Standing Senate Committee on Agriculture and Forestry

Comité sénatorial permanent de l'agriculture et des forêts

CLIMATE CHANGE: WE ARE AT RISK

INTERIM REPORT

The Honourable Donald Oliver, Q.C.
Chair

The Honourable John Wiebe
Deputy Chair

June 2003

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THE STANDING SENATE COMMITTEE ON AGRICULTURE AND FORESTRY

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ORDER OF REFERENCE

Extract of the *Journals of the Senate*, Thursday, October 31, 2002:

The Honourable Senator Wiebe moved, seconded by the Honourable Senator Chalifoux:

That the Standing Senate Committee on Agriculture and Forestry be authorized to examine the impact of climate change on Canada's agriculture, forests and rural communities and the potential adaptation options focusing on primary production, practices, technologies, ecosystems and other related areas;

That the papers and evidence received and taken on the subject and the work accomplished by the Standing Senate Committee on Agriculture and Forestry during the First Session of the Thirty-Seventh Parliament be referred to the Committee and;

That the Committee submit its final report no later than December 31, 2003.

The question being put on the motion, it was adopted.

Paul C. Bélisle

Clerk of the Senate

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LIST OF ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
APF	Agriculture Policy Framework
C-CIARN	Canadian Climate Change Impact and Adaptation Research Network
CCAF	Climate Change Action Fund
CCPC	Climate Change Plan for Canada
CFA	Canadian Federation of Agriculture
CFS	Canadian Forest Service
CO_2	Carbon dioxide
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
N_20	Nitrous oxide
PARC	Prairie Adaptation Research Collaborative
PFRA	Prairie Farm Rehabilitation Administration
WISE	Water Institute for Semi-arid Ecosystems

FOREWORD

From November 2002 to May 2003, the Senate Standing Committee on Agriculture and Forestry examined the effects of climate change on Canada's agricultural and forestry sectors and rural communities. This study is a direct result of the Committee's previous study, *Canadian Farmers at Risk*.[1] As part of that study, the Committee travelled to the Maritimes to hear from farmers about their concerns. Farmers repeatedly expressed apprehension about changes in climate and were unsure as to how they could cope with – or adapt to – apparently new climate scenarios.

After identifying the leading researchers in the field of climate change and adaptation in Canada and abroad, the Committee heard from witnesses at the forefront in this area from universities, research centres, and governments across Canada as well as internationally. The Committee took a country-wide approach and actively sought the views of farmer organizations, rural associations, ecotourism groups, and environmental and conservation organizations from all regions of Canada. The Committee held hearings in Ottawa and travelled to Saskatchewan, Alberta, and British Columbia (see the Appendix for a complete list of witnesses). Throughout the hearings, the Committee was especially interested in learning about effective adaptation strategies for Canadians.

Farmers, forest operators and rural communities are already facing and adapting to a wide range of risks and opportunities that arise from changes in market conditions, domestic regulations, trade policies, technology, and other factors. This study thus extends the work presented in the Committee's last report, *Canadian Farmers at Risk*, which examined short- and long-term issues affecting the health of Canada's agricultural and agri-food industry.

This interim report expresses the views and concerns of the various witnesses. The Committee will release a final report in October 2003. That report will provide specific recommendations to help ensure that Canada successfully responds and adapts to climate change, thereby assuring the continued prosperity of our agriculture and forestry sectors and our rural communities.

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[1] *Canadian Farmers At Risk*, Report of the Standing Senate Committee on Agriculture and Forestry. June 2002. 1st Session, 37th Parliament. Available at http://www.parl.gc.ca/37/1/parlbus/commbus/senate/com-e/agri-e/rep-e/rep10jun02-e.htm.

EXECUTIVE SUMMARY

Chapter 1: Introduction

The Saguenay flood of 1996, the Red River flood of 1997, and the 1998 ice storm dominated the lives of several million Canadians and resulted in unprecedented numbers of weather-related insurance claims. Weather affects our daily lives, sometimes dramatically, as illustrated by these recent extreme weather events. Climate is different from weather: climate refers to *average* meteorological conditions – temperature, precipitation, and wind patterns, amongst other variables. But climate, too, can change, although the changes are apparent only over long periods of time.

Historically, changes in climate have occurred at a slow enough pace that humanity has been able to adapt to them without major disruptions. There is strong evidence, however, that climate change will accelerate during the coming century at rates beyond our historical ability to adapt. The predicted impacts will include not only more frequent extreme weather events, but also long-term environmental shifts that will profoundly affect economies and lifestyles around the world. For example, the main effect of climate change is likely to be on Canada's water resources.

During the course of its last study, the Senate Standing Committee on Agriculture and Forestry heard much evidence from farmers across Canada about the 2001 drought, and how badly it had affected them. How will Canadians cope if such droughts occur more frequently in areas where before they were exceptional incidents? From November 2002 to May 2003, the Committee studied the effects of climate change on Canada's agriculture, forests, and rural communities, with an emphasis on how these can best adapt to a changing climate. This summary highlights the Committee's findings. The overview of chapter 2 provides some background on the issue of climate change, while the overviews of chapters 3 to 7 summarize the research and evidence gathered by the Committee on the potential effects of climate change on agriculture, forests, water, rural communities and Aboriginal people. Chapter 8 identifies areas for government action to help rural Canada in its adaptation efforts.

Chapter 2: Background on Climate Change

The Committee was presented with evidence that shows our climate is, indeed, changing. One of the main indicators is the global trend of warming temperatures. Much of the scientific evidence was very technical, but it is included in this chapter since it provides important background for later chapters and recommendations:

- It is accepted that the average surface temperature of the globe has increased about 0.6^{o}C in the past 100 years, over sea and land.
- None of the natural factors affecting climate provides an obvious explanation for this observed global warming.
- By now there is sufficient scientific evidence to suggest that the warming trend of the earth observed in the last century is caused by human-induced emissions of greenhouse gases such as carbon dioxide (CO_2).

- This warming trend is likely to continue at a rate unprecedented in human history, and it will have consequences at the regional level on temperature, precipitation patterns and, more importantly, the frequency of extreme weather events.
- Because the warming effect will be amplified closer to the poles, countries such as Canada will be more vulnerable. In fact, some effects are already being felt in the northern part of the country.

There are actions that Canada and other countries can take to slow this change. Essentially, we need to reduce our emissions of greenhouse gases, such as CO_2:

- The Kyoto Protocol binds industrial countries to reduce their greenhouse gas emissions. Experts agree, however, that the implementation of the Protocol will not, by itself, curb – let alone reverse – the warming trend.
- The use of forests and agricultural soils to remove greenhouse gases from the atmosphere will only be a temporary measure to help Canada meet its Kyoto commitment; it will have little effect on the overall amount of greenhouse gases in the atmosphere.
- Stabilization of greenhouse gases at levels that avoid dangerous consequences for humanity will entail drastic measures far beyond those required for the Protocol. Hydrogen must become the fuel of the future, replacing fuels such as oil that are associated with emissions of greenhouse gases in the atmosphere. This transition could be made possible by investing in nuclear and renewable sources of energy.

Experts also agree that the climate will take time to respond to the changing quantities of greenhouse gases in the atmosphere. By the time we have significantly reduced greenhouse gas emissions, the climate will already have warmed and we will have had no choice but to adapt to new climatic conditions:

- Aside from some initiatives such as Canada's Climate Change Impacts and Adaptation Program, which funds research, and the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), only limited resources have been allocated to adaptation to climate change.
- There is a need for a long-term commitment to support, fund and monitor progress toward adaptation, and the Government of Canada should take a leadership role on this issue.

General Remarks on Chapters 3, 4 and 5

The Committee received evidence from many researchers – climatologists, soil scientists, resource economists, biologists, entomologists, and others – who provided detailed information about their work on the potential effects of climate change on agriculture, forestry, and water resources, as well as their studies of potential adaptation options. Chapters 3, 4 and 5 focus on the state of knowledge about the potential effects of climate change on these three resources. In order to put the findings into perspective, the following points should be noted:

- Most of the research on the effects of climate change on agriculture, forests, and water resources uses models designed to study the planet as a whole. Model

developers told the Committee that such models are too broad to give an accurate assessment of future implications at a regional level.

- Researchers involved in the field of impact and adaptation, however, believe that these models can, indeed, yield some useful results at a smaller scale; but they agree that it remains a challenge to try to downscale findings to local levels.
- Results from these studies provide scenarios of plausible future events. They are by no means forecasts of what climate change will bring.
- The coverage of these studies has been somewhat piecemeal; they do not address the entire diversity of our country.

In light of the above-mentioned remarks, it is important that we try to develop greater accuracy and confidence regarding what will happen, and where. It is equally important that we first determine where Canada's agriculture industry and our forest industry are vulnerable, in order to be able to improve their resilience.

Chapter 3: Agriculture

Changes in climatic conditions will affect agriculture in three different ways:

- Changes in average climatic conditions will modify Canada's agricultural map. It is generally accepted that higher temperatures, and enhanced CO_2 in the atmosphere, will enable better yields, new crops and a northward extension of agricultural land. Locally, however, these benefits might be offset by a number of factors, including reduced water availability, limited soil availability in the north, increased soil erosion if droughts and floods become more frequent, increased insect outbreaks, and more vigorous weeds.
- All witnesses agreed that changes in the year to year variation in temperature and precipitation will be far more significant for the agricultural sector than changes in the average conditions. We can expect that climate change will alter the frequency of anomalous years; that is, some extreme conditions will become less frequent, while others will become more frequent. It was mentioned many times that Canada can expect more frequent and widespread droughts, particularly in the Prairies.
- The impact of climate change on the rest of the world will also have implications for Canada's agricultural sector. Many prices are determined by world markets, meaning that the economic effect on this sector in Canada will depend also on how Canadian productivity may change relative to that of other countries.

Farmers are already innovative and adapt to various stresses, including variations in weather, trade policies, and commodity prices. Historically, a range of adaptation options has been available to farmers to cope with various risks and conditions, and these options will continue to help them in the future. They are:

- technological development, including the development of new crop varieties;
- farm financial management, including crop insurance;
- farm production practices, including diversification and irrigation; and
- government programs, including support programs and taxation.

Technological development and improvements in agricultural practices will have an important role in enabling adaptation to climate change. But it is crucial that farmers also improve their capacity to deal with the risks that currently exist, in order to enhance their ability to deal with future risk, including those associated with climate change. Farmers will have to build on their strengths and identify where their farm operations are vulnerable.

Chapter 4: Forests

Climate change is also likely to affect Canada's forests in different ways:

- Researchers are not certain whether Canadian forests will experience increased or decreased productivity as a result of climate change. On one hand, a longer growing season and increased CO_2 in the atmosphere will encourage tree growth. On the other hand, increased damage to forests and trees is expected due to winter thaws and extreme weather events (violent winds, for instance), and greater risk of forest fires and insect outbreaks such as the Mountain pine beetle in British Columbia.
- Researchers also expect to see the temperate forests and the boreal forest move northward as a result of increased temperatures. A number of factors will limit this migration, however, and Canada could potentially lose species and end up with weedy and less vigorous forests.
- Such impacts of climate change on forests are likely to affect Canadian society and the economy. For instance, socio-economic effects may include changes in timber supply and rent value, changes in land values, loss of forest for recreation, and dislocation of parks and natural areas.

The effects of climate change on forests will require appropriate anticipatory adaptation from the forest sector. Notwithstanding the uncertainty about the impact of climate change on forest ecosystems over the next decades, several witnesses urged that the Canadian forest industry rapidly apply current knowledge on forest fires, insects and diseases in its long-term planning of forest operations. Current knowledge on forest fires, for example, can be used to plan for harvesting rotation.

It was also stressed that the uncertain impact of climate change on the Canadian forest industry and on the rural communities that depend on healthy forests for their well-being may represent a good opportunity for all forestry stakeholders to undertake a profound reflection about forest management of the future.

Chapter 5: Water

The main effect of climate change is likely to be on Canada's water resources. While predictions of how precipitation regimes will change are very uncertain, evidence is consistent on the following points:

- We can expect more variability in precipitation: there will be years that are wetter than normal, but there will be other years that are much drier than normal. Storms and droughts may occur more often.

- Adaptation measures will mainly concern engineering and infrastructure – irrigation, water treatment plants, etc. – but also technology to improve water use efficiency. Those measures will vary locally and will depend on the users – agriculture, forestry, tourism, etc.
- Given the demands for water by agriculture, the forest industry, and households in rural and urban areas, the evidence indicates that water-use conflicts will increase.
- If water-use conflicts increase, decision-makers will have to determine what uses are appropriate and inappropriate, and where the available water is best allocated.

Chapter 6: Rural Communities

Rural Canada is an important contributor to the country's wealth, supplying 15% of the Gross Domestic Product and 40% of Canadian exports. Because it relies largely on natural resource-based industries, rural Canada will be more vulnerable to climate change. The following points arose from the hearings:

- Over the past several decades, the population and composition of rural communities in Canada have been changing dramatically, due to migration and structural transformations in agriculture and other resource-based industries. In 2000, for example, off-farm income represented 56% of the total farm income.
- The livelihoods of rural Canadians are already stressed by low commodity prices and by trade conflicts such as the softwood lumber dispute, among other things.
- Climate change will bring additional stresses, which may aggravate those already affecting rural Canada.
- Climate change will have significant financial and economic repercussions on natural resource-based industries. If the financial basis of farming, forestry, and other natural resource-based industries is threatened, so is the viability of rural communities.
- Physical infrastructure in some communities will also be challenged by rising sea levels and increased weather-related damage.
- Social cohesion will be threatened if, among other things, water use conflicts increase.
- In order to cope with these changes, rural communities will have to start considering climate change in their planning. A starting point could be to raise their awareness of this issue, notably through participation in C-CIARN workshops. This stresses the importance of a communication strategy on climate change (chapter 8).

Chapter 7: Aboriginal People

The Committee met with elected representatives from the Metis Nation of Alberta and the Kainai Nation. Representatives from C-CIARN North also provided insights into the situation of the Inuit. The following points were highlighted:

- The knowledge and life experience of the elders have produced observations that are closely linked with recent scientific findings on the trend of climate change.
- Indigenous peoples of the North are more sensitive to climate change than non-indigenous peoples, because their homelands, culture, traditional knowledge, and hunting habitats will be directly affected.

- Partnerships among scientists, aboriginal Nations, and northern communities have increased in the past two decades, notably in regions where scientific research has been focused.
- Aboriginal people need better access to programs that would help them adapt to climate change.
- As Aboriginal people achieve rights to the management of resources and land ownership, their organizations are seeking a more meaningful role in research, outreach action, and international negotiations on climate change.

Chapter 8: What Do We Need to Do to Adapt?

While it is still too early to clearly identify effective adaptation measures that should be taken, there is room for government action. This chapter presents and discusses three areas for proactive action on climate change: research, communication, and government programs.

Research

While research on adaptation to climate change is still in its infancy, Canada is at the forefront and Canadian researchers are leading numerous international activities on this issue. Such research, however, suffers from the following problems:

- a lack of funding, relative to the funding allocated to the reduction of greenhouse gas emissions;
- a lack of suitably qualified graduate students; and
- difficulty in securing funding for research that involves many different disciplines.

Witnesses suggested various approaches to fostering research:

- enhance government research capacity;
- facilitate partnerships between research organizations;
- create research chairs on adaptation, and graduate student awards; and
- create a central facility to bring together researchers from various disciplines.

