change much over most of Ontario during the next few decades, more precipitation is likely to fall as occasional storms. More frequent spring, summer and fall rainstorms will increase the risk of flooding as well as erosion of riverbanks and turbidity in drinking water sources. Increased lake effect precipitation is likely to occur in the lee of the Great Lakes because of more ice-free, open water in winter. Along with an earlier spring, this may in turn lead to a greater volume of spring run-off.

Water, as would be expected, is the subject of policies, regulations, programs, plans and management activity across numerous ministries, public agencies and municipal bodies. Climate change is altering many of the assumptions, science, and past practices that were used in the development of those policies and programs. In some cases potential adaptation strategies designed with one impact in mind can be counterproductive or maladaptive in the light of a different impact.

It is important that mainstreaming of climate change into current government policies and actions should look for and create synergies between ministries if they are to be effective and efficient. The integrity of the hydrological cycle or the movement of water both on the surface and below ground should be the foundation for policy, including policies affecting land use planning. Efficient drainage systems that remove water and prevent it from sinking down to the water table may inadvertently contribute to the difficulty of adapting to a warmer climate with longer dry periods.

Recommendation 29

The Ministry of the Environment, the Ministry of Natural Resources, and the Ministry of Agriculture, Food and Rural Affairs should undertake a systematic review of the legislation which guides water quantity and quality management and amend it where necessary to ensure that current legislation does not inadvertently create barriers to climate change adaptation but instead promotes adaptation measures in a coherent, consistent and synergistic manner. This review should include the Ontario Water Resources Act, the Safe Drinking Water Act, the Drainage Act, the Clean Water Act, and the Environmental Protection Act.

A considerable part, about 28% for the City of Toronto in 2007, of municipal energy use is devoted to cleaning drinking water and treating wastewater. Conserving water is both a means of reducing the emission of GHGs as well as adapting to potential water scarcity in the event of drought.

Recommendation 30

The Ministry of the Environment should accelerate its work to develop strong and comprehensive water conservation strategies across the province, including:

- Reduction targets for major discretionary purposes such as municipal water use;
- Introducing requirements in the Ontario Building Code for water conserving amenities such as low flush toilets; and
- Conservation incentives to users.

2.2.9.1 Clean Water Act

The Clean Water Act, 2006 along with the source water protection planning process it identifies, is an integrated watershed approach designed to ensure that communities identify potential risks to their drinking water supplies and take actions to reduce those risks. Assessment Reports prepared by Source Protection Authorities will identify areas where the quantity and quality of water might be insufficient to meet anticipated future needs. Water budgets, which will be affected by climate change, are required for the preparation of the Assessment Reports. They are science-based and require the integration of historical climate data and trends, incorporation of the impact of drought and an assessment of growth related to water usage. The Assessment Report will evaluate cumulative water takings and their impacts, and also improve understanding of both ground and surface water movement.

Risk assessment is one of the final steps in the source protection planning process leading to the development of Source Protection Plans. These Plans identify how the risks identified in the Assessment Report will be managed within Source Protection Areas and are to be submitted to the Minister of the Environment for approval by 2012. Once the Plans are approved, decisions under the Planning Act, (including Official Plans), as well as prescribed provincial instruments, must conform to the mandatory policies in the Plan.

The Panel is pleased to note the important steps already taken collaboratively by the Ministry of the Environment and by the Ministry of Natural Resources to include consideration of climate change in the source water protection planning process. It is not only a useful example of the benefits of mainstreaming climate change into an existing process, but also illustrates the technical challenges, including the need for appropriately scaled climate change modelling. That need should be met in a way that is consistent from region to region and suitable for informing other water budgeting issues.

Recommendation 31

The Ministry of the Environment should use water budgets that include cumulative impacts of climate change at the watershed scale to review and, where necessary, adjust the Permit to Take Water Program and introduce water conservation measures.

2.2.9.2 Ontario Low Water Response Program

The Ontario Low Water Response Program was created in 1999 as a result of drought in south-western Ontario. The Program is currently designed to mitigate the effects of drought through the implementation of short-term low water management strategies, which complement long-term approaches that manage both water supply and demand. Program implementation relies on local Water Response Teams led by Conservation Authorities and comprising stake-holders representing key water users in the watershed. These teams address water manage-ment under low water conditions by reducing demand when supplies are low.

There are three low water condition levels with Level III being the most serious, requiring conser-vation, restriction and regulation to safeguard essential water supplies that may be threatened by other water uses. Following the drought of 2007, we understand that the Province is enhancing the Ontario Low Water Response Program to better facilitate local and provincial actions and decision-making.

Recommendation 32

The Ministry of Natural Resources should undertake a comprehensive review of the Ontario Low Water Response Program to adjust for projected drought conditions in areas determined to be vulnerable to extended dry periods, and should link this review to water use reporting and water conservation in the context of integrated watershed management.

2.2.9.3 Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement

In 2005, Premier McGuinty joined the Quebec Premier and the governors of the eight U.S. Great Lakes states in signing the *Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement* to strengthen the protection and conservation of basin waters. They committed to:

- Ban water diversions with strictly regulated exceptions;
- Strengthen water conservation through programs in each jurisdiction;
- Introduce common environmental standards for regulating basin water use;
- Strengthen the role for information and science in decision-making; and
- Enhance collaboration among the ten jurisdictions through a Regional Body set up to oversee implementation.

The Panel understands that implementation of the Agreement will result in changes to the Permit to Take Water Program under the Ontario Water Resources Act. The Province is also formulating a Water Conservation and Efficiency Strategy to meet its Agreement commitments. Furthermore, the Province is also involved in a number of

regional efforts with the other Great Lakes jurisdictions, including the development of protocols to guide water use information reporting to a regional database, and discussion of a collaborative Science Strategy that will provide a foundation for assessing cumulative impacts of basin water uses at least every five years, with consideration given to climate change effects and uncertainties.

Recommendation 33

Regulations, policies and programs to implement the intra-basin transfer regulation and conservation commitments of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement prepared by the Ministry of the Environment and the Ministry of Natural Resources should be reviewed by adaptation experts to ensure the impacts of climate change are taken into account and appropriate adaptive solutions included. Both the collaborative Science Strategy and the Regional Body on Agreement Implementation should include collaboration with not only regional Great Lakes partners but adaptation experts to guide the development of adaptive solutions.

2.2.9.4 The Lake Simcoe Protection Plan

The Lake Simcoe Protection Plan is a comprehensive, science-based, watershed wide plan to protect the "ecological health" of the lake at the same time as hosting a prosperous economy in the surrounding municipalities. It is described as "both precautionary and adaptive" insofar as it exercises "caution in favour of the environment when there is uncertainty about environmental risks" and "will evolve and improve over time based on new science, changing conditions of the lake and experience in implementing the plan."

The Lake Simcoe Protection Plan, released in June 2009 by the Ministry of the Environment, requires the development of a climate change adaptation strategy. The strategy will identify key recommended adaptation actions needed to increase the resiliency of the Lake Simcoe watershed to the impacts of climate change, identify roles and responsibilities for relevant parties, and identify potential amendments to the Plan to ensure the recommended actions are undertaken.

The Lake Simcoe planning process, which includes the involvement of those living and conducting business in the watershed, as well as the extensive use of science and recognition of the need for monitoring, modelling and research in the context of climate change, make it a good example for consideration in the protection of other watersheds.

Recommendation 34

The climate change adaptation strategy called for in the Lake Simcoe Protection Plan should be considered as a pilot project with potential application to strategies for increasing the climate resilience of other watersheds.

2.3 Support Communities

STRATEGIC GOAL 3:

Strongly encourage, facilitate and support local communities, municipalities, stakeholders, and First Nations in implementing a science-based, adaptive, climate risk management approach by providing them with information, training, tools, and where necessary, authority to take local action.

To be successfully and fully implemented, adaptation must be undertaken at the local level where the various impacts of climate change are actually felt. Communities of many kinds should be strongly encouraged and facilitated in doing their own "mainstreaming" including, for example, municipalities and First Nations. All such participants in developing future climate change resilience, security and prosperity of the province need help of various kinds to enable them to carry out

effective climate risk management. This help or "enabling support" includes access to the best scientific information about present and future climate risks and other relevant information. It also requires trained personnel with access and capacity to use analytical methods and tools. Perhaps most important, some communities may need stronger empowerment and authority to enable them to take locally appropriate action on climate change risks.

2.3.1 Building Capacity for Adaptation Action

Some forward-looking community organizations and municipal governments are already taking action on climate change adaptation, but very few have done so in a systematic way. Often adaptation has been in reaction to a weather event, such as the flooding in Peterborough in 2003, rather than in anticipation of an impact outside the "coping range" (Figure 9) of the community. An imminent event made more likely by climate change might be a drought with impacts that are beyond the critical threshold of water stressed farm crops or may seriously diminish quality and quantity of a community's drinking water sources. Risks are most apparent when they become reality. But reactive adaptation is expensive in financial and human costs.

AHEAD OF THE STORM: PREPARING TORONTO FOR CLIMATE CHANGE

The City of Toronto's reputation as one of North America's leading cities on climate change took another step forward in 2008 with City Council's unanimous endorsement of a climate change adaptation framework called *Ahead of the Storm: Preparing Toronto for Climate Change*. The framework is one of more than 100 actions included in Toronto's *Climate Change, Clean Air and Sustainable Energy Action Plan*, also unanimously endorsed by City Council.

Ahead of the Storm includes a series of short- and longer-term actions to increase the resilience of the City's people, infrastructure and building stock to changing weather patterns generated by climate change, with particular focus on the impacts of extreme weather events. It also outlines the longer-term actions, such as the development of a risk assessment tool to guide the development of a comprehensive adaptation strategy.

Public and expert consultation sessions resulted in the creation of the Toronto Urban Climate Change Network, which engages a broad range of stakeholders, including the provincial and federal governments, universities, and NGOs to jointly address climate change impacts and adaptation issues. Partnering with the insurance industry, the City of Toronto has developed a web-based Municipal Reference Collection on Climate Change Adaptation. In April 2009, the Toronto Urban Climate Change Network hosted an infrastructure and climate change adaptation forum.

While some municipalities, especially larger towns and cities, have begun to consider the need for adaptive measures, many local decision-makers are either not yet aware of potential climate change impacts in their communities or do not have the experience and resources required. They are neither familiar with, nor do they have access to, the tools and processes of climate risk assessment and management. Even in communities where there is broad understanding and significant actions are taking place, there is an urgent and widespread need for data, current information, case studies of best practice, as well as training in the use of technical, process, and community engagement methods and tools. Building the climate change knowledge, risk assessment skills and adaptive capacity of communities is indispensable.

Several good introductions and guidebooks have been published to assist municipalities including *Adapting to Climate Change – An Introduction for Canadian Municipalities*, prepared by the Canadian Impacts and Adaptation Research Network in 2006 and *Canadian Communities' Guidebook for Adaptation to Climate Change*, prepared by L. Bizikova, L., T. Neale and I. Burton in 2008. However, interactive communication in facilitated workshops has consistently proven to be an effective and practical initial step in engaging a range of decision makers and stakeholders in communities.