Communication

Scientific information is complex by nature, and effective communication has been a common concern at all the public hearings. Three main points emerged from the hearings:

- It is important not to sensationalize the issue and needlessly scare the public; nevertheless, the Committee would be remiss if it were to ignore the clear message from witnesses that Canada is soon likely to face much greater changes than it has experienced in the last hundred years.
- In addition to the conventional view that information must flow from researchers to the industries and communities, it is equally important that the research community learn from producers, the rural population, and Aboriginal people. As a relatively new entity, C-CIARN is beginning to initiate such two-way discussions between researchers and stakeholders.
- A single, monolithic communications plan may not be appropriate to reach rural Canada. Any communications strategy should use existing networks within rural

communities to ensure that current information is effectively distributed. The capacity for extension services to deliver information to producers and woodlot owners has been severely curtailed over the last 20 to 30 years, and should be restored.

- The access to broadband technology is also essential to rural communities to enable rural Canadians to actively search the information by themselves.

Government Programs

Current public policies such as taxation, farm programs, and provincial regulations on forest practices may either hinder or encourage adaptation efforts. In order to create a favourable environment that allows farmers and forest operators to adapt, governments should consider the following points:

- To adapt proactively to climate change, the agriculture and forest industries may require longer-term incentives that would counter the short-term ones provided by markets.
- A general goal of government policies should be to encourage the adoption of opportunities to adapt to climate change, or at the very least to avoid preventing the adoption of such opportunities. Therefore, climate change considerations should be incorporated into Canadian agricultural policy, forest management legislation, certification standards for environmentally friendly products, and other policies that are relevant to the well-being of rural communities. In doing this, we will make our industries, ecosystems, and communities less vulnerable to climatic changes, while also helping them to adapt to other stresses.

CHAPTER 1: INTRODUCTION

The Saguenay Flood of 1996

The Saguenay Flood was Canada's first $1-billion disaster. Torrential rains over Quebec's Saguenay region during 19-21 July led to flooding and mudslides that destroyed parts of Chicoutimi, Jonquière, La Baie, Ferland, and Boilleau. In a few hours, the area around La Baie, Bagotville, and Jonquière was transformed into a soup of mud. Several people died and 10,000 had to flee their homes. There were 16,000 victims in total. Most local power and about 8,000 land-line telephones were cut off, creating a widespread emergency situation.

The Red River Flood of 1997

The Canadian portion of the Red River crested at Winnipeg early on May 4, causing the worst flooding the region had seen since 1852. With more than 256,000 hectares under water across southern Manitoba and the Dakotas, about 75,000 people were forced to abandon their homes. The river turned into a huge lake, nicknamed the Red Sea, which covered 1,840 square kilometres. The eight-week ordeal caused $450 million in damage. It is estimated that damage would have exceeded $6 billion without the Red River Floodway, constructed in the 1960s to divert floodwaters around Winnipeg.

The Ice Storm of 1998

The ice storm dominated lives and landscapes in huge areas of eastern Canada during January 1998. It affected five million people – about 17 per cent of Canada's population – and stretched a distance of more than 1,000 kilometres, from Georgian Bay to the Bay of Fundy. Eastern Ontario and Quebec were pelted by freezing rain that clung to trees, power lines and transmission towers for six days. Thirty-five people died, and millions of trees were destroyed. More than a million people in Quebec and about 100,000 in Ontario were left without power for days. Insurance claim payouts approached $1.44 billion, three times the amount paid out for any other natural disaster in Canada; total costs were estimated at $2.5 billion.

The Saguenay flood of 1996, the Red River flood of 1997, and the 1998 ice storm resulted in the highest number of weather-related insurance claims ever made in Canada. Before 1998, Canadian insurers had never paid out more than $500 million for natural disaster claims in any year. Costs related to natural disasters were 65% higher from 1993 to 1998 than in the previous five-year period.

Droughts Since 1999

1999:

Atlantic Canada's drought in 1999 wilted crops and parched livestock, and resulted in some of the lowest rainfall totals in 50 years.

2000:

In southern Alberta, many dryland grain producers suffered significant crop failures, regardless of whether they had access to irrigation. Lethbridge received no rain for over 60 days.

2001:

Drought affected the whole country: the growing season was the driest in Canada in 34 years. Southern Alberta suffered its driest year in more than 130 years. The 2001-2002 winter was not only the eighth-warmest winter in more than half a century, but also one of the driest.

2002:

While Southern Alberta experienced flash flooding, intensive drought continued through the rest of the province.

What is Climate?

Weather affects our daily lives, sometimes dramatically, as illustrated by recent extreme weather events in Canada. Weather can also vary drastically from one year to another. This unpredictability compounds the risks faced by weather-dependent sectors such as farming and forestry. Managers in these sectors have to make investment decisions without being certain of the weather for the next week, or even the next day. Farmers, in particular, must make decisions without knowing what meteorological conditions will occur for the upcoming growing season on which their annual income may depend.

Climate, however, is different from weather. Climate refers to *average* meteorological conditions – temperature, precipitation, and wind patterns, amongst other variables. Climate is not stable, but changes are apparent only over long periods of time, including shifts between glacial and interglacial periods. Historically, changes in climate have occurred at a slow enough pace that humanity has been able to adapt to them without major disruptions. For example, since the middle of the 20th century, we have seen a northward expansion of crop varieties as a result of warming conditions and research developments; winter wheat, almost unheard of in Western Canada in the 1960s, has expanded in the Canadian Prairies. There is strong evidence, however, that the rate of climate change will accelerate in the next century at rates beyond those we historically had ability to adapt to. For example, models suggest that the earth's temperature will rise by 1.4^{o}C to 5.8^{o}C over the next 100 years, an increase that is unprecedented in human history.

Why is Climate Change Important?

During the course of its last study, the Senate Standing Committee on Agriculture and Forestry heard much evidence from farmers across Canada about the 2001 drought, and

how badly it had affected them. How will Canadians cope if such droughts occur more frequently in areas where before they were exceptional incidents? The projected change in climate will bring many changes in precipitation patterns and wind patterns – in short, increased weather variability from year to year. ***This variability is predicted to be unlike what farmers, the forest industry, and rural communities have faced before.***

Canada's agricultural and forest industries, and our rural communities, must prepare themselves for these climatic changes. Our challenge is to be able to adapt to the predicted changes in climate. From November 2002 to May 2003, the Committee heard from a variety of stakeholders – researchers at universities, government organizations, and institutes in Canada, the United States, and the United Kingdom; farmers, commodity groups, and foresters; conservation and nature groups, and eco-tourism groups; representatives from rural communities; and Aboriginal people. ***The Committee was pleased to learn that Canadian scientists are at the forefront of climate change research, and that our climate change models are considered amongst the best in the world.***

Focus on Adaptation

While the Committee gathered evidence of the effects of climate change, its causes, and mitigation efforts, it became clear that our agriculture and forest industries must adapt to new climate conditions. Mitigation and adaptation must go hand-in-hand for Canadians to cope successfully with our changing climate. Unfortunately, very few concrete adaptation strategies have been developed for our agriculture and forest industries. The Committee was struck by the limited resources that have been allocated to adaptation research, in comparison to the funds spent on mitigation techniques. In fact, this study marks the first time a public forum has been held in Canada on the issue of adaptation to what is commonly referred to as the biggest environmental challenge facing our planet.

This revelation was especially disconcerting given that the Government of Canada's own *Climate Change Action Plan* specifically recognizes that "adaptation to climate change will be required regardless of the success of actions to reduce emissions" (p. 51). ***In examining the impact of climate change on Canada's agriculture, forests, and rural communities, it became clear to the Committee that adaptation strategies must be given a more central focus in order to ensure that these industries and communities continue to thrive in the future.***

CHAPTER 2:
BACKGROUND ON CLIMATE CHANGE

> **"The general public now has the impression that the science of climate change is swinging like a pendulum, from being real to not real, depending on which issue of Nature came out. Of course, this is not what climate science is about. […] climate science is on very firm footing […] and it is not something that we are going to solve overnight with one policy like Kyoto. It will require much more extensive policy options in the future."**
>
> *Dr. Andrew Weaver, Professor,*
> *School of Earth and Ocean Sciences, University of Victoria.*[2]

The Committee heard from many researchers from across Canada, the United States, and the United Kingdom. Much of their scientific evidence was very technical, but essential for this study. Their evidence is summarized in this chapter; although much of this chapter is technical, it provides important background for later chapters and recommendations.

The Committee was presented with the evidence that shows our climate is changing. One of the main indicators is the global trend of warming temperature. The predicted increase in the earth's average temperature is between 1.4°C and 5.8°C over the next 100 years. While this may not seem to be a big change, it is actually extremely large. Between the last Ice Age and today, the average global temperature has changed only 3.5 °C. These human-induced changes to our climate will have an effect on our agriculture, our forests, and our rural communities. For example, the changing climate does not just mean temperatures will change, but so will precipitation patterns. Thus, by no means is temperature the only issue – water resources may become the most important concern for Canadians and humanity.

There are things we can do to slow this change – essentially we need to reduce our emissions of greenhouse gases, gases like carbon dioxide (CO_2). While this reduction is required, it will not be sufficient. Since the Industrial Revolution in the latter half of the 1800s, we have set in motion this change in climate. Circumpolar countries like Canada will be more dramatically affected than other parts of the earth, thus it is all the more essential that Canadians develop strategies to adapt to this new climate regime.

[2] Standing Senate Committee on Agriculture and Forestry, Issue No. 12, 2nd Session, 37th Parliament, Vancouver, February 28, 2003, Afternoon session.

A. Our Climate is Changing…

Evidence from a variety of sources, such as Antarctic ice cores, provide us with data going back thousands of years. These data strongly suggest that the concentration of carbon dioxide in our atmosphere affects global temperatures and our climate.

Climate, which refers to a region's average weather conditions (temperature, precipitation, wind, etc.), changes over time. Changes are readily detectable over long periods, including shifts between glacial and interglacial periods. Policy makers, however, are more concerned with changes occurring over much shorter periods of several decades. It is generally accepted that since the late 1800s, the average surface temperature of the globe has increased about 0.6°C over sea and land. Climate models suggest that this warming trend is likely to continue at a rate unprecedented in human history: the predicted increase in the earth's average temperature is between 1.4°C and 5.8°C over the next 100 years.

Box 1: Scientists and Climate Change

The main problem in studying climate change is that trying to understand how climate works involves many disciplines (biology, climatology, mathematics, to name just a few) as emphasized by Henry Hengeveld:

> "[T]rying to understand climate change is a bit like putting together a huge jigsaw puzzle. If we think of each [research] paper as one piece in the puzzle, this is a jigsaw puzzle with 10,000 or more pieces, with each scientist having a few of the pieces to bring to the table. It means that no single scientist can hope to give you the picture." (Standing Senate Committee on Agriculture and Forestry, Issue No. 1, 2nd Session, 37th Parliament, Ottawa, November 21, 2003)

Debate among researchers does exist. Scientific research, like our judicial system, is adversarial: it involves peer-reviewed processes and referees. Scientists are also highly specialized. In judging a scientist's competence to speak on an issue, it is always important to know if he (she) has done research in the area of interest and published it in a peer-reviewed publication.

Although the IPCC does not itself conduct research, it is composed of hundreds of research scientists from universities, research institutes, and government agencies from around the world that study the existing peer-reviewed literature and put every piece of research on climate into the context of the greater mass of information. Its reports are extensively peer-reviewed and levels of confidence are attached to each conclusion, since there is almost never 100% certainty. The U.S. National Academy of Science concluded that the last IPCC report is an "admirable summary of research activities in climate science." Seventeen academies of science from 17 other countries, including Canada and the United Kingdom, also indicated that the IPCC's work represents the consensus of the international science community on climate change science. Since the IPCC is the only organization that provides a thorough assessment of the state of knowledge on climate change, the Committee strongly endorses its conclusions and sees the IPCC as the most reliable source of information on the science of climate change.

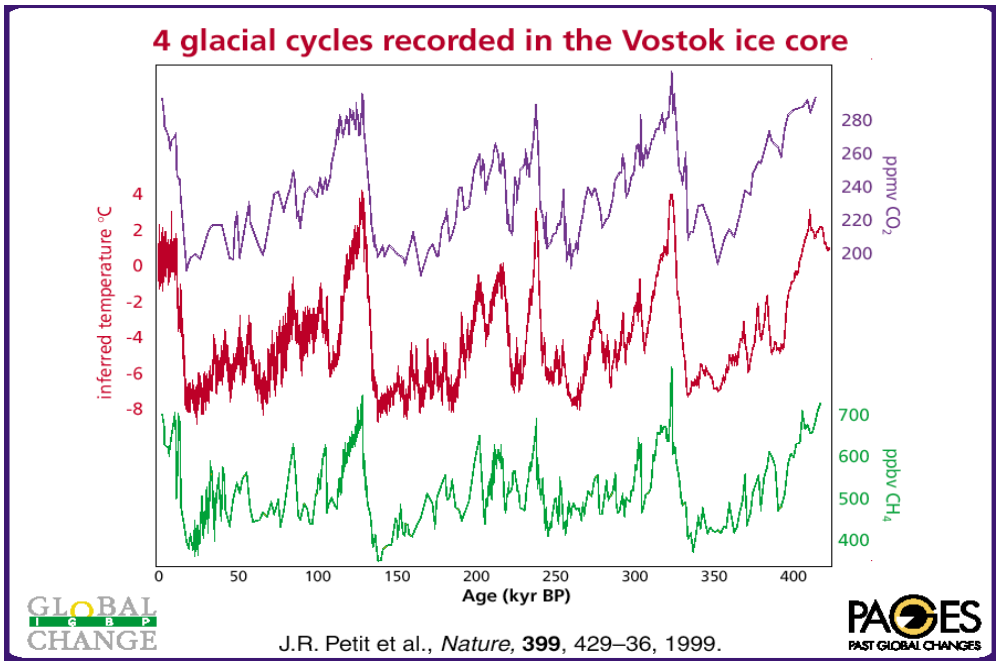
For the past several decades, researchers have tried to explain this phenomenon, looking at the possible causes and implications of a warming climate. Virtually all the witnesses who appeared before the Committee emphasized the importance of the work of the Intergovernmental Panel on Climate Change (IPCC) in improving our understanding of the climate change issue. Established in 1988 by the World Meteorological Organisation and the United Nations Environment Programme, the IPCC's role is to assess the scientific, technical and socio-economic information relevant to understanding the scientific basis of climate change, its potential effects, and options for adaptation and mitigation.

In 1996, the IPCC issued the following statement: "The balance of evidence suggests a discernible human influence on global climate." As this statement was made in a Summary for Policy Makers, it was subject to UN regulations: it required word-for-word approval by every UN member state. Only two countries, Kuwait and Saudi Arabia, objected. In its third assessment report in 2001, the IPCC statement was far stronger and received far less opposition: "There is now new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

Mr. Henry Hengeveld, chief science advisor at Environment Canada, summarized the IPCC findings. Naturally occurring gases, including carbon dioxide (CO_2) and methane, play a role in keeping our planet warm enough to support life as we know it. These gases are referred to as greenhouse gases (GHG). The greenhouse effect was first theorized in 1824 by a French mathematician, Jean Fourier. Greenhouse gases allow the incoming solar energy to reach the atmosphere and the earth's surface, but block outgoing heat energy and re-radiate it in all directions, including back to the surface. Without this effect, the earth's temperature would be 33 degrees colder than it is today and our planet would be unliveable.

Observations of Antarctic ice cores yield data on climate and atmospheric composition from millennia ago. Evidence from these ice cores strongly suggests that atmospheric CO_2 concentrations have historically affected global temperatures.

Figure 1: Correlation Between Greenhouse Gases and Temperature



Source: Andrew Weaver, brief submitted to the Standing Senate Committee on Agriculture and Forestry, Vancouver, February 28, 2003.

Variations in the concentration of atmospheric CO_2 and methane as recorded in Antarctic ice cores over the last 400,000 years coincide with variations of the temperature over the

same period. When GHG levels were high, the climate was warm; when GHG levels were low, the climate was cold (Figure 1).

Studies of atmospheric carbon dioxide levels show that over the last 400,000 years, they have never exceeded about 300 parts per million. At the time of the last Ice Age – around 21,000 years ago – atmospheric carbon dioxide levels were at about 190 parts per million, and over the following 19,000-plus years they rose; by the time of the Industrial Revolution in the last half of the 1800s, atmospheric carbon dioxide levels had risen to about 280 parts per million. Therefore, in this span of over 19,000 years, the level rose about 90 parts per million (90 = 280 – 190 parts per million). Since the Industrial Revolution the level has increased from 280 million parts per million to the current level of 370 parts per million, the difference of which is also 90 parts per million (90 = 370 – 280 parts per million). Thus, humanity has caused the same increase in 150 years as what had been caused by natural forces over a period of over 19,000 years.

As mentioned above, an increase of about 0.6^{o}C in the average surface temperature has been observed since the late 1800s, over sea and land.[3] In exploring the reasons for this warming trend, researchers have considered various factors affecting the global climate, including solar output and volcanic emission of aerosols. Scientists have examined these two factors over the last 140 years and assessed, based on model projections, how the earth's climate system should have responded to these natural forces. Some of the changes in the first part of the 20th century could be explained by solar and volcanic eruptions, both because solar intensity increased and the number of volcanic eruptions decreased, putting less dust in the air.

In the last 50 years, however, the reverse is true. A higher number of volcanic eruptions added more dust to the air, while solar activity did not vary much; based on those two factors alone, the climate system should have cooled. Instead, it warmed quite rapidly. When scientists included the increased GHG concentrations in the models, the results closely reproduced actual observed conditions. In effect, the observed increase in temperature could not be modelled without including GHG in the equation.

B. …And the Changes Will Affect Us

The changes in climate will have a profound effect on Canadians – the way we produce our food, use our natural resources, and live our daily lives. There are uncertainties but while researchers are trying to improve our knowledge and understanding of climate change, Canadians in our north are already witnessing many changes.

As mentioned above, models developed around the world have predicted an increase in the earth's average temperature of between 1.4^{o}C and 5.8^{o}C over the next century. This range reflects the uncertainties in climate change projections. The uncertainties arise from several assumptions that are embedded in the models: assumptions with respect to human behaviour and our GHG emissions, with respect to the response of the carbon

[3] The actual range lies between 0.4^{o}C and 0.8^{o}C; a range is specified due to the uncertainty caused by potential error in the data.

cycle to changes in climate, and with respect to biophysical factors such as clouds. There is likely little uncertainty with respect to the lower limit, while there is great uncertainty with respect to the upper limit. The Committee was told that an increase of 1.4°C in the earth's average temperature would be unprecedented in human history.

An increase in the earth's average temperature does not mean an even increase in every part of the world. The evidence the Committee received suggests that the warming will be amplified at high latitudes because of the snow or ice *albedo* feedback: when the land surface changes from white (snow or ice cover) to dark (soil and vegetation), it absorbs more solar radiation and warms further. Warming will also occur more in the interior of continents (regions that are away from the ocean) relative to the exterior of continents, and more in winter relative to summer, and night relative to day.

With an uneven distribution of temperature increases, the circulation of air masses and ocean currents will be affected and will influence local climates. Different parts of the globe will feel a variety of effects including changes in the timing and distribution of precipitation, and changes in temperature fluctuations. The IPCC has acknowledged that climate change encompasses more than changes in temperature. It indicated that we can also expect changes in the frequency of anomalous years; that is, some extreme conditions will become less frequent, while others will become more frequent. It was mentioned many times that Canada can expect more frequent and widespread droughts, particularly in the Prairies.

These changes are already visible in Canada's North. Both the Yukon and Mackenzie regions have warmed by 1.5°C over the past 100 years, which is close to three times the global average increase. Discussions with Yukon communities were initiated by the Northern Climate ExChange in 2000 to get a sense of the level of concern about climate change. From these discussions, it quickly became evident that climate change is no longer an abstract idea in the Yukon, and has emerged as a major public issue.

Many northerners are making firsthand observations of climate change, and this local knowledge is adding an important dimension to our understanding of the issue. Ms. Aynslie Ogden, Manager of the North Region of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), mentioned reports that elders in Nunavut are hearing frogs and crickets and seeing thunderstorms, events that have not occurred there before. Indeed, increasingly there are insects, birds, wildlife and climate occurrences that have never been observed, and the people do not have a word for them in their traditional language; for example, in Sachs Harbour on Banks Island, people saw robins but did not have a word for "robin" because the species had never been seen there before. Such stories are starting to abound across northern Canada.

A major concern of residents is in the absence of predictability; people can no longer rely on past experience and traditional knowledge to predict when seasons will change; nor can they predict hunting conditions as ice conditions change wildlife patterns (migration, etc.). These changing ice conditions may result in there being no polar bears in the Hudson Bay area within about 50 years. Mr. George Quintal of the Metis Nation of

Alberta told the Committee that water levels in lakes and rivers have decreased in the northern part of Alberta, affecting spawning sites and fish populations on which the Metis rely for their diet.

"Are our northern populations the messengers for the rest of the world?"[4] How great will the impact of climate change be? It appears from the testimony that some regions and sectors might benefit from climate change while others might lose. In both cases, climate change will have significant environmental, social, and economic effects on Canada and Canadians. Our ability to adapt will enable us to capture the opportunities and reduce the negative impact.

C. The Solution is to Reduce Emissions…

Although the Committee's mandate was to examine the impact of climate change and the potential adaptation options, many witnesses addressed the issue of reducing greenhouse gas emissions. This was not surprising, since current national and international efforts to tackle the issue of climate change primarily target the reduction of GHG emissions. Three emission-reducing instruments were suggested to the Committee: the Kyoto Protocol – a critical first step in our long-term strategy to reduce emissions – an emissions trading system that can help to minimise our reduction costs, and a longer goal of decarbonizing our energy sources.

1. The Kyoto Protocol

In 1997, the Kyoto Protocol was developed through the United Nations Framework Convention on Climate Change. The Kyoto Protocol binds the industrialized countries that ratify the Protocol to reduce their GHG emissions. It is widely accepted, however, that even after introducing significant measures to reduce GHG emissions, some additional degree of climate change is inevitable. All witnesses agreed that because the climate system will take centuries to respond to the existing GHG levels, the Kyoto Protocol will have little effect on the climate in the next century.

To illustrate this point, Dr. Andrew Weaver from the School of Earth and Ocean Sciences, University of Victoria, compared scenarios using one particular model: if nothing is done to reduce GHG emissions, the model predicts an increase of 2.08ºC in the global temperature and a sea-level rise of 50 cm. If every country, including the United States, were to meet its Kyoto target, the increase in temperature would be 2ºC and the sea-level rise would be 48.5 cm. If these countries were to go beyond Kyoto targets and make a further 1%-per-year reduction after 2010 through the end of the century, this model predicts an increase in temperature of 1.8ºC with a sea-level rise of 45.5 cm.

The Kyoto Protocol is the critical first step in a long-term strategy to deal with our changing climate. By itself, the Protocol will not solve the problem; but it will buy a little time to adapt to the changes. Compliance with the Protocol will delay by 10 years (from

[4] *Sila Alangotok: Inuit Observations on Climate Change*, video document realized and produced by the International Institute for Sustainable Development, 2000.

2060 to 2070) the point at which carbon dioxide double from current levels. But as Environment Canada pointed out, the ultimate objective of the Framework Convention on Climate Change is to stabilize concentrations at a level that will avoid dangerous consequences for humanity.

2. The Emissions Trading System

In the *Climate Change Plan for Canada* (CCPC) released in 2002, the federal government presented measures and policies to meet its Kyoto target and tackle climate change. One of the cornerstones of the strategy to cut GHG emissions from large emitters will be an emissions trading system that will generate a monetary value for carbon. The details are under discussion, but according to the CCPC, companies would be required to have permits for their emissions. A large proportion of the required permits would be provided free to companies, based on their historical level of production and their emission intensity. With respect to their remaining permits, companies would have a choice of investing in emissions reductions or purchasing additional permits or "offsets."

When properly managed, forests and agricultural soils can remove carbon from the atmosphere and store it in the soil or trees; in this sense, they are referred to as *terrestrial sinks*. Each equivalent unit of CO_2 that has been removed and stored in agricultural soils or forest would create a *carbon credit* that could then be sold to those GHG emitters for whom the cost of emission reductions would be greater than the price at which the credits are being sold. The CCPC proposes to establish a framework by which carbon credits could be sold as offsets within the emissions trading system (Box 2).

Box 2: Carbon Credits

Current projections are that Canada's existing forest management practices will result in a sink of 20 megatonnes (MT) of carbon. Changes in farm practices, such as going from conventional to minimum tillage, also promote carbon sequestration in the soil. Based on the current scenario, it is estimated that such agricultural practices will sequester 10 MT of carbon. Carbon credits could be created for each equivalent unit of CO_2 that has been removed by agricultural practices, notably through carbon sinks. These credits could then be sold to emitters of GHG. According to the *Climate Change Plan for Canada*, these 10 MT will not be eligible to be sold as offsets in the emission trading system. Only incremental emissions reductions that will go beyond current farm practices and the estimated 10 MT would create tradable credits.

Farmers heard by the Committee were concerned that the proposed emission trading system would not recognize farmers' past contribution to the reduction of GHG emissions, and that it would ultimately create an incentive for those already using minimum tillage to plough their land before 2008 (the beginning of the first Kyoto commitment period) and to return to reduced tillage after 2008 so that they are eligible to create tradable credits. Farmers also wanted some reassurance that the person who is storing the carbon should get the remuneration.

Lastly, the Committee heard concerns about the liability associated with selling credit. Once a farmer starts selling credits, how long must he or she maintain current practices? What liability will the farmer have if he or she decides it is more advantageous to plough that land, releasing the carbon into the atmosphere? To overcome this problem, some farm groups have suggested a lease system whereby a farmer would lease back his or her practices of sequestering carbon in the soil for a fixed period of time.

Many witnesses pointed out that Canada has great potential to store carbon, and that these sinks will help Canada meet its target under the Kyoto Protocol. On the other hand, Dr. G. Cornelis van Kooten, a forestry economist at the University of Victoria, suggested that a carbon tax would be a cheaper way to address emission reductions.

Box 3: The Science of Agricultural Sinks

Mr. Henry Janzen, a soil scientist at Agriculture and Agri-Food Canada's Lethbridge Research Centre, summarized some of questions regarding agricultural sinks:

- How do we measure the carbon uptake in an accurate and cost- effective way? Analysis of soil samples is the most accurate method but it remains extremely expensive. There is already a requirement for Canada to estimate our soil carbon change, and models are used that estimate carbon gain as a function of practices and soil types. Models imply more uncertainties, such as the uncertainty over adoption rates of practices.
- How do we make sure that practices that help carbon storage do not increase emission of another GHG? Any given farming practice may influence all of the GHG, and we need be very careful that we do not advocate a practice that may store carbon but, for example, increases N_20 emissions.
- For how long will an agricultural soil sequester carbon? It is the change in cropping practice that enables carbon sequestration, rather than the practice itself. After this practice has been used for some time, carbon exchanges reach an equilibrium and no further carbon is stored in the soil. Therefore, if a farmer has used no tilled since 1995, is he or she still sequestering carbon now?
- What happens if, for some reason, cropping practices change again on the land that has sequestered carbon? If someone has been using no till for many decades and decide to plough again, CO_2 will be released very quickly.

His studies indicate that the cost of creating forest sinks through afforestation would be too expensive even when carbon uptake benefits are taken into account. Furthermore, there are still some scientific uncertainties regarding the benefits of agricultural soil sinks (Box 3), and they may not be a long-term solution due to their ephemeral nature: soils release CO_2 very quickly when cropping practices change.

Nevertheless, a consensus does exist when it comes to sustainable long-term solutions to climate change: witnesses agreed that they require significant reductions in GHG emissions many times beyond the Kyoto commitments, and it cannot be done without focusing on energy systems.

3. The Decarbonization of Global Energy Systems

In order to significantly affect energy systems and GHG emissions, we need to develop primary energy sources that do not emit carbon dioxide into the atmosphere, and that reduce end-use energy demand. Yet, the Committee was told that most of the approaches taken so far are essentially transitional, incremental improvements of mostly existing technologies. What is necessary is the "decarbonization of the energy system," that is, a shift from high-carbon-content to low-carbon-content fuels.

In fact, our society has been naturally evolving toward this decarbonization. An examination of the primary sources of energy over the last centuries indicates a clear evolution from wood to coal, then oil, and finally gas as the dominant primary fuel. In Canada, natural gas has now overtaken oil as the primary fossil fuel source.

The key factor in decarbonization is to reduce the number of carbon atoms in any fuel and increase the number of hydrogen atoms: for example fewer CO_2 emissions are associated with natural gas or methane than with coal. The ultimate evolution is to go to pure hydrogen, which creates no CO_2 emissions.[5]

[5] Coal has a carbon to hydrogen ratio of 2, natural gas has a ratio of 0.25, and pure hydrogen that has a ratio of 0. Energy sources with higher carbon to hydrogen ratios have larger CO_2 emissions associated with their use.

Dr. Ned Djilali of the Institute for Integrated Energy Systems at the University of Victoria illustrated our ability to introduce zero CO_2 emissions technology with two examples. He examined two services that society needs, and their energy sources. Harvesting, the first example, currently has essentially only one possible source of energy, crude oil (processed into diesel fuel, which is used in a combine). This energy system is very difficult to wean from fossil fuels, and therefore from GHG-emitting technology.

On the other hand, the second service, potable water, can be obtained through a number of possible primary energy sources and pathways. There are fossil fuel paths, through the use of diesel fuels to run water treatment plants, or through electricity and a generating power plant that uses coal or natural gas as its primary source. There is, however, an alternative path that uses electricity obtained via renewable energy, such as wind turbines, hydro, or generating stations powered by geothermal or nuclear power.

The example of potable water highlights the fact that there is a sector of energy systems, the *stationary sector*, that is primarily fed via the electricity grid. The electricity carried by the grid is generated by a variety of sources, some renewable, some non-GHG emitting, and some non-renewable. It is here that zero CO_2 emission technology can be introduced.

Separate from this main grid is the *mobile sector*, including transportation, which is largely dependent upon fossil fuels. The challenge will be to translate zero CO_2 emission primary energies into fuel for the mobile sector. One possible way to achieve this objective would be to transform any additional power from renewable sources, which are not always available due to the transient nature of the sun, winds, and tides, into hydrogen production. The extra hydrogen could then be either stored or fed into fuel cell energy transformation technology. By using hydrogen as a fuel, the mobile sector could be liberated from its dependence on fossil fuels. A hydrogen electricity-based system could be flexible and adaptable. Furthermore, since it could be adapted to local availability, it would not be a "one solution fits all" approach.

A number of problems must be solved before we can move to a completely *decarbonized* society. Major issues include reducing hydrogen production costs, converting hydrogen into electricity via fuel cell technology, and the development of storage and distribution systems. One often-noted problem concerns investment in the supply of hydrogen: there will be no systematic deployment of a hydrogen infrastructure until there is sufficient demand to make it cost-effective, yet sufficient demand will not exist until the infrastructure is in place.

To overcome this chicken-and-egg situation, targeted policy measures will have to be taken. While it is not within this Committee's mandate to recommend these policies, the Committee does believe that a clear vision is required of the government – a vision that recognizes the environmental and economic benefits of this approach. Canada is a world leader in some energy-related technologies, and we should take advantage of this expertise.