We are pleased to note that the proposed Ontario Regional Adaptation Collaborative (see Recommendation 59) includes a major outreach component to be delivered by the Ontario Centre for Climate Impacts and Adaptation Resources (see below) and the Clean Air Partnership to urban and rural communities throughout the province. Based on workshops, case studies and "train the trainer" sessions, the proposed program will also include an important effort to refine and tailor vulnerability, risk assessment, and adaptation tools.

2.3.1.1 The Ontario Centre for Climate Impacts and Adaptation Resources

In 2007, the Province began its support for adaptation outreach through the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) at Laurentian University in Sudbury. The Centre has offered workshops in communities along with researchers to inform and communicate climate change impacts and climate risk management to municipalities. OCCIAR has also established a partnership with the Clean Air Partnership and its urban partners in Toronto in order to expand its capacity to deliver services to urban centres.

OCCIAR's approach has been to use a 'community consultation model' bringing decision-makers (e.g. council members, mayors) together with engaged practitioners (e.g. managers in departments such as planning, transportation, water treatment, stormwater management, and others) to ensure that workshop experts, elected officials and municipal staff work in co-operation to recognize local vulnerabilities, risks and opportunities.

A more comprehensive and larger organization is now needed to bring multiple local partners together and ensure decision-makers and stakeholders in many more communities soon have the information, understanding and tools they need to implement adaptive measures.

Recommendation 35

The Ministry of the Environment should build on the work of existing leaders in the adaptation field in Ontario, including the Ontario Centre for Climate Impacts and Adaptation Resources and the Clean Air Partnership, to create a comprehensive, one window, climate change impacts and adaptation outreach program to:

- Build adaptive capacity in urban, rural, and First Nation communities and within economic sectors;
- Promote a risk management approach to local climate related decision-making; and
- Work with the research community and government in the development and delivery of training, tools and climate information.

Recommendation 36

The Ministry of the Environment should establish a working group to liaise with government program partners such as the Ontario Centre for Climate Impacts and Adaptation Resources, Conservation Authorities, and municipalities in order to provide public access to tools of value in climate change adaptation through means such as websites and workshops.

Building community capacity can be envisaged as increasing experience in the four successive nodes of the "vulnerability assessment and risk management process" used by OCCIAR (Figure 11).

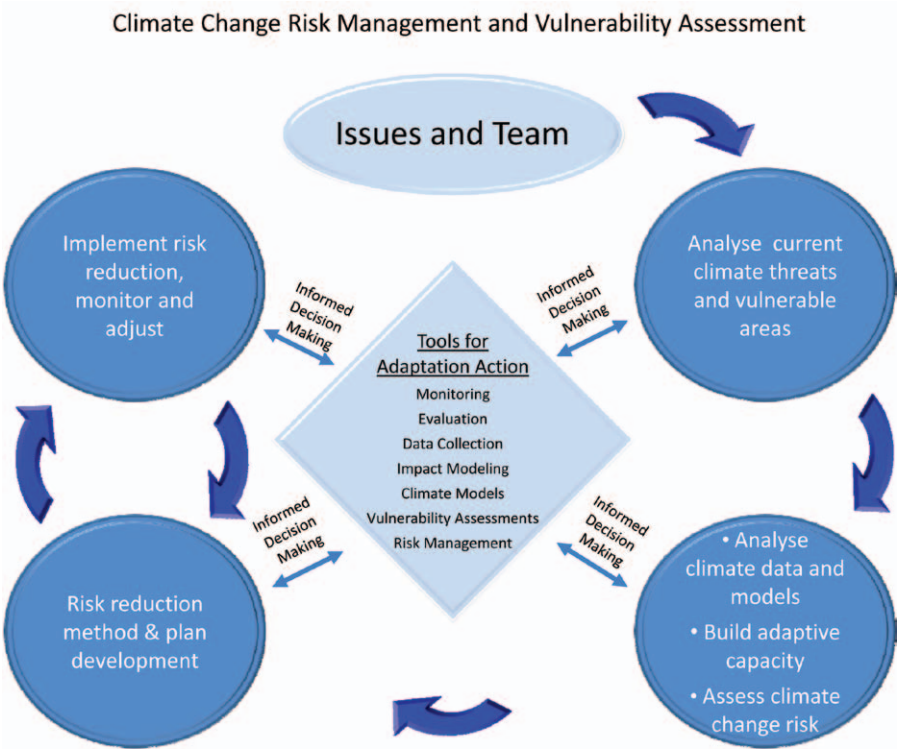
Communities at an *early* stage will have examined their vulnerability to weather events that have occurred in the past as well as opportunities and assembled a team of community partners to begin a systematic assessment of risks based on those vulnerabilities and opportunities. Their next step will involve risk-based assessments of important vulnerabilities using a variety of tools, data, and information made available from external sources such as government or OCCIAR.

Communities at an *intermediate* stage will have completed a systematic review of climate risks, chosen priorities, developed responses to those priorities, and begun to integrate adaptive responses into planning, programs, and regular operations.

Communities at an *advanced* stage will have a comprehensive adaptation action plan with risks and opportunities fully integrated into decision-making within the community by the municipal government itself as well as by community partners such as Public Health Units, and stakeholders such as tourist outfitters or farmers.

It is important that community partners and stakeholders are engaged in a regular dialogue so that a broad, integrated view of potential climate

Figure 9: Vulnerability Assessment and Risk Management Process



Source: OCCIAR, 2009

impacts and risks is developed. Adaptation actions for one impact can be maladaptive for another if they are developed in isolation. Synergies and co-benefits emerge from discussion among partners from different sectors with different experiences. A local climate risk, climate change or adaptation collaborative is a useful approach to achieving community teamwork.

2.3.2 First Nations Communities

There are 134 First Nations communities in Ontario, spread across widely differing ecological zones from the Deciduous (Carolinian) Forest in the south, through to the Boreal Forest and carbon rich peatlands of the Far North; 106 of these communities are in northern Ontario.

In light of the social, economic and environmental issues facing First Nations, there is a need to establish joint projects to assess the vulnerability of their communities to climate change as well as the capacity needed to deal with future climate change risks. This should be accompanied by development and implementation of adaptation plans in communities mutually judged to be at higher risk. As Indian and Northern Affairs Canada continues to expand its climate change adaptation programs into more southern parts of the country, opportunities to coordinate adaptation planning will arise.

Several First Nations groups are already developing climate change adaptation resources. For example, the national Centre for Indigenous Environmental Resources in Winnipeg has produced a strategic adaptation framework that provides tools to assist First Nations. Additionally, a report prepared for the Assembly of First Nations, *Climate Change and First Nations: Recommendations for Action*, identifies some of the most critical and immediate responses.

The most isolated communities in Ontario are those in the Far North. A total of 24,000 residents live in 36 scattered communities in 42% of Ontario lying north of the current commercial timber harvesting limit – roughly north of the 51st parallel and one of the truly wild spaces on the planet. As well as being isolated and dependent on increasingly short lived winter roads, these communities, and the ecosystems surrounding them, will experience the greatest climate change of any in Ontario. For example, winter temperatures are projected to increase by 4°C to 6°C, melting permafrost, severely affecting spring melt, run-off, and flood risks in some communities.

Increased climate resilience in Far North communities must be sought through appropriate community-based engagement involving the use of Traditional Aboriginal Knowledge as well as climate change science. In July 2008, the Government of Ontario announced the Far North Planning Initiative to protect at least 225,000 square kilometres of the Far North in an interconnected network of conservation lands. Through a broad land use strategy and local community planning, the Far North Planning Initiative will help determine ways to protect the ecology of the region, even in the face of extraordinary climate change, while enabling sustainable development for First Nations communities.

Recommendation 37

In order to address the climate change risks of First Nations communities in Ontario, especially those in the Far North, the Province should coordinate with Indian and Northern Affairs Canada and relevant political and territorial organizations and Tribal Councils to:

- Assess community climate vulnerability and future risks, evaluate adaptive capacity, promote the development of adaptation plans and encourage the building of resilience in First Nations communities, and
- Assess existing climate change adaptation planning tools and their potential for application in Ontario First Nations communities. This should be followed by pilot or demonstration projects with two or three First Nations communities to investigate and demonstrate applications of these tools.

2.3.3 Engaging Conservation Authorities

Over 90% of Ontario's population is located within the jurisdiction of 36 watershed-based Conservation Authorities with a broad environment related mandate focused on surface and groundwater water resources, flooding issues, and habitat conservation.

Most Conservation Authorities have a good deal of experience in working with municipal and provincial governments, community organizations, and landowners. All are now involved in the implementation of the Clean Water Act (2006) as Source Water Protection Authorities that are required to take climate change into account while preparing risk assessments and source water protection plans for communities within their jurisdictions. Individual Conservation Authorities are therefore building the experience and capacity required for them to be important agents in raising community understanding and action on climate change adaptation. Their exact roles will differ from place to place depending on the nature of the adaptation issues and initiatives already under way, and will evolve over time.

Recommendation 38

The Ministry of the Environment and the Ministry of Natural Resources should work with Conservation Authorities to:

- Assess the capacity building required for individual Conservation Authorities to play a collaborative leading role in the integration of climate change adaptation considerations into adaptive watershed management activities beyond their existing role in source water protection;
- Define that role; and
- Determine how the necessary capacity can be developed.

2.3.4 Land Use Planning

The land use planning process is a critical mechanism for implementing climate change adaptation at the municipal level. Policy direction for local and provincial land use planning is set through the Planning Act, the Provincial Policy Statement (PPS) and other provincial plans such as the Greenbelt Plan, the Growth Plan for the Greater Golden Horseshoe and the forthcoming Growth Plan for Northern Ontario. The Municipal Act assigns the responsibility for infrastructure services and decisions to municipalities. Municipalities use the land use planning tools set out in the Planning Act to carry out their responsibilities for land use designations and zoning regulations, the development of built infrastructure such as roads and bridges and water and wastewater facilities, and for enforcing the Building Code and infrastructure standards.

For example, the site plan control and the development permit system allows municipalities to set conditions on development applications that could require green roofs and/or permeable pavement to be incorporated in new development, in order to better manage increased stormwater run-off. The PPS, issued under the Section 3 of the Planning Act is a touchstone statement of the fundamental principles and values embodied in the Province's planning policies. It provides policy direction on matters of provincial interest related to land use planning. Municipal planning documents, such as official plans and zoning bylaws must be consistent with the PPS. When the PPS is amended, municipal official plans must be amended to reflect the change in policy during the next five-year review.

The PPS covers broad areas including "building strong communities," "wise use and management of resources," and "public health and safety." Specific policy areas within the PPS that must take climate change into account include infrastructure and public service facilities such as sewer and water services, as well as natural and human made hazards such as flooding and erosion. The concept of planning to increase the resilience of communities and economic activity in the face of climate

change should be reflected in the "Vision for Ontario's Land Use Planning System" and must be a transcending theme in the upcoming review of the PPS in 2010. "Building Strong Communities" means building strong *and* climate-resilient communities.