Much to the Committee's surprise, Dr. Djilali said that currently, the only feasible path to a systematic GHG-free hydrogen economy – whereby we would supply 80 to 90% of our energy requirements through a hydrogen energy system – is by the widespread introduction of nuclear power. Some witnesses also suggested that technological development that should have occurred in the nuclear energy field over the last several decades has been thwarted since it has limited appeal to Canadians.

These advocates see a clear need to reassess the option of nuclear energy, given the needs of Canada and the world into the 21st century and beyond. A proper risk analysis should include the issue of waste management in 50 years' or 100 years' time. In addition, the uncertainty regarding the direct effects of climate change must be measured against the certainty of some negative effects if no radical steps are taken to address the GHG emission issue.

Box 4: The Livestock Industry and Power Generation

BioGem is a privately held corporation in Alberta that provides biogas, electrical and thermal generation systems to the intensive-livestock industry. It developed the first commercial biogas plant operating on the public grid in Canada. The technology has been tested and proven through an association with a European firm. There are 130 systems worldwide, one of which is operating in Alberta.

The Committee visited this plant, which operates in a Hutterite colony with the manure of a 1,200-sow, farrow-to-finish unit. The manure is put it into an anaerobic digestion cycle that produces methane (biogas). The biogas is harvested off to an internal combustion engine, which is the prime mover for a generator that produces power for the use of the farm and the plant. The excess can be sold into the public grid for revenue. At the end of the cycle, the product is separated, the solids and liquids are cleansed, and the water is reclaimed and used in the barn. Benefits for the producer are significant: it eliminates the monthly electrical costs and reduces heating costs (21% of the unit's operating costs), reduces manure hauling costs (14% of the unit's operating costs), and reduces the amount of manure that has to be taken to the field by approximately 86%, not to mention providing an odourless environment!

The Committee wants to stress, however, that renewable energy sources have a crucial role to play in Canada's future energy system. During its trip through western Canada, the Committee witnessed efforts in this area, notably the Vision Quest wind turbine facility near Pincher Creek (Alberta). The Committee also visited a hog operation near Viking, Alberta, that uses liquid manure to produce electricity (Box 4) a powerful opportunity for farmers to reduce pollution and odours, and address climate change at the same time.

As the climate system will take centuries to respond to the levels of GHG already emitted by human (industrial) activity, only future generations will be able to concretely measure the success of our current mitigation efforts. In the meantime, we will need to adapt to new climatic conditions.

D. …And Adapt to the Effects

To say that the mitigation of climate change has received the lion's share of media and public attention as well as government funding around the world is an understatement. Discussion of the Kyoto Protocol has diverted so much attention from adaptation both in Canada and internationally that the debate is decidedly skewed. This is especially disappointing for Canadians since the Canadian government is officially committed to

promoting adaptation. The Committee was commended for focusing on the issue of adaptation to climate change and for providing a forum to discuss this important matter. The Committee tried to answer the following questions: is research on adaptation strategies being done in Canada? What is being done? Who is doing it?

Adaptation to climate change also lacks the attention it deserves because it is a long-term need – which is exactly why a Senate Committee has a role, as suggested by Dr. Mohammed H.I. Dore, Department of Economics, Brock University:

> "perhaps the Senate is the only body that has a long-term view of the well-being of Canadians […] I think that […] the impacts of climate change really are long-term issues."[6]

Similarly, Mr. Peter N. Duinker, Manager of C-CIARN's Atlantic Region, stated that:

> "It is high time that we moved ahead on this topic of impacts and adaptation. Your work and our work at C-CIARN are vital parts of that agenda."[7]

Although the impacts of climate change, and adaptation to those impacts, require further attention and funding, the intensity and passion showed by all witnesses illustrate a vibrant research community that has been examining this issue. Their efforts deserve wider recognition. For example, few Canadians are aware of the *Canada Country Study* completed in 1998. This study was the first-ever assessment of the social, biological, and economic impacts of climate change on the different regions of Canada. Climate experts from government, industry, academia, and non-government organizations were brought together to review existing knowledge on climate change impacts and adaptation, identify gaps in research, and suggest priority areas where new knowledge was urgently needed.

Since then, the Government of Canada's Climate Change Impacts and Adaptation Program, a sub-component of the Climate Change Action Fund (CCAF), has been providing funding for research and activities to improve our knowledge of Canada's vulnerability to climate change, to better assess the risks and benefits posed by climate change, and to build the foundation for well-informed decisions on adaptation. Canadian research on impacts and adaptation carried out since 1997 is currently being synthesized by Natural Resources Canada into a comprehensive report entitled *Climate Change Impacts and Adaptation: A Canadian Perspective*. This report will provide information on various sectors such as water resources, agriculture, forestry, fisheries, coastal zones and health, as well as general information on impacts and adaptation, advances in research techniques and remaining knowledge gaps. Sector-specific chapters on agriculture and forestry were published in 2002.

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[6] Standing Senate Committee on Agriculture and Forestry, Issue No. 14, 2nd Session, 37th Parliament, Ottawa, March 27, 2003.

[7] Standing Senate Committee on Agriculture and Forestry, Issue No. 5, 2nd Session, 37th Parliament, Ottawa, December 12, 2002.

In addition, federal, provincial, and territorial governments have supported the creation of the Canadian Climate Impacts and Adaptation Research Network to link researchers and stakeholders. C-CIARN comprises six regions (British Columbia, Prairies, Ontario, Quebec, Atlantic, and North) and seven national sectors (Agriculture, Water Resources, Coastal Zone, Health, Forest, Landscape Hazards, and Fisheries) connecting researchers and stakeholders across the country. C-CIARN regions and sectors work together to increase our understanding of climate change impacts and adaptation, identify knowledge gaps, and define research priorities. A national coordination office housed at Natural Resources Canada manages the C-CIARN's operations. Two research groups, OURANOS in Quebec and the Prairie Adaptation Research Cooperative (PARC), have been created to enhance research efforts.

Released in December 2002, the *Climate Change Plan for Canada* deals mostly with GHG emission controls, not adaptation strategies. It does, however, identify four key areas of necessary collaboration between government, academia, and the private sector to advance adaptation efforts:

1. development and research approaches to adaptation planning and tools development;
2. expansion of the assessment of vulnerability to climate change impacts to all areas of Canada;
3. identification of priority areas/regions where there is a need to consider future actions; and
4. development of increased awareness of the impacts of climate change and the need to address them through adaptation.

Where do these actions fit into the whole Canadian strategy on climate change? Of the $1.6 billion the government has invested in climate change action since 1998, government officials who appeared before the Committee estimated that approximately $100 million had been spent on various aspects of the science of impacts and adaptation. From the Climate Change Action Fund's annual budget of $50 million, $2.5 million per year have been allocated to impacts and adaptation research.

This lack of attention is rather disappointing, because Canada is officially committed to promoting adaptation. While the *United Nations Framework Convention on Climate Change*, upon which the Kyoto Protocol is based, is concerned with reducing emissions, it also explicitly promotes adaptation. Specifically, Article 4 says that:

> All Parties […] shall […] formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing […] measures to facilitate adequate adaptation to climate change…[8]

[8] United Nations, *United Nations Framework Convention on Climate Change*, 1992.

Summary

Scientific evidence indicates that our climate is changing. This change in climate will affect humanity, and the effects will be most profound in circumpolar countries like Canada. We have to reduce our emissions to try to minimize the negative effects of our changing climate – that is we will have to mitigate our emissions – but we also will have to adapt. While the Committee recognizes that mitigation and adaptation to climate change do go hand-in-hand, funding for adaptation efforts needs to be dramatically increased to help our country prepare for the future. There is also a need for a long-term commitment to support, fund, and monitor progress toward adaptation; the Government of Canada should take a leadership role on this issue. The federal and provincial ministers of Environment and Energy met in May 2002 and supported the development and implementation of a national adaptation framework. To the Committee's knowledge, this framework is still only a very crude structure, but it could provide the institutional hooks necessary to promote adaptation to climate change.

CHAPTER 3:
EFFECTS OF CLIMATE CHANGE ON AGRICULTURE: WHAT DO WE KNOW?

> "**Assuming that this climatic change phenomenon will be with us for quite a while, we have to recognize that the way people react, adapt, or do *not* react or adapt, is going to probably make the difference between whether or not the final impacts are okay or really bad**." [*emphasis added*]
>
> *Dr. Christopher Bryant, Professor,*
> *Department of Geography,Université de Montréal*[9]

Although the exact effects of a changing climate on Canada's agricultural sector are unknown, some trends are distinguishable. These effects can be divided into two categories. The first group of effects are biophysical in nature – effects on crops due to warmer temperatures, changing levels of carbon dioxide, and changing precipitation patterns. The second category of effects relate to the economics of the agriculture industry – the effect of changing productivity in Canada and international markets on the profitability of agriculture.

Canadian research on impact and adaptation in agriculture carried out since 1997 has been synthesized into a comprehensive report entitled *Climate Change Impacts and Adaptation: A Canadian Perspective*, published in October 2002 by Natural Resources Canada. Some of the evidence that the Committee heard regarding the potential effects of climate change on agriculture is already contained in this report. This section highlights some key points of our current knowledge of this issue.

A. Biophysical Effects of Climate Change on Canadian Agriculture

Resource economists from Canada and the United States predict that Canada's agriculture will benefit from climate change. Some regions within Canada might expect net gain while other will lose; but, by and large, Canada's agriculture could be a net beneficiary. Some of the factors that explain this optimism are grounded in two basic predictions from research on climate change: temperatures will increase, particularly in regions closer to the pole, such as Canada; and atmospheric CO_2, the primary nutrient for plants, will rise. These two factors could have the following effects on crops and forage:

- an increase in plant productivity,
- a longer growing season, and
- accelerated maturation rates.

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[9] Standing Senate Committee on Agriculture and Forestry, Issue No. 16, 2nd Session, 37th Parliament, Ottawa, May 6, 2003.

The effect of higher temperature on plants is expected to be positive in ecosystems where the current annual mean temperature is below 15°C, as is the case for Canada. It is expected to be neutral or even negative in ecosystems within zones that have an annual mean temperature above 15°C. Therefore, consequences for agriculture in Canada could be improved yields for existing crops, the possibility of growing new crops, and a northward shift of favourable cropping conditions. Dr. Robert Grant of the University of Alberta mentioned that as much as 60 million new hectares could become available for agricultural production, because of the northward expansion of cropping conditions. This gain could offset the possible loss of agricultural land in other parts of the world such as Africa, northeastern Brazil, and Australia.

There are several important caveats, however, to this optimism, relating to soil productivity, temperature, water availability, soil erosion, and pests It was mentioned several times that soil conditions in the north of Canada may not be adequate to sustain any agricultural production. In the three Prairie provinces, only 1.44 million hectares could become available if climate conditions move 550 to 650 km northward (the figure is based on the most suitable soil for agriculture production north of the 55th parallel [class 4 soils]). There are, indeed, limitations to these positive projections.

Another moderating factor on the positive projections for agriculture is temperature itself. Although higher average temperatures might result in greater productivity, higher temperatures can also negatively affect agricultural production: extreme heat increases crop damage and influences animal health. For example, Mr. Gilles Bélanger from AAFC concluded from his research that warmer winters could negatively affect some perennial crops in eastern Canada, notably by reducing cold hardening in the fall and an increase in the number of winter thaw events.

The availability of water for agricultural production will become a major issue and may limit the positive effects of higher temperatures. Yet, how changes in precipitation patterns will exactly play out, is currently unknown. The Committee was however assured that precipitation patterns will change. Indeed, several witnesses told the Committee that precipitation patterns are the

Box 5: Water and Agriculture

A common characteristic of all scenarios presented to the Committee is the increased frequency of drought in the Prairies. Unlike meteorological drought, which is characterized by a lack of rainfall, agricultural drought is defined by a deficit in soil moisture for growing a crop. Under current climate change scenarios, research presented by AAFC officials found that the Prairies will face a large soil moisture deficit, as increased precipitation will be offset by increased evapotranspiration (loss of water from plants and soil). On the other hand, Mr. Sean McGinn, from AAFC's Lethbridge Research Centre, presented research that shows a small increase in soil moisture in all three Prairie provinces. He also mentioned that farmers could take advantage of warmer springs to seed earlier. The accelerated growing season would also allow earlier harvest, avoiding the more arid conditions that exist later in the growing season.

Ms. Denise Neilsen, from AAFC's Pacific Agri-Food Research Centre, presented research on water availability for irrigated crops in the Okanagan Valley. She found that irrigation requirements would increase in the Okanagan Valley. Although the main lake and channel might contain enough water to sustain this demand, agriculture is dependant on tributary flow that will likely experience water shortage.

At the farm level, potential adaptation options to deal with water or moisture shortage include soil and water conservation practices such as reduced tillage, shelterbelts, soil mulching, water-efficient irrigation systems (micro-irrigation), and reduced grazing stock.

most difficult variable to predict. For example, precipitation may increase, but this may not be beneficial if it falls at the wrong time for crops. Or, the amount of rain that used to fall over a two day period may fall in three hours.

Compounding this uncertainty are two opposing facts. Higher temperatures mean higher evapotranspiration rates (loss of water from plants and soil), increasing the amount of water crops will need. On the other hand, higher concentrations of CO_2 in the atmosphere reduce transpiration rates and therefore would increase water use efficiency by plants. Ultimately, the effect of climate change on water availability is unknown, thereby potentially limiting the positive projections of climate change on agriculture (see Box 5 for regional details). It is apparent in the face of this uncertainty, farmers may have to actively manage their water resources more than they have had to in the past, perhaps by storing it. Water is discussed in greater detail in Chapter 5.

Soil erosion may also become of greater concern with changing precipitation patterns. More soil erosion may occur if there is an increased intensity of rainfall (such as short deluges) and changes in wind patterns. Flooding and drought, two extreme climatic events that are commonly projected to increase, are major factors that aggravate the risks of agricultural soil erosion, and temper projections of productivity increases.

Temperature and precipitation affect not only crops and livestock – insects, weeds and disease also respond to temperature and moisture levels. Grasshoppers, for instance, can serve as indicators of climate trends. Dan L. Johnson, a research scientist at AAFC's Lethbridge Research Centre, presented evidence that climate change is likely to benefit invasive species and increase the threats of insect outbreaks. For example, research on grasshopper population in Alberta and Saskatchewan showed that grasshopper reproduction and survival are enhanced by warm, dry conditions; such conditions are likely to occur under current climate change scenarios.

Carbon dioxide also affects weeds. Mr. Daniel Archambault, a research scientist at the Alberta Research Council, mentioned that there have been changes in the weeds found in Alberta, and that enhanced CO_2 may increase their growth. He also mentioned that herbicide and pesticide efficiency could decrease because of increased CO_2.

Aside from the effects of these individual variables – temperature, soil, and water – the combined effects of temperature, enhanced atmospheric CO_2, and moisture availability also leads to seemingly contradictory results that vary by region. For example, Mr. Samuel Gameda, a research scientist at AAFC, showed a possible extension of corn and soybean areas in Atlantic Canada, and a potential for corn and soybean yields in Quebec and Ontario to be as high as those currently seen in the Midwest of the United States. Mr. McGinn, from AAFC's Lethbridge Research Centre, presented results from research conducted at AAFC's Eastern Cereal and Oilseed Research Centre that showed no changes in yield in the Prairies for spring crops such as barley, canola, and wheat as a result of earlier seeding dates and better water use efficiency made possible through enhanced CO_2 in the atmosphere.

The exact outcome on agriculture from changes to these individual variables nor their combined effects is unknown at this time. It is known that climate change will cause the past patterns to change. But the projections are really only well understood on a global basis, not on a national let alone provincial basis. The Committee realizes that these biophysical effects will be localized, and that more research is needed to improve our understanding of them.