Recommendation 39

The Ministry of Municipal Affairs and Housing, in collaboration with other ministries, should prepare firmly worded policy for inclusion in the Provincial Policy Statement during the upcoming review in 2010 to the effect that all planning authorities, in making decisions, must take into account risks arising from climate change. Further, the Ministry of Municipal Affairs and Housing should consult with planning authorities, the research community, and professional engineers and planners in preparation for issuing guidelines regarding the implementation of the policy.

Recommendation 40

The Ministry of Municipal Affairs and Housing should:

- Use education and hands-on outreach such as workshops to promote the use of existing land use planning tools in the Planning Act to increase the resilience of communities to current vulnerabilities and future climate risks while reducing GHG emissions; and
- Develop model by-laws or encourage adoption of existing examples of municipal by-laws which require integration of climate change adaptation and mitigation measures in proposed developments.

2.3.4.1 Official Plans

There are 444 municipalities in Ontario, all with Official Plans developed and approved under the Planning Act either by an upper-tier municipality or directly by the Minister of Municipal Affairs and Housing. All Official Plans must be consistent with the Provincial Policy Statement and are subject to review every five years.

Recommendation 41

The Ministry of Municipal Affairs and Housing should begin discussion with individual municipalities, the Association of Municipalities of Ontario, and the Northern Ontario Municipal Association concerning the need to include climate risk assessment and adaptation planning in Official Plans during the next five-year review cycle.

2.3.4.2 Growth Plans

There are also a number of provincial plans that provide provincial land use and development policy direction in specific geographic areas. For example, the recent Growth Plan for the Greater Golden Horseshoe outlines a vision and strategy for where and how the region should grow over the next 30 years. It provides direction for growth and intensification to minimize urban sprawl while maximizing the use of existing infrastructure to support new growth and to protect farmland and greenspace.

The Growth Plan for the Greater Golden Horseshoe's policies support climate change mitigation by requiring compact, complete and mass transit-oriented communities. Explicit consideration of climate change would reveal additional opportunities to support climate change adaptation in the policies and implementation guidelines for these plans. For example, requirements for regional integrated stormwater management plans could require on-site stormwater management, using low impact development as a means to reduce flooding due to increased extreme weather events.

Recommendation 42

The Province should develop guideline materials that highlight all possible measures to adapt to climate change impacts as part of the implementation of the Growth Plan for the Greater Golden Horseshoe.

Recommendation 43

The Province should ensure that all future growth plans consider climate change impacts as part of the terms of reference for the planning exercise. This consideration must assess community and sectoral climate vulnerabilities and take into account potential future climate impacts as they relate to land use planning, infrastructure, and ecosystem matters.

2.3.4.3 Environmental Assessment

The Environmental Assessment Act evaluates the possible environmental impacts of a project and applies to undertakings (enterprises, activities, proposals, plans or programs) by provincial ministries and certain public bodies such as Conservation Authorities. Some undertakings involving projects described as "routine" with relatively predictable environmental effects are evaluated under a Class Environmental Assessment (EA) provision. Class EAs cover municipal roads, sewer and water infrastructure, highway construction and maintenance, forest management, and Conservation Authority activities.

The purpose of the Environmental Assessment Act is to provide "for the protection, conservation and wise management in Ontario of the environment". It was not written with the potential impact of the environment on the project in mind and consideration of climate change risks has not, to this point, been a normal part of the technical review of project proposals.

Two kinds of cases illustrate the change in circumstances:

i) Those where a combination of the impacts of a project coupled with the projected impacts of climate change exacerbate a potential issue, such as the future sufficiency of local water supply; and

ii) Cases where future climate change risks impose limitations on a project, such as locations where climate change may increase the risk of future flooding because of severe rain events.

The current interpretation of "environment" in the Act is that it is essentially unchanging, subject only to the natural variability of the past and that the coping range of projects need only correspond with that of the past. We know that is no longer the case. It may be possible to interpret "environment" dynamically and to continue to cover protection and conservation with such a broad interpretation. However, the conceptual and practical inconsistencies between the conditions that drove the language of the Act and current reality may be too great.

Recommendation 44

The Ministry of the Environment, in collaboration with other ministries, should review the Environmental Assessment Act and the technical mandates and guidelines provided to reviewers for the purpose of determining:

- How those technical mandates should be changed to include the implications of climate change; and
- Whether, and if so how, the Act needs to be amended to accommodate consideration of climate change risks imposed on undertakings.

In any event, the Ministry of the Environment should require all project proposals subject to the Environmental Assessment Act to take climate change risks into account. Further, the Ministry of the Environment should ensure that guidance, supporting the environmental assessment process at all stages, includes information for proponents about projected climate change impacts and risks as well as adaptation and co-benefit adaptation mitigation measures that respond to those risks.

2.3.5 The North

Climate-related changes in Ontario are highly likely to be most pronounced in the northern region of the province, especially in the Far North, beyond the limit of commercial forestry and including the Hudson Bay Lowlands. Climate change models prepared for Natural Resources Canada's report, *From Impacts to Adaptation:*

Canada in a Changing Climate 2007, project winter temperature increases by 2050 of between 4°C and 6°C over the Hudson Bay Lowlands and between 2°C and 4°C over the rest of northern Ontario, similar to the rest of the province.

In general, climate change modelling tells us that the northern winter climate will become warmer and wetter, resulting in winter rain mixed with more snowfall. Hudson Bay and James Bay, as well as inland lakes and rivers throughout northern Ontario, will experience a reduced period of ice cover and earlier spring run-off accompanied by an earlier loss of snow cover. Projections of precipitation are more uncertain than for temperature. Areas in the Far North may see increases in the range of 10-30%, with the largest increase in winter. A modest increase in summer precipitation may not be sufficient to counter increased evaporation, resulting in a higher risk of forest fires in summer. Extreme and intense precipitation events are projected to increase and present a greater risk of flooding, especially if they occur during spring run-off, as well as snow load stress on buildings. Ice storms may also be more frequent in the future.

2.3.5.1 Growth Plan for Northern Ontario

The Province is developing a Growth Plan for Northern Ontario with a shorter-term focus on attracting and sustaining economic and community growth in the Near North, but also including development in the Far North. Bill 191, the proposed Far North Act, 2009 is intended to provide context for the involvement of First Nations, the role of community land use planning, and ecosystem protection in the Far North.

The Province is developing a Growth Plan for Northern Ontario with a focus on attracting and sustaining economic and community growth in the Near North. Aside from a few larger towns, communities in the Near North are generally small,

COMMUNITY ASSESSMENTS – NORTHERN ONTARIO

To assess the vulnerability of a sector or community to the impacts of climate change in northern Ontario, the Ontario Centre for Climate Impacts and Adaptation Resources conducted a stakeholder/sector scan in Timmins and Sioux Lookout. The assessments followed a step-wise process that helped define the sensitivity/susceptibility of the community to the present and future impacts of climate change through input from community stakeholders. Throughout the facilitated and structured meeting, stakeholders were asked to share their knowledge and experience as it pertained to vulnerability to climate change.

The capacity to adapt varies spatially across northern Ontario with more populous communities having the advantage of a larger, more diversified economy, larger populations and more expertise (post secondary institutions). Smaller communities in northern Ontario are more vulnerable to climate change, not necessarily because of increased exposure or sensitivity to climate risks, but also because they have lower levels of adaptive capacity.

Mining Currently sensitive and vulnerable in areas of tailings management, water quantity and closure planning.

Forestry Less known to participants aside from awareness of changes in the timing of seasons thus affecting forestry operations.

Winter transportation Roads, rail lines and airports/air strips, and especially winter roads are very sensitive to changes in the winter season. This leads to impacts on human health because of interrupted access to social and health services outside the communities, economic activity, and the elevated price of goods and services.

Power transmission infrastructure Old age highlights the sensitivities to current and future climate.

Tourism Winter season activities such as snowmobiling are sensitive due to a shorter ice-cover and snow period, and less reliable snow conditions caused by winter rainfall, particularly in the southern section of the Near North.

often widely separated along road and rail corridors and frequently dependent on climate-sensitive economic activities, especially forestry and tourism. The influence of climate change is already being felt on tourism, especially on winter season activities such as snowmobiling, because of a shorter ice-cover and snow period and less reliable snow conditions caused by winter rainfall.

As noted earlier in this report, forestry will feel the impacts of climate change in a number of different ways and on a range of time scales. An increase in the frequency and extent of forest fires is already evident.

As well, an improvement in tree growth rates where water is not a limiting factor can be expected in some species. However, conditions will be more favourable for forest pests and invasive species, such as the spruce budworm and mountain pine beetle in jackpine stands. Most significantly, northward-moving climate conditions or "climate envelopes" are shifting faster than tree species can migrate.

Recommendation 45

The Ministries of Northern Development, Mines and Forestry and the Ministry of Energy and Infrastructure should integrate climate change vulnerabilities, risks and opportunities in the Northern Ontario Growth Plan and promote the use of adaptation-mitigation co-benefit technologies, design and planning principles in implementing the growth plan.

Mining, and accompanying operations of milling, smelting and refining, is less directly vulnerable to climate change than forestry. However, the vulnerability of power lines and transportation routes, including winter and ice roads, air strips and rail lines, to the impacts of climate change also inherently hinder the ability of mines to operate, as does the availability of water.

Extreme drought periods and high precipitation storms threaten impoundments where tailings are stored. Breaches in tailings dams following extreme rainfall are well documented internationally thus highlighting the need for increased resilience in the engineering of such structures. Closure and future abandonment of mine sites underscore the need for consideration of future climate in the development of closure plans for all mining operations, especially tailings disposal areas.

Recommendation 46

The Ministry of Northern Development, Mines and Forestry should immediately require consideration of climate change in closure plans for mining facilities and should require companies to review and, where necessary, revise existing plans to be sure that risks arising from climate change have been taken into account.

2.3.6 Emergency Management

Every municipality in Ontario is required by legislation to take certain steps to prepare for emergencies. These steps include:

- Having a trained Emergency Management Coordinator, an Emergency Control Group and an Emergency Operations Centre to respond to actual emergencies;
- Conducting an annual Hazard and Risk Assessment and publishing a Emergency Response Plan which is reviewed annually; and
- Conducting public education on any specific hazards that exist within the municipality.

Emergency Management Ontario (EMO) monitors Ontario's 444 municipalities on an annual basis to ensure Emergency Response Plan requirements are met. EMO staff work with municipalities to assist them in maintaining their plans and programs as necessary.

A changing climate, however, brings a new set of risks and threats and some of the anticipated impacts of climate change will increase risk for

people in communities throughout Ontario. Although every municipality in Ontario is required to have an emergency response plan in place, climate change is projected to result in more extreme weather conditions, which may cause problems that are not included in the existing emergency response plans.