Picture 1: Soil drifting near Oyen, Alberta, May 5, 2002

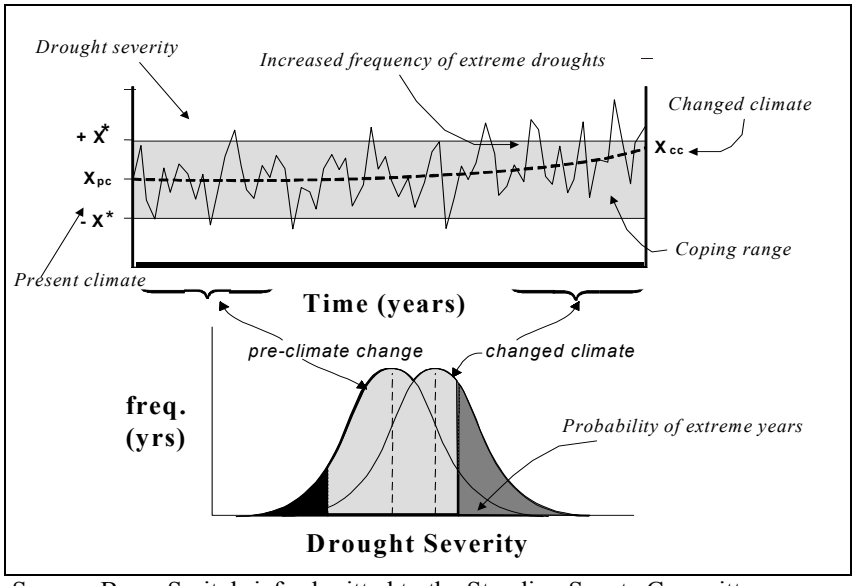
Source: Dave Sauchyn, brief submitted to the Standing Senate Committee on Agriculture and Forestry, Ottawa, February 4, 2003.

As mentioned by Mr. Ed Tyrchniewicz, President of the Agricultural Institute of Canada, climate change is about temperature, precipitation and variability – the latter being, in his view, the most important factor from agriculture's perspective. Dr. Barry Smit from the University of Guelph emphasized that "we hardly ever get average climate. We get the variation from year to year." It seems obvious that the farmers can manage the conditions that occur in an average year. Indeed, most agricultural systems can accommodate minor deviations from the average within what is called the *coping range* (Figure 2).

With climate change, however, all of these conditions will shift. The average year may still be within the coping range but it is important to note that, even without a change in magnitude of the extremes, a change in the mean will bring a change in the frequency of

some extremes. An example relevant to agriculture would be more frequent and more serious droughts. In scientific terms, the probability of an extreme year may increase from one in ten to one in three.

Figure 2: Climate Change Includes Changes in Extremes



Source: Barry Smit, brief submitted to the Standing Senate Committee on Agriculture and Forestry, Ottawa, March 20, 2003.

B. Economic Effects of Climate Change on Canadian Agriculture

All witnesses agreed that changes in year to year variation in temperature and precipitation will be far more significant for the agricultural sector than changes in the average conditions. As stated by the President of the Agricultural Institute of Canada, the issue ultimately relates to risk management at the farm level.

In addition to changes in agricultural production, changes in climate will result in changes in market variables such as market prices and input prices. Although production is determined locally by local weather conditions, international markets determine many market prices. What will be important for Canadian farmers is how their productivity changes relative to the rest of the world. If our competitors experience sharp declines in some of the crops that Canada might be relatively more capable of producing under a changed climate scenario, this situation could be beneficial for our farmers.

Nevertheless high yields may not be financially beneficial for farmers, if they are coupled with low prices. Conversely, if Canadian farmers experience low yields but nonetheless produce better than the rest of the world, they may benefit from high prices.

In previous studies of Canada, Dr. Siân Mooney from the University of Wyoming found that overall net revenues from the Prairie provinces could be increased by climate change. Dr. Mendelsohn, a natural resources economist from the Yale School of Forestry and

Environmental Studies, also expects to see fairly large benefits for Canada's agricultural sector. Such findings are, however, very dependent upon the number of assumptions that underlie the different models and studies. For example, some of these optimistic predictions do not account for soil and water limitations in northern latitudes.

C. Adaptation Options for Agriculture

The net impact of climate change on Canadian agriculture will largely depend on the adaptation measures that farmers take. In the context of climate change, adaptation means adjusting farm management techniques to the expected effects of climate change in order to reduce risks or realize opportunities.

Farmers are already innovative and adapt to various stresses, including variations in weather, trade policies, and commodity prices. For example, farmers in Western Canada are adopting or expanding certain practices, such as not tilling their soil, in order to protect their topsoil during droughts, keep moisture in the soil, and reduce the amount of greenhouse gases being released into the atmosphere.

Historically, a range of adaptation options has been available to farmers to cope with various risks and conditions, and these will continue to help them in the future. Dr. Barry Smit, one of the leaders in research on adaptation in Canada, classified these options into four categories:

- technological development, including the development of new crop varieties, feed rations, and weather information systems;
- farm financial management, including crop insurance, income stabilization programs, and diversification of household income;
- farm production practices, including diversification, irrigation, changes in the timing of farm operations (such as earlier seeding), conservation tillage, and agroforestry; and
- government programs, including support programs and taxation. (See Box 6 for an example of a government support program.)

Box 6: The Alberta Agriculture Drought Risk Management Plan

Recurring droughts that characterize Alberta's climate can have serious financial and social impacts on the agriculture industry. Since 1984, the Alberta government has spent $1.8 billion on *ad hoc* drought relief. In order to provide a consistent response to drought and reduce long-term impacts, in 2002 the provincial government implemented the Agriculture Drought Risk Management Plan (ADRMP). It involves two provincial departments, the federal Prairie Farm Rehabilitation Administration, and, on an *ad hoc* basis, representatives of municipalities located in affected areas.

The ADRMP is composed of three strategies that comprise various activities and measures to better prepare farmers, decreasing their vulnerability to droughts:

- The **drought preparedness** component aims at increasing the level of readiness of farmers and governments to respond to droughts,
- Accurate and up-to-date **drought reporting** will help to ensure the appropriate response to the specific situation,
- The **drought response** strategy comprises a response toolbox to reduce drought impacts on farmers.

Dr. Michael Brklacich, a professor at Carleton University, advised the Committee that these options will have to be evaluated to see whether they will work in the future, since uncertainty remains with respect to climate conditions in the second part of this century.

Research efforts have tried to model the technical feasibility and efficiency of crop systems, notably through a variety of crop models developed and applied in the Canadian context. These models try to estimate how changes in climate and adaptation options might dampen the potential negative effects of climate change.

Dr. Roger Cohen from the University of Saskatchewan developed a decision support tool for farmers called *Grassgro* that can be used to review adaptation strategies on the Prairies. *Grassgro* assesses how weather, soils, and management practices combine to affect pastoral production, profitability, and risk. Based on various climate change scenarios and adaptation options, this model can determine what sort of strategies are likely to ensure that cattle producers can remain viable.

Beyond the technical and practical aspects of the different options, farmers will ultimately have to make adaptation choices. Dr. Michael Mehta, a sociologist from the University of Saskatchewan, defined adaptive capacity as the ability of a system or an individual to adjust to climatic variability, often by minimizing the likelihood and consequences of adverse outcomes. As such, adaptive capacity is similar to risk management, and farmers' attitude toward climate change will be the key to successful adaptation. Dr. Smit mentioned that farmers already face two choices: wait until the effects are felt and then do the best they can, including giving up farming; or be aware that some risks exist, and be proactive in reducing their vulnerability.

Few researchers addressed adaptation in analyzing the decision-making process at the farm level. Although limited, their research has provided some useful insights:

- Adaptation in agriculture is driven more by the vulnerabilities associated with extremes. Farmers are concerned about responding to climatic extremes rather than responding to long-term changes in climatic averages. If an area becomes more suitable for a specific crop, they can cope with this type of change as they have done in the past – the extension of canola and chickpeas in Western Canada serve as examples.
- Adapting in a reactive way could be costly. For example, a representative of Alberta Agriculture, Food and Rural Development mentioned that the provincial government has spent $1.8 billion on *ad hoc* drought relief in Alberta since 1984. In western Canada, the Committee heard from Mr. Bart Guyon, a rancher in a region of Alberta that had never previously been concerned about a lack of water. When drought hit his region in 2002 and he ran out of water and pasture for his elks and bison, he was forced into making "panic decisions."
- Adaptation strategies are specific to locations and settings. They will vary from place to place and from farm to farm.
- Adaptation to climate change is one component of risk management strategies for producers. Climate is not looked at in isolation; farmers put it in a broader context that includes trade policy, input costs, world prices, changing environmental regulations in Canada, and a whole suite of other factors that they must face and adjust to on a day-to-day basis. Adaptation is a farm-level strategy, and it must be understood in the context of the broader decision-making process.

Farmers will have to build on their strengths and identify where their farm operations are vulnerable. Dr. David Burton, who holds the first Chair in Climate Change at the Nova Scotia Agricultural College, identified some of these strengths, weaknesses, opportunities and threats for the agricultural sector in Atlantic Canada. Low profit margins, for example, limit farmers' ability to respond to changes such as new environmental regulations. The diversity of production systems in Atlantic Canada, however, increases the stability of the sector since a farmer is able to generate revenue from several activities on the farm, offsetting negative outcomes from any one of them.

Technological development, and improvements in agricultural practices, will have an important role in enabling adaptation to climate change. But it is crucial that farmers also improve their capacity to deal with the risks that currently exist, in order to enhance their ability to deal with future risks, including those associated with climate change.

Summary

The overall outcome of climate change on agriculture will be determined by both biophysical and economic conditions. What will happen exactly as temperatures increase, water availability changes, soil conditions are altered, and more atmospheric carbon dioxide is available is unclear. But, farmers have a tremendous capacity to adapt to changing circumstances. If climate change were to occur gradually, farmers would have time to adapt to new circumstances. Yet, this is not what the research predicts. The Committee was repeatedly told that changes in climate change will cause increased variability and more extreme weather events; for example, there will likely be more floods and more droughts. Adaptation strategies will have to be refined as more is known about the exact changes in climate. Adaptation to increased severity in localized conditions will be an increasingly important component of risk management strategies for producers.

CHAPTER 4:
EFFECTS OF CLIMATE CHANGE ON FORESTS: WHAT DO WE KNOW?

As mentioned earlier with regard to the agriculture sector, most of the Canadian research on impact and adaptation in forestry has been summarized into a comprehensive report entitled *Climate Change Impacts and Adaptation: A Canadian Perspective – Forestry*, published in October 2002 by Natural Resources Canada (NRCan). This report focuses on the impacts of climate change on forests in Canada, the consequences of these changes for the forestry sector, and potential adaptation options. While only forestry issues are considered in this section, it must be recognized that the effects of climate change, as well as adaptation decisions in the forestry sector, will be influenced by, and have implications for, other sectors such as tourism and recreation, and water resources.

The effects of climate change on Canada's forests could be numerous and include:

- major changes in future forest growth and survival;
- tree species migration and ecosystem shifts;
- increased shoot damage and tree dieback due to winter thaws;
- increased risk of forest fires and insect outbreaks; and
- increased damage to forests due to extreme weather events.

Such biophysical impacts of climate change on forests are likely to affect Canadian society and the economy through forest companies, landowners, consumers, governments, and the tourism industry. For instance, socio-economic effects may include:

- changes in timber supply and rent value;
- loss of forest stock and non-market goods and services;
- changes in land values, land use options, and non-market values; and
- dislocation of parks and natural areas and increased land use conflicts.

The effects of climate change on forests will require appropriate anticipatory adaptation from the forest sector. In order to encourage the inclusion of climate change in forestry management decision-making, some suggest the use of model simulations; others advocate increased communication between researchers and forest managers. To date, however, climate change research in Canada related to forestry has focused primarily on biophysical impacts, such as growth rates, disturbance regimes, and ecosystem dynamics. Much less attention has been devoted to socio-economic effects and the ability of forest managers to adapt to climate change. NRCan's report identifies many knowledge gaps and research needs concerning both the effects of, and adaptation to, climate change.

During its hearings the Committee heard from many experts who have been key players in research on the impact of, and adaptation to, climate change in the forest sector. Much

of this research has focused on expected changes in forest fire frequency and intensity, and expected increases in pests and diseases.

A. Biophysical Effects of Climate Change on Canada's Forests

As with agriculture, there are two sides to climate change with respect to forests. Canada's forests will be affected by climate change; at the same time, they offer opportunities to partially mitigate climate change. Forest ecosystems will likely experience a variety of impacts, both positive and negative, as climate changes occur (Box 7). As well, forests have the ability to take up carbon dioxide out of the atmosphere through photosynthesis, making them an effective tool in partially mitigating climate change.

Box 7: Possible Scenarios for Canadian Forests

Natural Resources Canada summarized the major effects of climate change on forests:

"Along the coast, we foresee an increased growing season and warmer winters, with increased incidents of insects and fire in forests. In the Prairies, we anticipate that some species will disappear at the edges of the current range and that grasslands and temperate deciduous species may migrate northward. Currently, we are seeing a decline of Aspen in the parklands, and that is largely driven by a combination of drought and insects.

In the North, Canada's forest is expected to shift northward about 100 kilometres for every degree of warming. That has some caveats around it such as soil nutrients, which can have a major impact on whether that migration happens. As a general comment, we do expect that the boreal forest will probably decrease in size as the climate continues to warm.

In Western Canada, we see an increased incidence and intensity in wild land fire, whereas in the east, the frequency of fire is likely to decrease. This is largely reflective of the regional climate models and what they are predicting."

(Standing Senate Committee on Agriculture and Forestry, Issue No. 3, 2nd Session, 37th Parliament, Ottawa, November 3, 2003.)

Witnesses told the Committee that there will be impacts on tree growth, as well as on other factors such as nutrients in the soil and particular conditions that are required for some species to regenerate. In theory, warmer climates and a longer growing season should encourage tree growth. Milder winters and longer growing seasons may also affect the hardening process of trees, which ensures that the buds do not break out prematurely. Productivity may be enhanced by more carbon dioxide, since plants require CO_2 for photosynthesis – although nutrients will have to be available to optimize the potential benefit of the additional CO_2.

It is assumed that climate change will result in an increased intensity of natural disturbances such as fires, insects and disease, as well as more extreme weather events such as ice storms and droughts. Changes in forest and species composition are likely to result from natural disturbances such as fire and insects, and from climactic conditions, such as the length of the growing season and the precipitation regime. In some situations, increased pest infestation may exacerbate fire occurrence or frequency; in the past, for example, mountain pine beetle infestations have resulted in hundreds of thousands of hectares of dead trees that are a real fire threat. Some experienced researchers now believe that the boreal forest is about to become not a sink for carbon dioxide but a source of carbon dioxide because of forest fires.

The Canadian Forest Service (CFS) is expecting a northern movement of temperate forests and of the boreal forest as a result of increased temperatures. Nevertheless, there are other factors that come into play. Soil nutrients are one key factor that may seriously limit how far certain species will move, because they are not evenly distributed across the landscape. Other factors such as quantity and quality of light are also important and may have a direct influence on the small size of trees that would grow in a northward-expanded boreal forest. Moreover, some specialists fear that insects may migrate north more rapidly than tree species. Dr. Jay Malcolm from the University of Toronto mentioned that in order to follow the climatic conditions northward, plant species will have to migrate at unprecedented speed. Therefore, if tree migration does not keep up with the rate of warming, we could potentially lose species – notably the slower, late-successional species that are often of interest to the forest industry – and we might end up with weedy and less vigorous forests. An additional concern exists for Atlantic Canada since there is no land south of that region; therefore, new plant communities may emerge if plant species are unable to migrate from the south.