The citizens of Ontario municipalities may not be aware of the new threats climate change may pose for their well-being and safety. The Panel recognizes potential benefits to public safety through increasing public transparency and awareness of municipal emergency planning through reminders to the public of individual responsibilities to be able to maintain themselves for extended periods until assistance is provided. The complex, integrated and interdependent nature of our society means that impacts that had not been anticipated can arise through these interdependencies.

A significant opportunity exists to strengthen Municipal Emergency Response Programs and Plans through the development and transfer of knowledge of potential climate change impacts to municipal emergency management officials and other municipal personnel.

Recommendation 47

The Ministry of Municipal Affairs and Housing in partnership with Emergency Management Ontario should engage municipalities through the Association of Municipalities of Ontario to:

- Ensure the transfer of knowledge of on-going climate change impacts to appropriate municipal emergency planning officials to enhance their annual emergency response plan review process and assist in the provision of public hazard education programs;
- Encourage leading municipalities to share risk-based Emergency Response Programs and Plans where issue-specific responses have been developed for climate change related events, such as flooding and blackouts; and
- Encourage municipalities to adopt risk-based land use and emergency response planning.

2.3.7 Tourism

In 2008, the Ministry of Tourism reported that tourism accounted for $19.9 billion in the economy of Ontario in 2007, accounting for 3.4% of the province's GDP. Snowmobiling alone is said to be worth $1 billion.

Almost all tourists in Ontario are influenced by the weather, especially those choosing from a wide variety of popular outdoor activities such as alpine and cross-country skiing, snowshoeing, snowmobiling, boating, beach recreation and swimming, sailing, hiking and camping, fishing, hunting, golfing, fall colour viewing, landscape and wildlife viewing including bird watching, canoe tripping, and kayaking. Provincial and National Parks are important venues for many of these activities. Cultural attractions such as summer and winter festivals, First Nations events, museums, science centres, theatres, historical and architectural sites, are often part of an itinerary or package and are also to some extent influenced by weather.

The Ottawa Winterlude Festival has already adapted to a warmer and less reliable February climate by scheduling the Festival over three weekends rather than over 10 continuous days, as well as making contingency provisions for refrigerated trucks to conserve ice for ice carving events, extra snow making and substituting events if cancellations are necessary.

Research projects that the snowmobiling season in northwestern Ontario in the 2020s may decrease by 24 to 45 days from its current length of about 100 days per year (Scott and Jones, 2006). By 2050 the season could decrease by 32 to 87 days depending on global GHG emissions. In southern Georgian Bay, where some of the province's most concentrated networks of trails occur, the current season is about 69 days and is projected to decrease by 30 to 47 days within 20 years.

In contrast to winter recreation, the season for warm weather activities like golf is expected to increase in the southern Great Lakes region from two to seven weeks in the next 20 years. Water requirements for turf irrigation might well become

a greater issue in some areas as the season lengthens. Changes in cold water sport fish populations, near-shore water quality issues and water levels, wildlife migration, and more frequent extreme rainfall events will be other changes affecting outdoor recreation.

While the total value of tourism and its ancillary recreational equipment suppliers might not change a great deal, and could even increase, there will be a shift in the balance of outdoor recreation from winter to warm weather activities. Adaptation will allow there to be a considered transition rather than disruption in this very important sector of the province's economy.

Recommendation 48

The Ministry of Tourism should work with communities, the research community, and tourism associations to assess current vulnerability of tourist activities to climate change, monitor climate-related tourism trends as well as communicate the potential impacts, risks and opportunities of climate change for tourism as change occurs and trends become more evident.

2.4 Develop and Disseminate Knowledge and Tools to Manage Risk

STRATEGIC GOAL 4:

Develop and strengthen the continuous creation and communication of knowledge about adapting to climate change, reducing climate risks and taking advantage of beneficial opportunities through programs of research, monitoring, public awareness, and education.

Successful climate change adaptation depends upon several streams of knowledge, diverse sources of information, careful processes that keep people engaged, and tools for understanding vulnerability as well as for processing, analysing and modelling data to determine future risks. Adaptation choices have to be made knowing that projections of future climate are uncertain, but also knowing that the climate of the past will not be the climate of the future.

One size does not fit all. The knowledge, information, tools and climate projections for one region of the province may be very different from what is needed elsewhere because of local influences – perhaps the proximity of the Great Lakes or simply latitude in a province that stretches from vineyards to permafrost. Local knowledge from farmers and the traditional knowledge of Aboriginal elders are also valuable components of making the best local decisions.

2.4.1 Research

Understanding of long-term climate change impacts on a local scale is still in its infancy. Experience in developing, selecting and implementing adaptation options is far from the point where adaptation is simply a question of applying past experience. Case studies are still few and far between and best practices are only slowly becoming clear. Furthermore, most adaptation takes place in communities where traditional decision-making has not had to take account of changing climate risks. The personal, social and economic implications of changing policies and priorities to avoid risks that are beyond the past experience of the community are often hard to justify.

Support is therefore required for ongoing user and needs-oriented, science and social science research, especially to improve understanding and analysis of regional and local scale risks, adaptation options and opportunities.

Examples of important areas for illustrative purposes include but are not limited to the following:

- Projecting the impacts of climate change and assessing the risks for specific crop and livestock production in specific regions of Ontario over the short-term (3–5 years) as well as the long-term (10–30 years);

- Developing long-term adaptive agricultural management strategies and technologies including water management and selection of crop varieties, to reduce projected risks and take advantage of opportunities;
- Developing crop varieties with greater resistance to pests and drought;
- Understanding the regional impacts of climate change on tourism and developing locally feasible adaptation options;
- Increasing the understanding of both the physical and socio-economic consequences of different options for climate change adaptation in agriculture, and better understanding of behavioural aspects of climate change adaptation such as farmers' decision-making;
- Increase adaptive capacity in the forest sector;
- Forest vulnerability assessment methodologies including assessment of vulnerability to damage caused by pests;
- Quantification of ecosystem services and values provided through the composition, structure and function of ecosystems already being affected or likely to be affected by climate change in order to better inform climate change adaptation actions; and
- Determining what barriers exist to adaptation in the agriculture sector and how these can be addressed. Increased use of new methodologies for assessing vulnerability would help address these gaps.

Recommendation 49

The Province should expand its support of science and social science adaptation research by establishing a dedicated fund at an initial level of $2 million annually for projects designed to encourage effective climate change adaptation throughout Ontario.

Recommendation 50

The Ministry of Research and Innovation should give high priority to projects involving the development, introduction and demonstration of new climate change adaptation technologies and should engage the Ontario Centres of Excellence in supporting research and commercialization of adaptation technologies as well as identifying current and future needs and barriers to the development of these technologies.

2.4.2 Monitoring

Monitoring of climate change parameters of many kinds, not just average temperature and precipitation but soil moisture, plant growth rates, intensity, duration and frequency curves for intense storms, river flow volumes, and evaporation rates among many others, will be required in focused, integrated monitoring programs. Reliable monitoring provides accurate baseline data on existing climate for risk assessment as well as validating projections against reality to inform adaptive management actions.

A great deal of high quality environmental monitoring data from stream flow to pathogen movement is already gathered by various ministries and provides a very good foundation for a greater focus on climate change. We understand that in some cases adjustments are already being made to existing monitoring programs. One such case is a review of the Surface Water Monitoring Network. The aim is to list prioritized enhancements for the stream gauge network that will contribute to adaptation strategies as well as continue to address its primary roles of flood and drought monitoring.

Recommendation 51

To ensure on-going access to the best available data, tools, techniques and technology, including regional climate change models, to support climate change adaptation in Ontario, the Ministry of the Environment with other appropriate ministries should establish a jointly chaired, inter-ministerial working group to:

- Review, integrate and co-ordinate existing climate-related monitoring programs;
- Identify and prioritize monitoring gaps which need to be addressed in order to undertake anticipatory adaptation actions, evaluate the performance of adaptive risk management choices; and bring about coordination and collaboration with multiple benefits across sectors; and
- Review and enhance the acquisition, analysis, sharing , and effective communication, within and outside government, of data sets and modelling related to climate trends, scenarios, extreme weather events, pest and disease incidence, and other impacts and risks that will help in planning and taking adaptation actions in communities and by stakeholders throughout the province.

Because monitoring cannot take place everywhere and for every parameter, the aim of climate change related monitoring programs should be to:

- Determine baseline conditions;
- Locate and understand critical areas vulnerable to climate change impacts;
- Provide reliable data to support modelling efforts; and
- Identify important climate and adaptation-related trends.

Multiple uses of monitoring data and maximum benefit from monitoring stations and programswill come from the best possible coordination between ministries and integration of related needs.

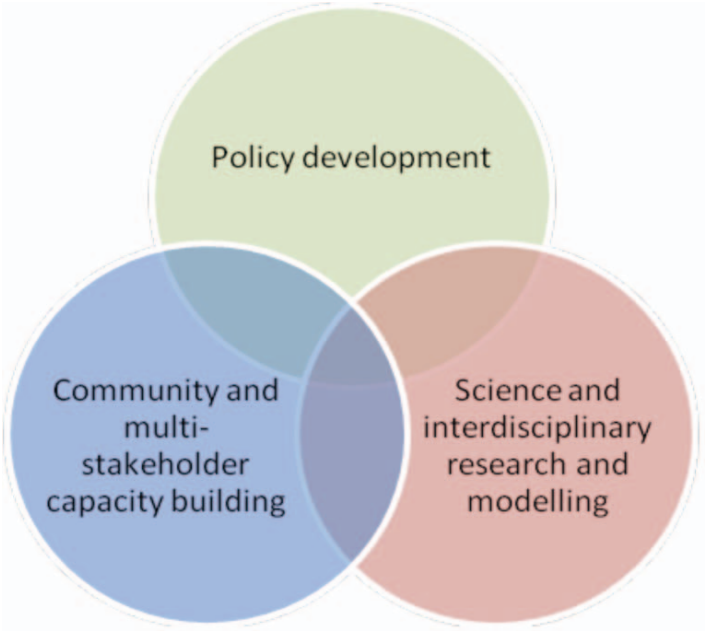
One of the information needs of greatest importance to communities in assessing vulnerability to weather events and climate change is easy on-line access to weather and water data. We are pleased to note that the proposed Regional Adaptation Collaborative is planning to develop a "Weather and Water Information Gateway" for communities and other interested stakeholders. This is an important initiative and exemplifies the local significance of data sharing in formats that are user-friendly and designed to fit local needs.

2.4.3 An Ontario Climate Change Network

Networks organized around a theme are a well known way of encouraging collaboration among people and groups with similar research interests. A forward looking climate change network should recognize the vulnerability approach to designing adaptation actions as well as the value of modelling. It should be interdisciplinary and as well as including climate science and modelling of climate change and its potential impacts, it should have strength in the economic implications of climate change and adaptation; adaptation technology development; policy development; social implications of climate risks; modelling adaptation processes; processes and incentives for engaging stakeholders; estimating risks and identifying adaptation options; considering means of assessing adaptation options and implementation strategies; reviewing adaptation successes and failures; identifying constraints on adaptation and conditions that facilitate adaptation; social and behaviour-based tools for community engagement and building capacity; ethical and cultural issues; international collaboration; and public communication.

The focus of an Ontario Climate Change Network would be on "enabling Ontario to adapt well to climate change". The purpose of the Network would be to facilitate rapid and effective integration of current research and knowledge into

Figure 10: The Three Spheres of Interest in an Ontario Climate Change Network



Recommendation 52

The Ministry of the Environment, the Ministry of Natural Resources, the Climate Change Secretariat and Ontario Centre for Climate Impacts and Adaptation Resources should jointly host a workshop before the end of January 2010, to consider options and make recommendations concerning the purpose, structure and funding of an Ontario Climate Change Network that would enable:

- Interdisciplinary science and social science research regarding climate change adaptation and communication of climate change science, issues and adaptation strategies in Ontario to be rapidly integrated into:
  - Government policy and programs at all levels
  - Community policies and decision-making
  - Stakeholder decision-making
- Access to the best available data, tools, techniques and technology, including regional climate change models, to support climate change adaptation in Ontario.

climate change adaptation into all areas of public policy, programs and economic activity. One question to be resolved in early discussions will be the place of reducing GHGs or mitigation of climate change. It will be important for the network to be focused on adaptation but to look for co-benefits with mitigation, especially at the community level.

Government should be an active participant in such a network in the way that the Ministry of the Environment, the Ministry of Natural Resources, and the Ministry of Municipal Affairs and Housing are active participants in the planned Ontario Regional Adaptation Collaborative supported by the Province and Natural Resources Canada.

2.4.4 Communication

Action on adaptation will be slow unless those who need to be engaged have the understanding, information and tools they need to take on projects in their own work settings. Furthermore, good action planning requires the contribution of local knowledge, insights and commitment of citizens across the province. Adaptation is a process, not an endpoint. It requires dialogue, not delivery of information.

PACIFIC INSTITUTE FOR CLIMATE SOLUTIONS

In 2007, the government of British Columbia invested $90-million in an endowment fund to create the Pacific Institute for Climate Solutions—a collaboration of four universities in British Columbia designed to develop adaptation options, conduct research on technology for a low carbon economy as well as research that monitors and models the magnitude of climate change and evaluates its physical, economic and social implications.

OURANOS

In 2001, the Quebec Government joined with Hydro-Quebec and Environment Canada to create a not-for-profit Consortium on Regional Climatology and Adaptation to Climate Change. Ouranos has brought together a network of more than 250 scientists and professionals from different disciplines. Its Climate Simulation Group acts as a single source of global and regional climate modelling for the Quebec government, its partners and clients.

Elected decision-makers at all levels, provincial government policy makers and staff in all ministries, community leaders, council members, city staff, First Nations leaders, stakeholders in all sectors, and members of the general public all need to understand the issues, the risks, and the beneficial opportunities.

Workshops and information sessions organized by the Adaptation Directorate (see Recommendation 2) will address the need within government. OCCIAR has been communicating with municipal decision-makers and will continue to do that through the proposed Regional Adaptation Collaborative along with the Clean Air Partnership, but the general public must also be engaged in a purposeful and planned manner.

Engaging members of the public in organized discussion of science and society issues is accomplished with "citizen forums" by governments in several countries around the world, especially in Denmark where they were introduced in 1987. Research has shown them to be much more effective than traditional open houses. Members of the public who commit to the process are engaged in dialogue involving two or even three interactive, participatory sessions. The result is recommendations in response to questions, often about policy options, posed at the outset. Climate change adaptation lends itself especially well to this format because of the benefit of gaining local knowledge for local and regional decision-making. The Panel's report might well serve as one of the main resource documents for the forums.

Recommendation 53

The Ministry of the Environment should initiate a series of citizen forums across the province as a way of engaging members of the public in dialogue about climate change adaptation and gathering local knowledge of benefit to the adaptation process.

2.4.5 Education

With climate change as an issue of increasingly urgent concern, Ontario's schools, colleges and universities should show equal urgency in making the implications of climate change and the principles of sustainability part of education at all levels.

The Province's success in helping reduce the severity of future climate change as well as adapting to unavoidable change depends on decisions made in the next decade not when today's schoolchildren are in government. Nevertheless, the next generation will live with the international as well as local consequences of climate change and should understand how and why it will increasingly drive decision-making. Environmental limits will become a larger part of their consciousness.

The Province has recently committed to embedding environmental education in the curriculum in every subject and every grade.

According to the report, *Shaping our Schools, Shaping Our Future: Environmental Education in Ontario Schools* prepared in June 2007 by the Working Group on Environmental Education, there is "likely a gap between the environmental education 'intended' in Ontario's curriculum and that which is taught and received in the classroom". The Ministry of Education is now moving forward on all 32 recommendations contained in the report. This includes an environmental education policy framework entitled *Acting Today, Shaping Tomorrow: A Policy Framework for Environmental Education in Ontario Schools*. Most notably, the revised (2008) Grade 8-10 curriculum now includes "Earth and Space Science: Climate Change" at the Grade 10 level that covers the science and issues of climate change. Adaptation is not, however, mentioned.

In 2003, the Ministry of Education established an ongoing cycle of curriculum review. This review is intended to ensure that curriculum remains current, relevant and is grade-appropriate. In addition, teaching resources are developed to support the delivery of the curriculum and the Ministry of Education supports teachers' federations in the development of training opportunities for teachers, for example, summer institutes and webinars. It will be very appropriate and timely for a special effort to be made to provide teaching resources and training opportunities for teachers of new climate change courses, such as the Grade 10 course, as they are introduced.

University and college students should find climate change and its impacts around the world considered in a wide variety of contexts in their courses: science, social science, philosophy, communication, international development, economics, political science, and many others. Engineering and medical students should be required by their professions to be familiar with the potential implications of climate change for their future practice.

Recommendation 54

As part of the curriculum review process, and following the introduction of climate change into the Grade 10 curriculum, the Ministry of Education and Training should continue to ensure that the science of climate change as well as the social, economic, and environmental impacts, along with the potential policies and actions for reducing the severity of future change and adapting to unavoidable change, are integrated into the elementary and secondary school curriculum. Further, a special effort should be made to provide teaching resources and training opportunities for teachers of new climate change courses, such as the new Grade 10 course, as they are introduced.

2.5 Collaborate with Other Governments

STRATEGIC GOAL 5:

Seek opportunities to influence and collaborate with other governments in Canada and internationally for the purpose of sharing climate change adaptation experience and developing cooperative activities.

When the United Nations Framework Convention on Climate Change (the Convention) was negotiated in the years prior to the 1992 UN Conference on Environment and Development, climate change was understood to be about air pollution by GHGs on a global scale. The main objective of the Convention became mitigation or control of GHG emissions, requiring collective action by all countries. Adaptation was a secondary objective, not because of its unimportance, but because it was considered to be a local matter that would be undertaken when and where it was needed.

The Convention recognized that the poorer and most vulnerable countries would need help in meeting some of the costs of adaptation. Developed countries (including Canada, listed in

Annex II to the Convention) agreed in Article 4.4 as follows: "The developed country Parties and other developed parties included in Annex II shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects".

Since 1992, ideas about adaptation have changed substantially. The climate has changed more rapidly than was anticipated and the need for adaptation has become more evident; not only in the poorer and most vulnerable developing countries but also in the richer more developed countries. Adaptation is not simply a local matter. It is important for Ontario to recognize adaptation as more than an internal matter for Ontarians to consider in isolation. Climate change impacts are now widespread throughout the world, and the need for adaptation is equally widespread. There are many important ways in which adaptation has multi-jurisdictional effects and consequences.

2.5.1 Trans-boundary Impacts

Trans-boundary climate change impacts mean that adjacent jurisdictions will face similar problems. One of the clearest examples in Ontario is the problem of falling water levels in the Great Lakes. This issue will affect all eight Great Lakes States, as well as Ontario; consultation and cooperation are clearly necessary. Cooperation will help ensure adaptation policies and measures in one jurisdiction do not have unintended or harmful effects elsewhere. The need for cooperation in adaptation can also extend beyond immediate neighbours. The spread of human, plant and animal disease vectors can have regional and indeed global effects.

Annex 3, Goal 5 of the *Canada – Ontario Agreement Respecting the Great Lakes Basin Ecosystem* (COA), which was signed with the Federal government in 2007, includes "climate change impacts in the Great Lakes Basin Ecosystem" as an area of "special focus". Ontario undertook to "continue working with other agencies and organizations to help communities around the Great Lakes ensure that foundation work is begun on managing the impacts of climate change".

Through the agreement, Ontario along with the Government of Canada, has initiated support for the development of evidence, indicators and model projections of climate ecosystem change in the Great Lakes Basin—for increasing understanding of climate change impacts on biodiversity, natural resources, water assets, human health and safety, the economy, and infrastructure, and for establishing linkages to climate change science, impacts and policy work of international, national, provincial and municipal governments, non-governmental organizations, industry and academia. This is a new goal area within the COA and offers an important platform for accelerating the study of climate change issues in the Great Lakes – St. Lawrence Basin, including the involvement of municipal governments and communities through groups like the Great Lakes – St. Lawrence Cities Initiative, and Conservation Authorities.

The Panel notes that the next iteration of the COA is timed for 2010, and sees this as a timely opportunity to include specific science-based adaptation actions to increase the resilience of the Great Lakes Basin Ecosystem to climate change. At the same time as singling out the COA as a framework for action from community to international level, we recognize that many other agreements also involve consideration of climate change impacts, and that it is important that these agreements be consistent.

Recommendation 55

The Province should work with its partners, including the International Joint Commission and its Boards, to ensure that all Provincial, National and International Great Lakes agreements, strategies and plans are consistent in their consideration of climate change impacts and adaptation. Such agreements include the Great Lakes Water Quality Agreement, the International Joint Strategic Plan for Great Lakes Fisheries Management, Great Lakes Fisheries Commission science priorities and Bi-National Lakewide Management Plans.

Recommendation 56

Ontario should continue to participate in national initiatives that ensure coordination and collaboration such as the Canadian Council of Forest Ministers climate change work carried out at the request of the Council of the Federation and the National Forest Pest Strategy.

Recommendation 57

The Province should work with the federal government and other provinces and territories to develop and implement an integrated, multi-hazard national public alerting system.

2.5.2 Identifying Trade Opportunities

Adaptation can be helped or hindered by the changing comparative advantage of Ontario in relation to production and trade. Longer growing seasons and warmer temperatures are likely to create new opportunities for the province's agricultural sector. This could mean fewer imports of commodities such as fresh fruits and vegetables. It is important for the provincial government to develop capacity to monitor and anticipate such changes to facilitate the role of Ontario's citizens and economy in taking advantage of them. This process will require capacity to understand changes in other jurisdictions as well as changes in Ontario.