From a regional perspective, major changes are expected, particularly in the North. Ms. Ogden, of C-CIARN North, noted that in the Yukon and Northwest Territories, forestry is a small but important and growing contributor to the economy. Data for Yukon indicate that the number of forest fires and hectares burned has been increasing since the 1960s. This trend is expected to continue as temperatures warm and lightning storms become more frequent. Predicted increases in summer precipitation may not be enough to offset the projected warmer temperatures. Studies conducted in the Mackenzie Basin show that, without changes in fire management, the number and severity of forest fires is projected to increase, and the average number of hectares burned annually is expected to double by 2050. Climate change will also have an impact on populations of forest pests, such as spruce bark beetle and white pine weevil. For example, spruce bark beetles killed almost all the mature white spruce over some 200,000 hectares in Kluane National Park in southwest Yukon between 1994 and 1999. A series of mild winters and springs provided good breeding conditions for the beetles, which allowed them to multiply rapidly. Similarly, the distribution of white pine weevil, which attacks Jack pine and white spruce, is strongly related to temperatures; this pest is expected to expand its range both northward in latitude and upward in elevation.

Dr. Dave Sauchyn, of C-CIARN Prairies, stated that the dominant impact of climate change in the Prairies is expected to be an expansion of dry grassland areas and a reduction in the damper land that supports trees. In terms of forestry, the major impact of climate change will be a change in forest productivity, but results from studies vary greatly depending on the factors considered. Productivity could be initially enhanced by more carbon dioxide, because plants require carbon dioxide for respiration and productivity. Ultimately, however, forest productivity could decline as a result of lack of soil moisture, and the drying out of the forest will lead to a greater frequency of fires and insect infestations. The changing climactic conditions will also affect the occurrence of commercially important tree species. Such uncertainty stresses the importance of research at the local level where these factors can be put together to reach more meaningful conclusions.

In British Columbia specifically, the Committee was told that projected impacts of future climate change include continued lengthening of the growing season, increased crop water demand and increased risk of fire and pest infestations. Concerns focus on reduced forest productivity and risks to forest growth in northeastern British Columbia, while forest pests and fire risks will likely increase in the B.C. interior and expand to higher elevations and latitudes. The expected changes in climate and their impact on B.C. forests will have to translate into new management approaches and decisions in forestry. Some research has already been undertaken into the possible relationship between the elevation at which certain species of seed are planted, and the eventual yield. Results appear to indicate that planting at higher elevations may maintain or increase the yield in the future, because temperatures cool with elevation. Similarly, the catastrophic example of mountain pine beetle may prompt foresters to reconsider the use of lodgepole pine in Western Canada when it is necessary to reforest an area (Box 8). According to Dr. Stewart Cohen, from C-CIARN B.C., the experiments with lodgepole pine seedlings demonstrate that reforestation plans will need to consider climate changes over the lifetime of newly planted trees. These considerations raise still further questions that will require more research: how will future harvest levels be affected? What will be the impacts on communities that depend on the forest industry?

Box 8: The Dramatic Impact of Mountain Pine Beetle on Forests in the B.C. Interior.

Dr. Stewart Cohen, of C-CIARN B.C., summarized the research undertaken by the Canadian Forest Service on mountain pine beetle outbreaks in British Columbia.

Observations showed that there have not been many outbreaks in areas where the summers were relatively cool, primarily higher elevation regions, and in areas where the winter minimums are below –40ºC. The last couple of winters have not produced these cold temperatures. Thus the beetles have been surviving the winters, and they have been able to expand their area of damage. The CFS has documented the recent outbreak as reaching close to 1.5 million hectares.

Not only have the winters been warm enough for the beetle to survive but susceptible pine trees, such as lodgepole pine, have been expanding in the area as the result of a management decision that was obviously taken for reasons of efficiency and productivity. This decision, however, combined with the warmer winters, created a new vulnerability that has aggravated the recent outbreak.

What about the future? The CFS has prepared projections that estimate future climactic suitability for the mountain pine beetle. These projections indicate that areas of high and extreme climactic suitability are expanding to the point that they dominate all of the low-elevation regions in the B.C. interior – south, central and north.

Researchers are not certain whether Canadian forests will experience increased or decreased productivity as a result of climate change. In theory, warmer climates and a longer growing season should result in more growth; on the other hand, more fires and more insects will inhibit growth. If forest productivity decreases as a result of climate change, Canada's competitiveness in the export of forest products is likely to be affected relative to that of other countries. The Committee was somewhat reassured, however, by the evidence of some experts who believe that forestry opportunities will remain. For instance, there could be significant increases in tree growth in Eastern Canada.

Picture 2: 2001 Mountain Pine Beetle Damage
(Red areas show insect infestations)

Source: Stewart Cohen, brief submitted to the Standing Senate Committee on Agriculture and Forestry, Ottawa, February 4, 2003.

In some studies of the Canadian forest sector, Dr. Perez-Garcia, from the University of Washington, found that consumers of forest products will benefit from climate change through more supply and lower prices, but timber producers are likely to see lower wood prices and fewer economic benefits unless they are in a position to expand market share. Dr. Mendelsohn, from the Yale School of Forestry and Environmental Studies, also expects to see benefits for consumers and decreasing global prices. Like economic projections for the agriculture sector, these results are very dependent upon the number of assumptions that underlie the different models and studies. For example, some of these scenarios do not account for soil and water limitations in northern latitudes. Many witnesses suggested, however, that climate change will probably not be the main driver of Canada's competitiveness; rather, economic factors such as trade issues (such as the softwood lumber dispute) and trade barriers will likely continue to determine whether the country remains competitive.

Moreover, as Dr. Gordon Miller, Director General of the CFS, pointed out, climate change will affect not only trees but all the major services and benefits Canadians receive from their forests. Representatives of the Canadian forest industry, like other witnesses, insisted on the fact that climate change was not only a scientific issue but a social issue as

well: ***"When we talk about the impact of climate change on the forest industry, we are talking about the impact of climate change on the livelihood of a million Canadians."***[10]

B. Adaptation Options for Forestry

Since ratifying the Kyoto Protocol, Canada has focused most of its efforts on the mitigation of climate change. Obviously, both agriculture and forestry can play a key role as sinks for carbon sequestration, thus helping Canada to reach its commitment under the Protocol. But climate change is already happening and will continue to happen, forcing Canadians to adapt in every aspect of their life. Clearly the forest industry is interested in both mitigation and adaptation. Forestry companies claim that they are already planting the right trees, given the predicted future conditions. ***The reality is that they must also manage our forests in a way that continues to support the large number of job generated by the forestry sector, while protecting the quality of Canada's environment.***

Representatives of the Canadian forest industry appearing before the Committee claimed that government should dramatically increase research into the effects of climate change on ecosystems, and strategies for adaptation. In the industry's view, a preoccupation with implementing the Kyoto Protocol must be balanced by an equally strong preoccupation with the effects of climate change on Canadian rural communities.

With regard to adapting to those effects, the industry is already taking steps to minimize losses due to forest fires by improving fire protection activities. For example, NRCan researchers have collaborated with provinces, the forest industry, and universities to develop and evaluate a concept known as "FireSmart forest management." This involves strategically integrating fire and forest-management activities to reduce the overall flammability of forest landscapes through actions such as harvest scheduling, cut-block design, reforestation, and stand tending. In cooperation with municipal, provincial, and federal organizations, the most recent scientific information on this subject has been synthesized into a guidebook that can be used to reduce fire risks to homes and communities.

Box 9: The use of tree plantations and fast-growing species

The Canadian Forest Service provided some pros and cons about plantations of fast-growing species:

The majority of plantations around the world use exotic species, rather than native species – although in some cases, native species are used as well. The Forest 2020 initiative envisions the use of fast-growing species, conifers as well as deciduous, with a particular emphasis on hybrid poplars and willows. These species do not currently figure significantly in Canada's commercial forestry practices. Hybrid poplars reach maturity at 18 or 20 years of age. Since they are fast-growing and sequester carbon quickly, their use may help to mitigate the effects of climate change.

On the other hand, these hybrids often require much more intensive management, the hybrid poplar being a notable example. It requires a lot more fertilization and irrigation to grow well relative to some other species. Furthermore, pests are a concern, since many insects and diseases in Canada can affect hybrid poplar.

Through classical tree breeding as well as biotechnology, research has been investigating more drought-tolerant varieties of trees. The gene that is responsible for drought tolerance has been identified in some species, such as white pine.

[10] Mr. Avrim Lazar, Forest Product Association of Canada, Standing Senate Committee on Agriculture and Forestry, Issue No. 7, 2nd Session, 37th Parliament, Ottawa, February 11, 2003.

Likewise, the industry can operate in a way to minimize losses due to insects and disease by applying appropriate silvicultural practices or innovative pest-management techniques wherever possible.

Moreover, forests are widely believed to help reduce atmospheric CO_2 through sequestering it in trees. More intensive silviculture leads to more sequestration. Even when the timber is cut, the benefits remain: when trees are used to build a house, the carbon is still sequestered in that house. It should be noted, however, that not all forest specialists share the same views on sinks and reservoirs. The Sierra Club stated that Canada's forests are currently emitting more carbon into the atmosphere than they are sequestering, due to the increase incidence of insect attacks and even more of wild fires over the entire national forest landscape since the 1970s.

Private woodlot owners can also play a significant role in the CO_2 sequestration part of the climate change equation. Provinces such as New Brunswick and Quebec have implemented programs that include large afforestation components for planting trees where forests did not previously exist, or had not for more than 20 years. In several other provinces, woodlot owners are also doing significant work in planting on marginal and abandoned farmland. It has been estimated that the potential for planting on private land is about 35,000 hectares a year over a period of 10 years. In this regard, the choice of species is key. For instance, although hybrid poplar can grow quickly and sequester a large amount of carbon over 20 to 25 years, the species does not do as well in the East as it does in the Prairies. White spruce, on the other hand, is frequently used on old fields in eastern Canada. Private woodlot owners therefore require considerable flexibility in the design of any such tree-planting program.

There are some uncertainties with respect to plantations. Richard Betts, a senior ecosystem modeller at the Hadley Centre, mentioned that afforestation in snowy regions such as Eastern Canada may actually warm the climate because of the *albedo* feedback i.e. if open land were replaced with forests, the land surface would be darker, particularly in regions with a long period of snow cover; it would therefore absorb more solar radiation and warm further, creating an additional warming effect on the climate.

The Committee also heard that a major problem with afforestation or any form of plantation is the large degree of uncertainty about which species to plant and where. In effect, while we can guess what climatic zone might be suitable for a tree in 50 years' time, that does not necessarily mean that a seedling planted in that area now would be well suited to it. According to the Sierra Club, this uncertainty is one factor that is delaying the forest industry in implementing adaptation measures.

In fact, the Committee noticed from some presentations that the forest industry seems to be adopting a somewhat "wait and see" approach towards adaptation to climate change. The Committee certainly commends the industry for having taken early action and succeeded in reducing its global GHG emissions by 26% since 1990. However, notwithstanding the uncertainty about the impact of climate change on forest ecosystems over the next decades, several witnesses strongly believe that the Canadian forest

industry must rapidly apply current knowledge on forest fires, insects and diseases in its long-term planning of forest operations. It is true that planning now for what the climate in Canada will be like in 100 years is difficult, but the industry can count on the help of science undertaken within the Canadian Forest Service and Canadian universities to ensure it has the capacity to plan for the future.

One good example for the forest sector to consider is the issue of forest fires in the eastern part of Canada's boreal forest. As indicated in Box 10, the burned area threshold is at approximately 1% of the total forestland base. Since the total annual area harvested also corresponds to 1% of the land base, this means that any increase in forest fire frequency (that is, the area burned, not the number or occurrence of fires) towards the 1% threshold may translate into a decrease in the timber supply that can be used for forestry. This in turn raises the issue of harvesting methods. In the boreal forest, the industry has been clear-cutting the forest as a means of mimicking the ecological role of fire in maintaining the age structure of the forest. With future changes in fire patterns and with continuing social pressure for preserving more old-growth forest, it might be necessary to increase the rotation period to 200 or 300 years, or to cut part of the land base in such a way to mimic the ecological dynamic of old-growth forests.

Box 10: The science of forest fires

Dr. Yves Bergeron has studied historical trends in forest fire frequency (area burned).

A big change in climatic conditions in Canada in the middle of the 19th century is the primary reason that the current burning rate of the boreal forest is lower than the past burning rate: there were far more fires in the past than there are now. Under current climate change scenarios we might expect a slight increase in the percentage of area burned, but nothing comparable with the pre-1850s situation, except in the Northwest Territories.

The burning rate is an important aspect to consider when planning for future harvest. Clear-cutting mimics forest fire. In the boreal forest, forest companies operate with a 100-year rotation, i.e., 1% of the land base can be harvested every year. A problem with the timber supply occurs when the burning rate is more than 1%, because it means that the fire is destroying more of the forest than should be harvested in any one year. For forest companies, a burning rate approaching 1% means a decrease in the timber supply that can be harvested.

Current burning rates are under 1%. Under various climate change scenarios, the burning rate of the boreal forest in most places in Canada will be closer to the 1% threshold. Locations that will be particularly affected will be the Taiga Shield, the boreal shield and the boreal plain. Only in the Rockies is a significant decrease in fire frequency forecast.

Details such as these are technical, but they show the importance of understanding what is happening in Canada's forests. In this regard, it is essential to have a good inventory and monitoring system that will help keep track of the changes currently taking place in forest ecosystems and provide a sound basis for developing mitigation and adaptation measures.

Some witnesses insisted before the Committee on the importance of implementing large protected areas for providing north/south corridors along which species can migrate to new habitat. Such natural corridors could allow species to migrate 50, 100 or 200 kilometres north. Canada has the opportunity to ensure those possibilities exist in some northern landscapes and forests that have not yet been fragmented by extensive road

networks and other developments. To the extent that protected areas can limit fragmentation, they can be an extremely valuable tool to allow for species adaptation.

The uncertain impact of climate change on the Canadian forest industry and on the rural communities that depend on healthy forests for their well-being may represent a good opportunity for all forestry stakeholders to undertake a profound reflection about forest management of the future. Some witnesses brought forward ideas about forest tenure, intensive forestry, protected forests and corridors, etc. The Model Forest Program offers field laboratories for testing new approaches to forest management. More and more people seem to believe that part of the solution to adapting to climate change in the forestry sector could be to undertake more intensive forest management in forested areas closer to populations and where the land tenure would be different. Perhaps the land base could be leased for a longer period to individuals, or private woodlot owners could produce timber for a company. Measures such as these would reduce the pressure on forest Crown lands in the north.

Canada's forests are more extensive and varied than those in most other countries, including the Scandinavian nations. As it was put forward in this Committee's report on boreal forest,[11] Canada can afford the luxury of combining intensive forestry and high-yield plantations with the use of virgin and second-rotation forests for timber production. We have the flexibility to include more of our forest resources in conservation areas, and we have the ability to sequester carbon in both the working and the standing forest. How we choose to manage our forests will determine whether they can continue to create wealth for Canada and sustain the communities and society that depend on them. If we fail to manage them properly, all Canadians will pay the price.

Summary

Climate change is likely to affect Canada's forests in different ways. Researchers are not yet certain whether Canadian forests will experience increased or decreased productivity as a result of climate change, but it is expected to see the temperate forests and the boreal forest move northward as a result of increased temperatures. Such impacts of climate change on forests are likely to affect Canadian society and the economy. Notwithstanding the uncertainty about the impact of climate change on forest ecosystems over the next decades, appropriate anticipatory adaptation from the forest sector will be required, and this may represent a good opportunity for all forestry stakeholders to undertake a profound reflection about forest management of the future.