2.5.3 Unintended Impacts

Adaptation measures undertaken in other jurisdictions could have potentially adverse effects in Ontario. This is true not only for contiguous provinces but also in places far removed from Ontario, Canada and the United States. It is likely that the global transmission of such effects will become an important part of climate change diplomacy. As such, Ontario needs the capacity to become more informed and active in international talks and negotiations to ensure it is aware of actions being undertaken elsewhere, and their potential impacts on the province.

Recommendation 58

The Province should seek a stronger and more active role, in partnership with other provinces and territories, in the development of adaptation policies. This includes policies on both the development of adaptation within Canada and elsewhere in the world, including influencing ongoing climate change negotiations at a bi-lateral and international level, focused on ways of implementing the adaptation components of the United Nations Framework Convention on Climate Change.

2.5.4 Sharing Expertise

The need for inter-jurisdictional collaboration can be cast in terms of protecting the welfare and economic interests of Ontario and Ontarians. By virtue of its high level of development and considerable adaptive capacity, as well as on grounds of equity and peaceful economic and social development, Ontario can be of assistance to other countries that are less fortunately placed. This includes the provision of humanitarian aid. Ontario also has expertise and is developing new capacities and approaches to adaptation that can be of value elsewhere.

It is important that Ontario develop an outward looking and cooperative approach to adaptation. Ontario is already involved in a number of forums that offer opportunities for the Province to share experiences and influence action on climate change adaptation. Ontario hosted a national Climate Change Adaptation Summit in 2008, which was an outcome of a Council of the Federation meeting in which the Ontario government pledged to take leadership on climate change adaptation. As a member of the Council of the Federation and as the current chair of the Canadian Council for Ministers of the Environment, Ontario is in an excellent position to bring attention to issues related to climate change impacts, and to influence action on climate change adaptation at an inter-provincial, national and international level.

The Government of Ontario should create new opportunities to expand its capacity and role in the growing international movement towards cooperative action on climate change adaptation. This report has shown that such matters are of vital interest to Ontario. As part of the development of a long-term approach to adaptation, the Panel believes that the Government of Ontario should strengthen inter-jurisdictional collaboration on climate change adaptation.

Natural Resources Canada has launched a two year funding program to create Regional Adaptation Collaboratives across Canada to advance regional adaptation planning and decision-making. This program is a welcome initiative of the federal government to support the building of adaptive capacity and improving resilience in all provinces, including Ontario. The Panel strongly urges the federal government to extend and expand national leadership for adaptation beyond this program and beyond 2012. Canada no less than Ontario, needs to ensure it is well prepared to lessen the impacts of climate change.

Recommendation 59

The Province should participate in the Natural Resources Canada funding program to jointly establish a Regional Adaptation Collaborative in Ontario. Further, the Panel encourages the federal government to extend and expand support for adaptation beyond the life and scope of this program.

References and Bibliography

Abraham, K.F., and C.J. Keddy, 2005. The Hudson Bay Lowland. Pages 118-148 in L.H. Fraser and P.A. Keddy (eds). *The World's Largest Wetlands: Ecology and Conservation*. Cambridge: Cambridge University Press.

Berrang-Ford L. et al, 2008. "Climate Change and Malaria in Canada: A Systems Approach" *Interdisciplinary Perspectives on Infectious Diseases*. Volume 2009, Article ID 385487.

Bizikova, Livia, Tina Neale and Ian Burton, 2008. *Canadian Communities' Guidebook for Adaptation to Climate Change*. Vancouver: Environment Canada and University of British Columbia.

Brown, H.C.P., 2009. "Climate change and Ontario forests: Prospects for building institutional adaptive capacity". *Mitigation and Adaptation Strategies for Global Change*, 14 (6): 513-536.

Browne, S.A. and L.M. Hunt, 2007. *Climate Change and Nature-Based Tourism, Outdoor Recreation, and Forestry in Ontario: Potential Effects and Adaptation Strategies*. Climate Change Research Report CCRR-08. www.mnr.gov.on.ca/198259.pdf.

Buttle, Jonathan, Tom Muir and Joan Fran, Economic impacts of climate change on the Canadian Great Lakes hyrdo-electric power producers: a supply analysis. *Canadian Water Resources Journal*. 29.2: 89-110.

Canadian Impacts and Adaptation Research Network, 2006. *Adapting to Climate Change – An Introduction for Canadian Municipalities*. www.c-ciarn.ca/pdf/adaptations_e.pdf.

CCSN (2009). Ensemble Scenarios for Canada, 2009. Produced by the Canadian Climate Change Scenarios Network (CCCSN.CA). Editor: N. Comer. Adaptation and Impacts Research Division, Environment Canada.

Centre for Indigenous Environmental Resources, 2006. *Climate Change and First Nations: Recommendations for Action*. www.cier.ca/WorkArea/showcontent.aspx?id=1252.

Chang, Heejun and Sarah Praskievicz. "A review of hydrological modeling of basin-scale climate change and urban development impacts." *Progress in Physical Geography*, 2009, 650-671

City of Toronto, 2009. Toronto home retrofitted to protect against basement flooding. http://wx.toronto.ca/inter/it/newsrel.nsf/bydate/32D924D23E73985985257617004A8231

Colombo, S.J., 2008. *Forests and Forestry in a Changing Climate. Climate Change*. Climate Change Research Report CCRR-12. www.mnr.gov.on.ca/258779.pdf

Environment Canada, "*Increase of Hot Days in Toronto*", *Science & Impacts of Climate Change: Presentation Graphics*, 2002

Grand River Conservation Authority, 1996. *Upper Grand River Fisheries Inventory*.

Greater London Authority. 2005. *Adapting to climate change: a checklist for development*. London: Greater London Authority London Climate Change Partnership.

Insurance Bureau of Canada. *Basement Flooding is on the rise – are you prepared?* www.ibc.ca/en/Natural_Disasters/documents/climchange_brochure.pdf.

IPCC, 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.). Cambridge: Cambridge University Press.

IPCC, 2007. *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge: University Press.

Lemmen, D.S., F.J.Warren, J. Lacroix, and E. Bush, (eds). 2008. *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Ottawa: Government of Canada.

Lemieux, C.J., D.J. Scott, P.A. Gray, and R. Davis, 2007. *Climate Change and Ontario's Provincial Parks: Towards an Adaptation Strategy*. Climate Change Research Report CCRR-06. www.mnr.gov.on.ca/198260.pdf.

Mickwitz, P. et al, 2009. *Climate Policy Integration, Coherence and Governance*. PEER Report No. 2 Helsinki: Partnership for European Environmental Research. Sastamala: Vammdan Kirjapaino OY.

Mortsch, L., E. Snell, and J. Ingram, 2006. "Climate variability and changes within the context of the Great Lakes Basin" in *Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Response to Adaptation Strategies*. L. Mortsch, J. Ingram, A. Hebb and S. Doka (eds). Toronto: Environment Canada and the Department of Fisheries and Oceans Canada.

Nakicenovic N., et al., 2000. *IPCC Special Report on Emissions Scenarios*. Cambridge: Cambridge University Press.

Ontario Medical Assocation, 2008. Ontario's Doctors: Thousands of Premature Deaths due to Smog. www.oma.org/media/news/pr080606a.asp.

Ontario Medical Association, 2005. *The illness costs of air pollution: 2005-2026 health and economic damage estimates*. Toronto: Ontario Medical Association.

Ontario Ministry of Agriculture, Food and Rural Affairs. *Summary of Agriculture Statistics for Ontario*. www.omafra.gov.on.ca/english/stats/agriculture_summary.pdf.

Ontario Ministry of the Environment, 2005. *Transboundary Air Pollution in Ontario*. www.ene.gov.on.ca/envision/techdocs/5158e.pdf.

Ontario Ministry of the Environment, 2009. *Healthy Great Lakes, Strong Ontario*. www.ene.gov.on.ca/envision/env_reg/er/documents/2009/010-6105.pdf.

Ontario Ministry of Natural Resources, 2009. *The Far North for Ontario*. www.mnr.gov.on.ca/273362.pdf.

Ontario Ministry of Tourism, 2008. *Ontario Tourism Facts & Figures*. www.tourism.gov.on.ca/english/research/figures/Facts_&_Figures_Vol7_No4.pdf.

Reid, S., Smit. B., Caldwell, W., and Belliveau, S., 2007. Vulnerability and adaptation to climate risks in Ontario agriculture. *Mitigation and Adaptation Strategies for Global Change*. 12 (4): 609-637.

Schipper, E. Lisa F. and Ian Burton (eds), 2009 *The Earthscan Reader on Adaptation to Climate Change*. London: Earthscan

Scott, D. and Jones, B. 2006. Climate Change & Seasonality in Canadian Outdoor Recreation and Tourism. Waterloo, University of Waterloo, Department of Geography.

Seguin, Jacinthe, (ed), 2008. *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*. Ottawa: Government of Canada.

Smit, B. et al, 2001. "Adaptation to climate change in the context of sustainable development and equity" in *Climate Change 2001: Impacts, Adaptation, and Vulnerability* (Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J.J. McCarthy, O. Canziani, N.A. Leary, D.J. Dokken and S.K.White (eds). Cambridge and New York: Cambridge University Press.

Statistics Canada, 2008. *Study: The age of public infrastructure, a provincial perspective*. www.statcan.ca/Daily/English/080213/d080213a.htm.

Swart, R. et al, 2009. *Europe Adapts to Climate Change: Comparing National Adaptation Strategies*. Peer Report 1 Helsinki: Partnership for European Environmental Research. Sastamal: Vammalan Kirjapaino Oy.

UKCIP. Adaptation Wizard. www.ukcip.org.uk/wizard

Varrin, R., J. Bowman, and P.A. Gray, 2007. *The Known and Potential Impacts of climate Change on Biodiversity in Recommendations for Adaptation.* Climate Change Research Report CCRR-09. www.mnr.gov.on.ca/196749.pdf.

Williamson, T.B.; et al, *Climate change and Canada's forests: from impacts to adaptation*. Edmonton: Natural Resources Canada, Canadian Forest Service and Northern Forestry Centre.

Willows, R. and Connell, R. (eds.), 2003. Climate Adaptation: Risk, Uncertainty and Decision-Making. UKCIP Technical Report. UKCIP, Oxford. 164pp. http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf

Working Group on Environmental Education, 2007. *Shaping Our Schools Shaping Our Future: Environmental Education in Ontario Schools*. www.edu.gov.on.ca/curriculumcouncil/shapingSchools.pdf.

Appendices

Appendices

Appendix A
Panel Member Bios

Dr. Ian Burton is an Independent Scholar and Consultant. He is an Emeritus Professor at the University of Toronto and a Scientist Emeritus with the Meteorological Service of Canada's Impacts and Adaptation Research Group. He was among the group of authors of the recent IPCC report who shared the 2007 Nobel Peace Prize with former U.S. Vice-President Al Gore. Ian has recently served as a consultant on climate change adaptation with the World Bank and the Secretariat of the UN Framework Convention on Climate Change. His main work now deals with the use of science in the policy process. Dr. Burton has also served as senior advisor to the International Development Research Centre and as a consultant to

UNESCO, the World Health Organization, the United Nations Environment Programme, US-AID, as well as with Environment Canada, Natural Resources Canada, and Health Canada and other Canadian government agencies and engineering firms. He has worked for the Ford Foundation in India, Sudan, and Nigeria and is a Fellow of the Royal Society of Canada and the World Academy of Arts and Sciences.

Dr. David Pearson is Professor of Earth Sciences at Laurentian University and member of the Cooperative Freshwater Ecology Unit at Laurentian University with an interest in Sudbury lakes, and Co-Director of the Laurentian University/Science North Graduate Diploma program in Science Communication. From 1980-84 Dr. Pearson was the Project Director for Science North, the science centre in Sudbury. He has also hosted two TV series: "Understanding the Earth" (TV Ontario) and "Down to Earth" (MidCanada TV); and was the scientist for CBC Northern Ontario's weekly "Radio Lab" program from 1981 to 1995. In 2000, he was awarded the Ward Neale Medal by the Geological Association of Canada for his contribution to public awareness of the geosciences in Canada. In 2003 he was awarded the prestigious McNeil Medal for the Public Awareness of Science by the Royal Society of Canada for extraordinary achievement in communication of science to students and the public.

In October 2004, **Grand Council Chief John Beaucage** was elected to serve the 42-member First Nations of the Anishinabek Nation. John was re-elected in 2006, by acclamation, a rare occurrence in the history of one of Canada's oldest political organizations. Prior to his election as Grand Council Chief, Beaucage was the elected Chief of Wasauksing First Nation and served in that capacity for eight years.

Beaucage is a graduate of the University of Western Ontario with a combined degree in English and economics, and he has done post-graduate work in First Nation planning at the University of British Columbia. He also was the recipient of a Honourary Doctor of Letters from Nipissing University in the 2009 Convocation. An economist by education, Beaucage worked for the Canada Mortgage and Housing Corporation (CMHC) for over 15 years in Ottawa, Thunder Bay, Toronto, Regina and Saint John, New Brunswick.

Grand Council Chief Beaucage played an instrumental role in the First Ministers' Meeting which took place in Kelowna, BC in November of 2005. Leading up to the First Ministers' Meeting, Beaucage served as the Co-chair for First Ministers' Working Groups for both Housing and Relationships.

In May of 2008, Beaucage was appointed Chairperson of the First Nations Market Housing Fund. The $300 million Fund was first announced in Budget 2007 and is a new and innovative way to give First Nations citizens the opportunity to own their homes on reserve.

Since leaving his position as Grand Council Chief, Beaucage is now working on developing green energy projects with a number of First Nations across the country.

Eyaabay (his traditional name) is a Pipe Carrier from the Bear Clan. A citizen of Wasauksing First Nation, he was raised on the Shawanaga First Nation and has extended family in Nipissing First Nation.

John and his wife Bonnie have been married for 37 years and have three children (Corey, Kimberly, Denys) and eight grandchildren.

Alain Bourque has a BSc in meteorology from McGill (1989) and a master in atmospheric science from Université du Québec à Montréal (UQAM, 1996). He was a meteorologist then climatologist with Environment Canada from 1989 to 2001 where he was involved in various activities related to the impacts of climate change and extreme weather, including the analyses of the 1996 Saguenay flooding and the 1998 Ice Storm. He has established and is currently coordinating the impacts and adaptation scientific program of the Ouranos Consortium since its creation in 2001. Ouranos is a consortium based in Montreal working on regional climatology and adaptation to climate change. He has published and contributed to various work on climate change and its impact including being the main author of the Quebec chapter of the Canadian Government assessment *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Additionally he contributed to the first Canadian assessment published in 1997, and reviewed the 2007 IPCC chapter on North America. Over the years, M. Bourque has made well over 300 presentations on climate change to a wide ranging audience.

Quentin Chiotti was appointed the Climate Change Programme Director at Pollution Probe in April 2007. He has a Ph. D. in Geography from the University of Western Ontario, and has worked extensively in the area of climate change since 1993, including working for the Adaptation and Impacts Research Group of the Meteorological Service of Canada, Environment Canada (1995-2002). From 1998 - 2002 he was the scientific authority for an Environment Canada led multi-stakeholder study on atmospheric change in the Toronto-Niagara Region. During this period he split his time between Environment Canada and Pollution Probe before joining the latter full time as the Air Programme Director and Senior Scientist in June, 2002.

He has published over 45 articles in scholarly journals and books, including co-editing a book on agricultural restructuring and sustainability, and was a contributor to the Canada Country Study, the first national assessment on climate change impacts and adaptation. He is the co-lead author for the Ontario chapter to the report *From Impacts to Adaptation: Canada in a Changing Climate 2007* led by Natural Resources Canada, and is a contributing author to the 2008 Report *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity* led by Health Canada.

Dr. Chiotti has taught at various Universities across Canada (University of Guelph, Carleton University, The University of Lethbridge, and the University of Toronto), is currently an associate member of the Graduate Faculty at the Centre for Environment, University of Toronto, and was the recipient of the 2007 Canadian Association of Geographers Award for Service to Government or Business.

Quentin has been a member of over twenty environment-related advisory boards and committees, that currently includes the Clean Air Foundation, the Management Committee of the Air Quality Health Index, Health Canada's Heat Alert and Response Systems Advisory Group, and the Clean Air Regulatory Framework Multistakeholder Group.

Dr. Judith Read Guernsey is Director of the CIHR Atlantic RURAL Centre on Physical and Social Environments and Health and Interim Head of the Department of Community Health and Epidemiology at Dalhousie University. Her research encompasses theoretical and policy implications of living in rural and remote environments and implications for health. She is a member of the Environment Canada Atlantic

Environmental Sciences Network, the Public Health Agency of Canada National Collaborating Centre on Environmental Health and the Canadian Population Health Initiative Council. She also serves as Director for the Atlantic Aerosol Research Node for the Canadian Aerosol Research Network, funded by the Canadian Foundation for Innovation. Previously, she was on the US Institute of Medicine Scientific Advisory Panel on Damp Indoor Spaces and Health. Dr. Guernsey has written and co-authored over 100 professional papers, technical reports and abstracts. She has been recognized for her work as Past Chair of the Occupational Epidemiology Committee for the American Industrial Hygiene Association and is listed in Who's Who in Industrial Hygiene.

David Lapp graduated with a bachelor's degree in geological engineering from the University of Toronto in 1978. He is a professional engineer, registered in Ontario and presently works as Manager, Professional Practice with Engineers Canada and has been part of the Secretariat to the Canadian Engineering Qualifications Board since 1997.

His current work focuses on environment and sustainability issues as they relate to the practice of engineering. He has worked in the area of climate change adaptation and engineering since 2001. Responsibilities include the implementation of a 2004 engineer's national action plan on climate change impact and adaptation, including a long-term project to evaluate the engineering vulnerability of public infrastructure to the impacts of climate change. Since 2007, David provides the Secretariat for the World Federation of Engineering Organizations Standing Committee on Engineering and the Environment, chaired by Engineers Canada.

Eva Ligeti is Executive Director of the Clean Air Partnership and Moderator of the Greater Toronto Clean Air Council. She is a co-chair of the Toronto City Summit Alliance Greening Greater Toronto Project, a lead author of the First International Panel on Climate Change in Cities (IPC3) Assessment Report and a member of the Steering Committee of Urban Climate Change Research Network (UCCRN) an international coalition of urban climate researchers. An adjunct professor at the University of Toronto, she teaches environmental law in the Graduate Program in Environmental Science. She served as Ontario's first Environmental Commissioner. She is a past principal at Seneca College of Applied Arts and Technology and former chair of its School of Legal and Public Administration.

Dr. Gordon McBean is a Professor and Director of Policy Studies for The Institute for Catastrophic Loss Reduction at The University of Western Ontario. He is Chair of Board of the Canadian Foundation for Climate and Atmospheric Sciences; Chair, International Science Committee for Integrated Research on Disaster Risk; and member of: Board of the International Institute for Sustainable Development; Ontario Premier's Climate Change Advisory Panel; Ontario Ministry of Environment's Expert Panel on Climate Change Adaptation; City of London's Mayor's Sustainable Energy Council; and other national and international committees. As a lead author and review editor for the Intergovernmental Panel on Climate Change, he shared in the awarding of the 2007 Nobel Peace Prize to the IPCC. He is: a Member of the Order of Canada; a Fellow of the: Royal Society of Canada; Canadian Meteorological and Oceanographic Society; and American Meteorological Society; and received the Patterson Medal for distinguish contributions to meteorology by a Canadian.

Jo-Ellen Parry is Manager of the Climate Change and Energy Program within the International Institute for Sustainable Development. Her work on adaptation focuses primarily at the international level, including analysis of the inter-linkages between adaptation and development, the future of adaptation within the international climate change regime, and management of pilot adaptation projects in eastern and southern Africa.

Dr. Barry Smit is a Professor at the University of Guelph and holds the Canada Research Chair in Global Environmental Change. He also serves as Director of the Canadian Climate Impacts and Adaptation Research Network – Agriculture. Dr. Smit has acted as a consultant to Canadian agencies including Canadian International Development Agency and several federal and provincial government departments. He has also advised international organizations including United Nations Environment Program and received a share of the Nobel Peace prize for his recent work on the IPCC report.