[11] *Competing Realities: The Boreal Forest at Risk*, Report of the Sub-Committee on Boreal Forest of the Standing Committee on Agriculture and Forestry, June 1999, 1st Session, 36th Parliament.

CHAPTER 5:
EFFECTS OF CLIMATE CHANGE ON WATER

"…water is, in fact, a rural resource."
Dr. Mohammed Dore, Brock University[12]

"…the climate anomaly of greatest concern is drought."
Dr. Dave Sauchyn, University of Regina[13]

Climate affects all aspects of the hydrological cycle. Consequently, changes in the climate are likely to affect water supplies and demands, as well as ecosystems that specifically depend upon regular supplies of water. The Committee heard evidence of how climate change might affect ecosystems and water supplies, potential impacts on water demands, the effect on our agriculture, forests and rural communities, and some adaptation strategies.

A. Effects of Climate Change on Water Resources

Climate change may affect the quantity, quality, timing, location, and reliability of water supplies. Warmer temperatures will alter the magnitude and the timing of precipitation. Furthermore, warm air holds more moisture and increases evaporation of surface moisture. With more moisture in the atmosphere, precipitation tends to be more intense, increasing the potential for extreme events such as floods. As Dr. Sauchyn, Coordinator, C-CIARN Prairies, stated:

> "We expect storms to occur with increasing frequency so that a rainstorm … of a certain size will occur more often."[14]

But of all the aspects of climate change that have been studied, such as temperature, precipitation is the least understood, and predictions on how precipitation regimes will change are the most uncertain. Dr. Sauchyn continued:

> "The forecast of precipitation [indicates] anything from a small decrease in precipitation to quite a large increase. Most of the scientific information points to actually increased rainfall and snowfall in the Prairie provinces…[yet] as a result of the higher temperatures, there will be a much greater loss of water by evaporation, and also plants will transpire more water. As a result of the increased water loss, the major impacts of climate change on the Prairie provinces are loss of soil moisture and surface water. Even though the good

[12] Standing Senate Committee on Agriculture and Forestry, Issue No. 14, 2nd Session, 37th Parliament, Ottawa, March 27, 2003.
[13] Standing Senate Committee on Agriculture and Forestry, Issue No. 6, 2nd Session, 37th Parliament, Ottawa, February 4, 2003.
[14] *Ibid.*

> news is a longer growing season, the major limitation, as a result of climate change, will be the loss of water. The loss by evaporation, in particular, will much exceed the increased precipitation that is forecast."[15]

Dr. Rhonda McDougal of Ducks Unlimited gave a regional perspective of the effects on agriculture in the Prairie pothole region, where most of Canada's crop activity is situated:

> "On the Prairies, a high percentage of farm families and rural communities rely on surface water sources for their drinking water, for livestock and all their other water needs. This is a real concern across the Prairies, which are in a water-limited situation every year, particularly in the last few years."[16]

Most troublesome for farmers and the forest industry is that,

> "the water cycle will be more variable, so there will be wet years. In fact, we expect there will be years that are wetter than normal but, at the same time, there will be years that are much drier than normal…"[17]

In Canada, snow and ice are the principal source of runoff that supplies our surface bodies of water, such as lake, rivers, and streams. Changes in snow accumulation in Canada's mountain ranges may not necessarily be gradual; indeed, there may be a "radical change" due to warmer winters. For the Prairies, the implications will be especially profound. Much of the water in Saskatchewan and Alberta is derived from glacier and snowmelt in the Rocky Mountains. This snowmelt is the basis for irrigation in southern Alberta and western Saskatchewan, and all of the cities in these two provinces derive their water either directly or indirectly from the Rocky Mountains. Yet, scientists expect most of the glaciers in the Rocky Mountains to disappear this century.

Similar changes are occurring in some other parts of the globe. For instance, Mount Kilimanjaro, which has not been ice-free for 11,000 years, will be ice-free within the next 20 or 30 years. On the other hand, Mr. Peter Johnson, Science Advisor for C-CIARN North, mentioned that the warming that has been taking place in the North Atlantic and over the Nordic countries has increased the amount of snow, which in turn has increased the massive glaciers in Scandinavia. In this case, the connection is being observed between warmer temperatures, increasing open water evaporation, and more snow.

Dr. Sauchyn stated that the "dominant impact of climate change on the Prairie provinces [will be] the expansion of the land that is currently dry and supports grasses, and a shrinking of the land that is currently relatively wet and supports trees…[one] can easily appreciate the implications of this for both agriculture and forestry." This loss in surface water will affect wetland ecosystems – habitats and wildlife:

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[15] *Ibid.*
[16] Standing Senate Committee on Agriculture and Forestry, Issue No. 8, 2nd Session, 37th Parliament, Ottawa, February 20, 2003.
[17] Standing Senate Committee on Agriculture and Forestry, Issue No. 6, 2nd Session, 37th Parliament, Ottawa, February 4, 2003.

> "As we see these wetlands drying up and disappearing on the Prairies, we will also see a loss of rare plant species. We will see a loss of habitat and of some of the shelter belts and willow rings around these systems. Therefore, we will lose habitat for species at risk, for species that use these places as watering holes and as protection from predators at various times in their life cycles." (Ducks Unlimited)[18]

Ms. Cheryl Bradley, from the Federation of Alberta Naturalists, mentioned that the modelling of river flows for the South Saskatchewan River Basin Water Management Plan process has determined that if instream flow needs are to be met for water quality, fish, riparian habitats and channel maintenance, limits for water allocation have been reached or exceeded in the Bow River, Oldman River, South Saskatchewan River and their tributaries. Mr. Petrus Rykes, Vice-President, Land and Environment Portfolio of the Council of Tourism Associations of British Columbia, conceded that even his area of west Chilcotin, which is surrounded by significant glaciers, the water table is drying up. Thus, if the snowpacks are not replenished, there could be water-related conflicts in the future.

B. Water Stresses on Agriculture, Forestry, and Rural Communities

> **"Land without water is a tough sell."**
>
> *Mr. Petrus Rykes, Vice-President, Land and Environment Portfolio of the Council of Tourism Associations of British Columbia*[19]

Although changes in precipitation patterns are still uncertain, they will force Canadians to operate very differently in terms of their use of water. Given the demands for water by agriculture, the forest industry, and households in rural and urban areas, the evidence indicates that water-use conflicts will increase.

Picture 3: Above: St-Lawrence River 1999 – extreme level lower by 1 meter. Below: 1994 – average for the last 30 years. If 1999 was the average, which extremes are added?

Source: Alain Bourque, brief submitted to the Standing Senate Committee on Agriculture and Forestry, Ottawa, December 12, 2002.

[18] Standing Senate Committee on Agriculture and Forestry, Issue No. 8, 2nd Session, 37th Parliament, Ottawa, February 20, 2003.
[19] Standing Senate Committee on Agriculture and Forestry, Issue No. 12, 2nd Session, 37th Parliament, Vancouver, February 28, 2003, morning session.

Across Canada from the Atlantic to the west coast, agriculture, forests, and rural communities are experiencing water stress. For example, in Atlantic Canada, Mr. Jean-Louis Daigle, of the Eastern Canada Soil and Water Conservation Centre, mentioned that a consultant group had undertaken an initial examination of water availability in consultation with the agriculture industry. The study concluded that there might not be a net shortage of water on an annual basis in the four provinces. It did, however, identify key issues including the availability of water in critical periods for agriculture, potential concerns over the allocation of water resources, and water quality for irrigation and the livestock.

The northern part of British Columbia is experiencing more rain and less snow. While this phenomenon has caused spring flooding, river levels later in the year are at record lows. This has affected numerous farmers, but in different ways. The Committee was told that one Prince George farmer used to water every second week; but in the last year, she needed to water only once during the whole year. A farmer in British Columbia's Bulkley Valley, however, reported that although there was a lot of rain last summer, he still had to irrigate the soil because the soil did not maintain its moisture level.

Furthermore, Ducks Unlimited mentioned that, as agricultural activity migrates north with climate change, agriculture will occur in areas of higher wetland density. There are even higher densities of wetlands in the boreal forest fringe regions of Manitoba, Saskatchewan and Alberta. There will be greater impacts in those areas with competing uses for those water resources.

Many sectors of the economy depend upon forests. Ecotourism groups, for example, are vulnerable to increased risks due to climate change. In 2000, in British Columbia alone, there were over 1,100 adventure tourism-related establishments using over 27,000 streams and lakes. Ms. Carol Patterson, President, Kalahari Management, gave examples of increased difficulties faced by ecotourism operators. For instance, in the case of activities that are dependent on water runoff, such as whitewater kayaking and whitewater rafting, some operators are finding insufficient water to maintain their business. For example, where they used to be able to run rivers for three months, they now may be able to run them for only one month.

Rural communities that are dependent upon agriculture and/or forestry will face the same water stresses. If Canada's agriculture and forest sectors are unable to cope with changes in water resources and quality, rural communities will continue to suffer not just in terms of a diminished economic base, but also in terms of quality of life as water becomes scarcer or its quality is compromised.

While some areas of Canada are likely to experience water shortages as the climate warms up, others may experience the reverse. Witnesses from various parts of the country emphasized that bigger storms can be expected due to climate change, and that rainfall may come in more intense bursts; this could result in increased soil erosion, and consequently affect surface water quality and the quantity of wastewater to be treated. In Atlantic Canada, erosion and flooding are serious concerns, as is the loss of coastal

wetlands, which play a vital role in the overall energy and biodiversity requirements of ocean ecosystems. Moreover, greater instability in weather events increases the concern regarding potential saltwater intrusion into freshwater ecosystems and drinking water sources.

If these patterns continue, multiple users will be competing for the same resource, and there is a real danger that water quality will be compromised. An adequate supply of good-quality water is essential for livestock, irrigation, human consumption, and industrial use.

C. Adaptation Strategies For Water Resources

Several witnesses mentioned that the main effect of climate change is likely to be on Canada's water resources, and that it could compromise Canada's ability to meet the needs of Canadians. While few adaptation strategies were actually suggested to the Committee, the members understand that the operational principles for adaptation will be different for agriculture, forestry, and rural communities due to the diverse level of resources and needs in these sectors. There are also regional, provincial, and north-south dissimilarities since the effects of climate change will vary across the country.

Strategies for adapting to climate change are perhaps most developed in the agriculture industry, where farmers have learned to adapt to changes in weather for many years. Witnesses mentioned practices that are already being used, such as conservation tillage and green cover crops to take marginal lands out of production, they could provide few examples of methods to help farmers manage this source of risk. Similarly, no concrete examples of adaptation to water stresses were provided for the forest industry, other than the mention of hybrid trees. Yet the Committee was told that these hybrids need intense management, such as heavy irrigation – which would make them of questionable value in an era of increased water conflicts.

Several witnesses did mention that with respect to water resources, adaptation measures will probably concern mostly engineering and infrastructure, for example, the development of large-scale irrigation systems and dams. Some witnesses cautioned, however, that any plans for new infrastructure must take long-term considerations into account. As mentioned by Dr. Dore, a professor at Brock University, the IPCC has advocated a "no regrets policy" – a policy that will generate net social benefits whether or not there is human-induced climate change. Working on technology to improve water use efficiency may be more practical in terms of adaptation measures.

Rural communities have limited resources to allocate to long-term planning concerning the changing weather. Dr. Dore mentioned that increasing precipitation in Eastern Canada will mainly affect wastewater treatment. Existing wastewater treatment capacity may not be adequate to handle high precipitation due to storm water runoff. Furthermore, high wastewater flows during high precipitation times and spring runoff will result in the combined sewers being bypassed and untreated wastewater ending up in lakes and rivers, polluting the precious resource. Water systems will have to be updated to ensure a safe

and adequate water supply. Therefore, certain areas will require transitional funding and adjustments to programs to ensure that their economic base and quality of life are maintained.

Finally, witnesses suggested that to maintain health of our rivers while also accommodating human population growth and economic diversification, measures are required to encourage water conservation and allow reallocation of water to uses deemed of higher value. In June 2002, the Alberta government authorized the use of water allocation transfers and water conservation holdbacks. Farmers have already taken such an approach; in 2001, sugar beet growers in Alberta were allocated a specific amount of water per allotment and used it on sugar beets, because they are a high-value crop, rather than on cereals. If water use conflicts increase in the future, decision-makers will have to determine what uses are appropriate and inappropriate, and where our water is best allocated.

Summary

The main effect of climate change is likely to be on Canada's water resources. While predictions of how precipitation regimes will change are very uncertain, we can expect more variability in precipitation with years that are wetter than normal, years that will be much drier than normal and an increased frequency of storms and droughts. Adaptation measures will mainly concern engineering and infrastructure – irrigation, water treatment plants, etc. – but also technology to improve water use efficiency. Those measures will vary locally and will depend on the users – agriculture, forestry, tourism, etc. Given the demands for water by agriculture, the forest industry, and households in rural and urban areas, the evidence indicates that water-use conflicts will increase. If water-use conflicts increase, decision-makers will have to determine what uses are appropriate and inappropriate, and where the available water is best allocated.

CHAPTER 6:
EFFECTS OF CLIMATE CHANGE ON RURAL COMMUNITIES

During the hearings, there has been much discussion on the effects of climate change on rural communities. What is a rural community, however, varies depending on how we define "rural". Thus, "rural population" remains a vague concept that represents between 22% (Statistics Canada definition)[20] and 33% of Canada's population (definition of the Organisation for Economic Co-operation and Development – OECD). Nevertheless, a common feature of all rural communities in Canada is their natural resource-based economies. Based on this factor alone, rural Canada is an important contributor to the country's wealth, supplying 15% of the Gross Domestic Product and 40% of Canadian exports.

Most of the research on the effects of climate change has focused on environmental problems, such as the impacts on forest growth, crops, and water. It should be made clear, however, that the vulnerabilities in the agri-food and forestry sectors go beyond environmental threats. The biophysical effects of climate change will have financial and economic repercussions. If the financial viability of farming operations, forestry operations, sawmills and other natural resource-based industries is

Box 11: Tourism and Climate Change

Last April, the World Tourism Organization convened a conference on climate change and tourism. It is only in the last few years that, according to Mr. Petrus Rykes, Vice-President of the Council of Tourism Associations of British Columbia, the tourism industry began to realize it is a resource industry that uses the land, and that it will therefore be affected by climate change. Tourism, and more specifically ecotourism – which promotes conversation of the natural environment in which it occurs – depend on Canada's agricultural landscapes, forests, and rural communities; therefore, any negative effect of climate change on these sectors and the communities will affect the industry.

After finding that hiking rates for the continent were down in 2000, the Outdoor Recreation Council of America undertook a study that concluded that the drop in numbers was the result of the large fires that occurred that year; potential travellers were under the impression that much of the west was ablaze. Forest fires and insect outbreaks (mountain pine beetle, for example) will affect activities such as hiking, horseback riding, and cross-country skiing. Other direct effects include lack of water for summer activities such as whitewater rafting, and lack of snow in the winter for skiing and dogsled operations. Changes in ecosystems will affect wildlife patterns and activities such as birdwatching and fishing. Furthermore, it is not necessarily the actual risk that might cause problems, but the perception of risk; if people feel they will be in danger or will not have the type of experience they want, they will not travel to those areas. In addition to these direct effects on activities, the tourism industry might face other consequences, such as higher insurance costs related to fire hazard, and liability issues if an operator does not deliver what he or she advertised.