Appendix B
Presentations to the Expert Panel on Climate Change Adaptation

March 4, 2008

Climate Change Adaptation and Drinking Water

- Keith West, Acting ADM, Drinking Water Management Division and Chief Drinking Water Inspector, Ministry of the Environment
- Ian Smith, Director, Source Protection Programs Branch, Drinking Water Management Division, Ministry of the Environment
- Carolyn O'Neill, Acting Director, Land and Water Policy Branch, Integrated Environmental Policy Division, Ministry of the Environment

May 26-27, 2008

Climate Change and Water: Helping Ontarians Adapt to Climate Change

- David Lindsay, Deputy Minister, Ministry of Natural Resources
- Dan Marinigh, Acting Director, Lands and Waters Branch, Natural Resources Management Division, Ministry of Natural Resources
- Paul Gray, Senior Adviser – Climate Change, Applied Research and Development Branch, Science and Information Resources Division, Ministry of Natural Resources

Expert Panel on Climate Change Adaptation
Ministry of Transportation

- Gerry Chaput, Chief Engineer, Highway Standards Branch, Provincial Highways Management Division, Ministry of Transportation
- Linda McAusland, Acting Director, Transportation Policy Branch, Policy and Planning Division, Ministry of Transportation

PIR and Climate Change Adaptation

- Carol Layton, Deputy Minister, Ministry of Public Infrastructure Renewal
- Bill Hughes, Assistant Deputy Minister, Infrastructure Policy and Planning Division, Ministry of Public Infrastructure Renewal

Mainstreaming Climate Change into Land and Water Policies of the Ministry of the Environment

- Sharon Bailey, Director, Land and Water Policy Branch, Integrated Environmental Policy Division, Ministry of the Environment
- Carolyn O'Neill, Manager, Great Lakes Office, Land and Water Policy Branch, Integrated Environmental Policy Division, Ministry of the Environment

Assessment of the Provincial Groundwater and Stream Water Monitoring Network Programs for Climate Change Adaptation Planning

- Carl Griffith, Assistant Deputy Minister, Environmental Sciences and Standards Division, Ministry of the Environment
- Deborah Conrod, Supervisor, Groundwater and Stream Water Monitoring, Environmental Monitoring and Reporting Branch, Environmental Sciences and Standards Division, Ministry of the Environment

Climate Change and Source Protection Planning: Action Plan

- Keith West, Acting ADM, Drinking Water Management Division and Chief Drinking Water Inspector, Ministry of the Environment
- Ian Smith, Director, Source Protection Programs Branch, Drinking Water Management Division, Ministry of the Environment

Ministry of Municipal Affairs and Housing
Presentation to Expert Panel on Climate Change Adaptation

- Audrey Bennett, Director, Provincial Planning Policy Branch, Local Government and Planning Policy Division, Ministry of Municipal Affairs and Housing
- David Brezer, Director, Building and Development Branch, Municipal Services Division, Ministry of Municipal Affairs and Housing
- Diana Jardine, Director, Municipal Programs and Education Branch, Municipal Services Division, Ministry of Municipal Affairs and Housing

Health and Climate Change Adaptation

- Brenda Mitchell, Director, Environmental Health, Ministry of Health and Long Term Care
- Dr. Brian Gibson, Senior Medical Consultant, Environmental Health
- Tiffany Jay, Acting Director, Emergency Management Unit, Public Health Division, Ministry of Health and Long Term Care

Addressing the Health Effects of Climate Change: Family Physicians are Key

- Jan Kasperski, CEO, Ontario College of Family Physicians
- Dr. Val Rachlis, Past-President, Ontario College of Family Physicians
- Dr. Alan Abelsohn, Member of Environmental Health Committee, Ontario College of Family Physicians
- Dr. David Rosen, Member of Environmental Health Committee, Ontario College of Family Physicians

September 25, 2008

OMAFRA and Climate Change Adaptation

- Bruce Archibald, Deputy Minister, Ministry of Agriculture, Food and Rural Affairs
- Dave Antle, Assistant Deputy Minister, Policy Division, Ministry of Agriculture, Food and Rural Affairs

Capital Planning 2009-2010

- Adrian Franko, Director, Infrastructure Planning and Budgeting Branch, Infrastructure Planning and Policy Division, Ministry of Energy and Infrastructure
- Kelly Shields, Acting Director, Strategic Policy Branch, Infrastructure Planning and Policy Division, Ministry of Energy and Infrastructure

Intensity, Duration and Frequency Curves

- Gerry Chaput, Chief Engineer, Highway Standards Branch, Provincial Highways Management Division, Ministry of Transportation
- Linda McAusland, Acting Director, Transportation Policy Branch, Policy and Planning Division, Ministry of Transportation

Mainstreaming Climate Change Adaptation into Ontario's Emergency Management Framework

- Dr. Aadu Pilt, Senior Scientist, Operations and Analysis, Emergency Management Ontario

Ministry of Northern Development and Mines
Ontario's Expert Panel on Climate Change Adaptation

- Kevin Costante, Deputy Minister, Ministry of Northern Development and Mines
- Ken Steele, Senior Policy Advisor, Corporate Policy Secretariat, Ministry of Northern Development and Mines

Ontario Centre for Climate Impacts and Adaptation Resources

- Al Douglas, Coordinator, Ontario Centre for Climate Impacts and Adaptation Resources

November 26-27, 2008

Climate Change Monitoring and Modelling in Ontario

- Carl Griffith, Assistant Deputy Minister, Environmental Sciences and Standards Division, Ministry of the Environment
- John Mayes, Director, Environmental Monitoring and Reporting Branch, Environmental Sciences and Standards Division, Ministry of the Environment

Climate Change Adaptation: Overview of the Provincial Policy Statement, 2005, Greenbelt Plan and Implementation Tools

- Audrey Bennett, Director, Provincial Planning Policy Branch, Local Government and Planning Policy Division, Ministry of Municipal Affairs and Housing

Ministry of Health and Long Term Care

- Allison Stewart, Acting Assistant Deputy Minister, Ministry of Health and Long Term Care
- Brenda Mitchell, Director, Environmental Health, Ministry of Health and Long Term Care

Climate Change Adaptation and Ontario Tourism

- Philip Howell, Deputy Minister, Ministry of Tourism

Climate Change Adaptation and Ontario's Electricity Sector

- Kaili Sermat-Harding, Director, Strategic Policy Branch, Ministry of Energy and Infrastructure
- Rick Jennings, Assistant Deputy Minister – Energy Supply, Transmission and Distribution Policy, Ministry of Energy and Infrastructure

Climate Change Forest Adaptation in Ontario

- David Lindsay, Deputy Minister, Ministry of Natural Resources
- Bill Thornton, Assistant Deputy Minister – Forests Division, Ministry of Natural Resources

Climate Change and Ontario's Fisheries

- David Lindsay, Deputy Minister, Ministry of Natural Resources
- Warren I. Dunlop, Senior Aquatic Ecologist, Fish and Wildlife Branch, Natural Resource Management Division, Ministry of Natural Resources

Climate Change Considerations for Land Use Planning in Ontario's Far North

- David Lindsay, Deputy Minister, Ministry of Natural Resources
- Afsana Qureshi, Far North Policy Manager, Far North Branch, Ministry of Natural Resources

Developing a Growth Plan for Northern Ontario

- Liz Zanetti, Manager, Northern Ontario Growth Plan Unit, Strategic Development Branch, Northern Development Division, Ministry of Northern Development and Mines
- Ken Steele, Senior Policy Advisor, Corporate Policy Secretariat, Ministry of Northern Development and Mines

Lake Simcoe Protection Plan

- John Lieou, Assistant Deputy Minister, Integrated Environmental Policy Division
- Sharon Bailey, Director, Land and Water Policy Branch, Integrated Environmental Policy Division

Hot, Flat and Crowded

- Hugh MacLeod – Associate Deputy Minister, Climate Change Secretariat, Cabinet Office

January 21-22, 2009

Ministry of Municipal Affairs and Housing
Presentation to Expert Panel on Climate Change Adaptation

- Audrey Bennett, Director, Provincial Planning Policy Branch, Local Government and Planning Policy Division, Ministry of Municipal Affairs and Housing
- Ralph Walton, Director, Local Government Policy Branch, Local Government and Planning Policy Division, Ministry of Municipal Affairs and Housing

Growth Plan for the Greater Golden Horseshoe

- Brad Graham, Assistant Deputy Minister – Ontario Growth Secretariat, Ministry of Energy and Infrastructure
- Tija Dirks, Director, Growth Policy, Planning and Analysis Branch, Ontario Growth Secretariat, Ministry of Energy and Infrastructure
- Hanna Evans, Director, Partnerships & Consultation Branch, Ontario Growth Secretariat, Ministry of Energy and Infrastructure

Climate Change Adaptation in Curriculum

- Sue Durst, Director, Curriculum and Assessment Policy Branch, Learning and Curriculum Division, Ministry of Education
- Karen Gill, Manager, Implementation and Review Unit, Learning and Curriculum Division, Ministry of Education

Ministry of Research and Innovation
A Ministry Overview for the Expert Panel on Climate Change Adaptation

- George Ross, Deputy Minister, Ministry of Research and Innovation
- Tony Vander Voet, Acting Assistant Deputy Minister – Science and Research Division, Ministry of Research and Innovation
- Tony Rockingham, Assistant Deputy Minister – Innovation and Commercialization Division, Ministry of Research and Innovation

Presentation to Ontario's Expert Panel on Climate Change Adaptation

- Philip Howell, Deputy Minister, Ministry of Economic Development
- Reed Barrett, Director, Sector Competitiveness Branch, Industry Division, Ministry of Economic Development
- Fernando Traficante, Director, Next Generation of Jobs Fund Secretariat, Ministry of Economic Development

Environmental Protection in Ontario

- Michael Williams, Assistant Deputy Minister, Operations Division, Ministry of the Environment

Overview of Environmental Assessment in Ontario

- Agatha Garcia-Wright, Director, Environmental Assessment, Operations Division, Ministry of the Environment

Overview of Environmental Approvals in Ontario

- Doris Dumais, Director, Approvals, Operations Division, Ministry of the Environment

The Ministry of the Environment's Role in Emergency Management

- Mary Hennessy, Director, Operations Integration Branch, Operations Division, Ministry of the Environment

Provincial Water Quantity Management and Climate Change Adaptation – Context

- Sharon Bailey, Director, Land and Water Policy Branch, Integrated Environmental Policy Division, Ministry of the Environment

Mainstreaming Climate Change into the Permit to Take Water Program

- Anne Neary, Director, SW Region, Operations Division, Ministry of the Environment

Developing Water Conservation & Efficiency Strategy for Ontario

- Carol Salisbury, Senior Policy Advisor, Land and Water Policy Branch, Integrated Environmental Policy Division, Ministry of the Environment

Ontario Low Water Program

- David Lindsay, Deputy Minister, Ministry of Natural Resources
- Dan Marinigh, Director, Lands and Waters Branch, Natural Resources Management Division, Ministry of Natural Resources

February 19-20, 2009

Ministry of Aboriginal Affairs
Presentation to the Expert Panel on Climate Change Adaptation

- Lori Sterling, Deputy Minister, Ministry of Aboriginal Affairs
- Alison Pilla, Assistant Deputy Minister – Strategic Policy & Planning Division, Ministry of Aboriginal Affairs

Eden Mills Going Carbon Neutral

- Libby Little

Adapting to Climate Change Conservation Authorities on the Front Line

- Don Pearson, General Manager, Conservation Ontario
- Paul Emerson, Chief Administrative Officer, Grand River Conservation Authority

Cabinet Office – Policy Process

- Betty Papa, Policy Advisor, Economic, Environment, Justice and Intergovernmental Policy, Cabinet Office

Environmental Commissioner of Ontario

- Gord Miller, Environmental Commissioner of Ontario

The Ministry of Finance: Planning and Budget Process

- Peter Wallace, Deputy Minister, Finance and Secretary of the Treasury Board, Ministry of Finance

April 16, 2009

Presentation to Expert Panel on Climate Change Adaptation

- Saad Rafi, Deputy Minister, Ministry of Energy and Infrastructure

Adaptation: Placing Ecosystems First

- Janet Sumner, Executive Director, Wildlands League
- Trevor Hesselink, Director, Forests Program, Wildlands League

Adapting *to* Climate Change *in* Ontario