Snow-making equipment and water purchases from hydroelectricity companies may be solutions for some operators in specific areas. In most cases, adaptation to climate-related changes will require creativity. Ms Patterson, of Kalahari Management Inc., mentioned that operators might have to diversify their product lines or their locations. Many companies have already added interpretative sessions to their main activities, for example. Mr. Joseph Hnatiuk, of the Ecotourism Society of Saskatchewan, suggested that ecotourism operators can use climate change as part of their interpretive and educational program by illustrating the effects of climate change and showing how important it is to address GHG emissions, and what we can or cannot do to adapt to climate change.

[20] Statistics Canada defines rural areas as "sparsely populated lands lying outside urban areas" or in other words those areas with a population concentration of less than 1,000 and a population density of up to 400 per square kilometre.

threatened, so is the viability of rural communities that rely on them.

Much emphasis has been placed on the need for these communities to diversify their economies so that they are less vulnerable to the effects of climate change. But it is important to note that tourism, hunting, fishing, winter sports, and Aboriginal culture are also affected by the changing weather patterns (Box 11). Thus, climate change is not just an abstract environmental problem, but also an economic issue that will affect the livelihood of many Canadians.

For example, Dr. Barry Smit mentioned that the 2001 drought was estimated by Canadian Wheat Board economists to have cost approximately $5 billion. The 2002 drought, which affected many parts of Canada, was even more costly. Mr. Bart Guyon, Vice-President of the Alberta Association of Municipal Districts and Counties, reported that the 2002 drought cost Canadian National alone more than $100 million in lost commodities.

The impact of climate variations is even stronger when communities are unprepared. Speaking from his own experience, Mr. Guyon described how in 2002 he had to drill four water wells and two dugouts on his ranch as a result of the drought. On a ranching operation, lack of water and pasture does not give much time to react, leading to draconian measures. While the Committee acknowledges that we cannot say that a particular drought is caused by climate change, scientific evidence does clearly indicate that we can expect changes in the frequency of extreme weather events. The recent droughts illustrate how serious such events could be for our unprepared communities.

Rural municipalities in Saskatchewan derive a significant amount of tax revenue from agricultural land. In some cases, there is no other industry and 100% of the municipal assessment consists of agricultural properties. Therefore, anything that affects the ability of the land to produce cash crops also affects the ability of taxpayers to pay their municipal taxes. Not only could rural municipalities lose revenue as a result of climate change, but also they could be faced with increased expenditures. Mr. Neal Hardy, President of Saskatchewan Association of Rural Municipalities, gave as an example the increased number of forest fires as a result of the 2002 drought. Several rural municipalities experienced significant firefighting costs: the rural municipality of Loon Lake alone spent $920,000 – twice its tax revenue. Dr. Dore, a Professor at Brock University, also advised that municipalities have responsibilities with respect to water. With changing precipitation patterns, they will need the financial resources to upgrade their infrastructure, including water storage, wastewater processing, and sewage treatment.

The three organizations representing rural municipalities who appeared before the Committee during its tour of Western Canada agreed that many stresses already affect the livelihoods of those who live in rural communities, including low commodity prices and the economic effects of trade conflicts such as the softwood lumber dispute. Sometimes severe weather patterns make things even more difficult; the successive droughts in the Prairies are a perfect example. Ms. Sue Clark, of the North Central Municipal

Association, however, told the Committee that rural residents do not necessarily link these weather events to climate change. Furthermore, small rural communities do not necessarily consider climate change as a key concern because of the multitude of other pressing issues they must face with limited resources.

Over the past several decades, rural communities in Canada, in particular agricultural communities, have been changing dramatically in population and composition, due to migration and structural changes in agriculture. Agriculture does not attract young people because of the risks, the capital investment, and the difficulty in making a living. In some areas, other industries, such as the oil industry in Alberta, help to offset losses in the agriculture industry. To illustrate this evolution, Mr. Guyon mentioned that in his community in Alberta, 85 to 90% of farmers have a second job. In 2000, for example, off-farm income represented 56% of the total farm income. This type of diversification is likely to accelerate as residents in rural areas look for ways to protect themselves from economic risks that may be aggravated by climate change. Therefore, it is obvious that climate change will bring risks which, combined with the other stresses on the rural sector in many parts of Canada, may speed up some of the changes that are going on in rural Canada.

In addition to the changes that have occurred in the social fabric of rural communities during the past several decades, climate change will also bring its share of social consequences. For example, Dr. Brian Stocks, from the Canadian Forestry Service, mentioned that a forest company might decide not to operate in an area because the odds are too low of growing trees to 80 years without their being prematurely destroyed by fire, insects or some other event. The company will then decide to log trees in another region or country; but the community that depends on this industry is not so mobile. If the Palliser triangle becomes too dry for agriculture, what do you do with the entire grain infrastructure there? Hypothetical situations such as these pose hard questions for rural Canada and its natural resource-based economy. There are no easy answers, but these communities must nonetheless begin to consider preparations in raising their awareness on the potential effects of climate change in their region, and incorporating these potential effects in their long-term planning.

Some possible solutions for rural communities would be first to communicate to their residents that climate change is occurring and that they will need to contend with it, just as they do with other economic risks. They will need to identify their priorities based on their local biophysical conditions and industry – whether it be agriculture, forestry, or some other natural resource. Their priority may be to ensure adequate waste water treatment or collection of water; priorities will vary across the country. Rural communities will have to obtain the necessary financing for their adaptation strategies, whether it is from their tax base, regional sources, provincial, or federal governments. They will have to implement strategies that are effective for their local conditions. Lastly, they will have to develop the necessary human capacity – the skills – to undertake these actions.

Many researchers have suggested that climate change is essentially a social phenomenon. It will create winners and losers, mostly due to the direct and indirect impacts on agriculture, forestry, and other sectors of the rural economy. These impacts will vary across regions, time horizons, and individuals. The advantage of planning for adaptation is that it can be implemented in an equitable and cost-effective way so to maximize the number of winners and minimize the number of those who may lose. Researchers involved in adaptation made it clear to the Committee that rural communities also need reinforcement; Dr. Mehta told the Committee that links exist between adaptive capacity and social cohesion. For example, if water use conflicts increase, some users may be denied the opportunity to use some adaptation options such as irrigation, and social cohesion will be threatened; A strong social fabric is crucial in order to make real improvements in adaptive capacity at the individual level.

Summary

Because rural Canada relies largely on natural resource-based industries, it will be more vulnerable to climate change. Over the past several decades, rural communities in Canada have been changing dramatically, due to migration and structural transformations in resource-based industries. The livelihoods of rural Canadians are already stressed by low commodity prices and by trade conflicts such as the softwood lumber dispute and climate change will bring additional challenges, which may aggravate the current situation. Climate change will have significant financial and economic repercussions on natural resource-based industries, and physical infrastructure will also be challenged by increased weather-related damage. In order to cope with these changes, rural communities will have to start considering climate change effects in their planning.

CHAPTER 7:
EFFECTS OF CLIMATE CHANGE ON ABORIGINAL PEOPLE

This report would be incomplete without mentioning the potential effects of climate change on Aboriginal peoples in Canada. The Committee met with elected representatives from the Metis Nation of Alberta and the Kainai Nation (also known as The Blood Tribe). Representatives from C-CIARN North also provided insights into the situation of the Inuit. Those three groups reported that Aboriginal people are seeing increasing evidence of climate change. The C-CIARN North representatives recalled that experience-based ecological knowledge is now broadly recognized as legitimate and accurate, and that it is particularly important in areas where scientific data collection is limited. Local observations can complement scientific information, offering a more regional, holistic, and longer-term perspective on some of the changes taking place. Dr. Rafique Islam, Sector Advisor of the Metis Nation of Alberta Association, reported that the knowledge and life experience of the Metis elders are closely correlated with recent scientific findings on the trend of climate change. According to the elders, climate change is palpable, and the change may worsen the environmental damage to traditionally used and occupied land that has already been caused by energy, forestry, and mining exploitation.

The IPCC has concluded that indigenous peoples of the North are more sensitive to climate change than non-indigenous peoples, because their homelands and hunting habitats will be directly affected. Changes in sea ice, the seasonality of snow and habitat, and diversity of fish and wildlife could threaten long-standing traditions and ways of life. In some areas of the North, indigenous peoples are already altering their hunting patterns to accommodate changes to the ice regime and distribution of harvested species.

Mr. Andy Blackwater, of the Kainai Nation, also said that the tribe’s elders have referred to the change in the climate, and how weather patterns are affected. Traditionally, they have different ways of predicting the weather over the next few days. In the Kainai culture, there is a month referred to as "the moon of the geese"; but now ducks and geese appear at other times of the year. March storms also used to be very predictable, and a lot of people would prepare accordingly; but increasingly they are not coming on time. Another concern is in the area of traditional medicine: there is the risk of a real shortage in the supply of roots and other vegetation used for traditional remedies. Aboriginal people are very conscious of, and very concerned by, changing weather patterns and other factors that affect their environment. The issue goes right to the heart of these people because in disrupting traditional knowledge, changing weather patterns affect the cornerstone of their culture: the knowledge that has been historically looked to for directions and guidance in life.

Although there is some (limited) potential for developing agriculture in the North under current climate change scenarios, the northern food supply will be more affected by the impacts of climate change on subsistence activities such as hunting and fishing. In other parts of the country, however, Aboriginal peoples have developed agriculture as a way to make a living. These peoples include Metis farmers and ranchers, and First Nations such as the Kainai Nation. The Kainai Nation reserve has 330,586 acres of land classified for agricultural use, 21,373 of which are irrigated. Like other farmers, they will face the effects of climate change on their farm operations, as they felt the effects of the 2001 and 2002 droughts.

Adequate access to government programs, including farm support, training, and research programs, has been discussed and represents a major issue for Aboriginal peoples. C-CIARN North representatives mentioned that interest in building partnerships among scientists, First Nations, and northern communities has increased in the past couple of decades. Most of the documented local and traditional knowledge has been collected in regions where scientific research has been focused. ***One further step, however, would be to improve access to programs that would help Aboriginal peoples to adapt to climate change. As Aboriginal peoples achieve rights to the management of resources and landownership, their organizations are seeking a more meaningful role in research, outreach action, and international negotiations on the climate change issue.***

Summary

Aboriginal people have been true witnesses of climate change: the knowledge and life experience of the elders have produced observations that are closely linked with recent scientific findings on the trend of climate change. For the past decade partnerships among scientists, and aboriginal people have increased, notably in regions where scientific research has been focused, but access to programs that would help them adapt to climate change is still very limited. As Aboriginal people achieve rights to the management of resources and land ownership, their organizations are seeking a more meaningful role in the actions to tackle climate change.

CHAPTER 8:
WHAT DO WE NEED TO DO TO ADAPT?

Researchers who appeared before the Committee presented much valuable information about the potential effects of climate change on Canadian agriculture, forests, and rural communities. They also told the Committee that those effects would start to become clearly evident some time in the 2030-2060 period. Circumpolar countries, including Canada, and the tropics are the two regions that will be affected first and most dramatically.

As mentioned by the Canadian Federation of Agriculture (CFA), however, our understanding of the implications remains at a broad level. We do not yet have a clear vision of what specific areas of our agriculture, forests, and rural communities will look like as a result of climate change. We are a long way, for example, from being able to advise farmers or forestry companies on suitable crops or trees for future climatic conditions. Given this situation, a key question for public policy makers is: at what point should public funds and other resources be allocated to assist communities and to implement adaptation strategies for our agriculture and forestry sectors?

The Committee endorses the idea that planned adaptation is preferable to simply allowing communities to find their own ways of getting by. A recommended approach would be to enhance research on the impacts of climate change, explore practical options for adaptation, and implement a number of "no regret" policies and measures – i.e., policies and measures that would improve our resilience to climate change, but that would also generate net social benefits regardless of whether climate change occurs. Examples include better risk management tools in agriculture, conservation of protected areas (north-south corridors), and enhanced wastewater treatment capacity.

Efforts to develop adaptation strategies require collaboration among all stakeholders, different levels of government, industries, and researchers. The national adaptation framework that resulted from the federal and provincial ministers of Environment and Energy meeting in May 2002 is a good starting point for collaborative initiatives. This chapter presents and discusses three areas for proactive action on climate change: research, communication, and government programs.

A. Research

> **"We have some of the best climate researchers in the world in Canada[…] there is no question that we have the leading scientists in the world here in Canada."**
>
> *Dr. Steve Lonergan, University of Victoria*[21]

[21] Standing Senate Committee on Agriculture and Forestry, Issue No. 12, 2nd Session, 37th Parliament, Vancouver, February 28, 2003, afternoon session.

"Given our incredible uncertainties, we have a huge need for incisive knowledge, and I would suggest that the way we get it is through research capacity building. We have a desperate need for that new knowledge. It needs to be future oriented."

Dr. Peter N. Duinker, Manager, Atlantic Region,22
Canadian Climate Change Impact and Adaptation Research Network

From the beginning of this study, it became clear that research on impacts and adaptation in relation to climate change is still in its infancy. The Committee was impressed, however, by the quality of the research undertaken in our country. Internationally, Canada is recognized as a leader in climate change adaptation, and Canadian researchers have contributed significantly to international initiatives on this topic. Dr. Barry Smit, for example, was the senior author of the Adaptation section of the IPCC Third Assessment Report. Canada is at the cutting edge of this issue, and it should stay that way since our country, which already feels some effects, will be one of the countries that is most affected by climate change.

Climate change has the potential to exert enormous influence – positively or negatively – on the future of our rural communities and on important sectors of Canada's economy. Improving our understanding of it is essential to our ability to prepare and adapt. Climate change research had, and still has, its share of funding, through the Climate Change Action Fund and other funding agencies; but most of these funds address the mitigation aspect of climate change. NRCan is devoting approximately $48 million to its climate change impacts and adaptation program for the period 1998-2006. Of that amount, about $8 million has been spent on research to date. Nevertheless, long before the negotiation and adoption of the Kyoto Protocol, NRCan's Canadian Forest Service was already undertaking research on the potential impact of climate change on Canada's forests and on adaptation to changes that had been observed by the late 1980s. The department now estimates that core funding for research has more than doubled over the last five years, notably through the Climate Change Action Fund and the C-CIARN program.

Nonetheless, many witnesses advocated giving more attention to impact and adaptation issues. There were also calls for a better balance between funding for mitigation and funding for adaptation, although no one suggested that a specific share of climate change funds be targeted to adaptation. Moreover, there are other constraints. For example, deans of forestry faculties across the country are reporting that, even more than a lack of research funding, a lack of facilities and, in particular, of well-qualified graduate students to do the research has become a limiting factor.

Witnesses suggested that if we want Canadian agriculture and forestry industries, and rural communities to adapt to climate change and undertake research that explores adaptation strategies, we must target our funding dollars to that specific area. As Dr. Brklacich put it, in the area of climate change, adaptation would otherwise "continue to languish as the very weak third partner." It seemed obvious to many that without

[22] Standing Senate Committee on Agriculture and Forestry, Issue No. 5, 2nd Session, 37th Parliament, Ottawa, December 12, 2002.

targeted funding, researchers will continue to do research on topics for which there is already an institutional capacity. If the objective is to have a better understanding of adaptation, we must provide an incentive to researchers to focus on this issue.

1. The Need for Integrated Research

Climate change needs to be addressed in an integrated way to understand the social and economic effects on communities and to identify effective adaptation measures. As mentioned previously, although climate change will affect natural ecosystems, adaptation is a social process. When climate change affects a locality, it will not make the distinction between individual elements such as agriculture, water, infrastructures, etc. It will affect the resources that define the place, the interactions between these resources, and the actions of the human population. Impacts cannot be looked at in isolation; linkages between issues and among the stakeholders also need to be studied (Box 12). The interactions between these three pillars – social, economic, and environmental – are not well understood nor studied for Canada.

Box 12: An Example of Integrated Research

Dr. Stewart Cohen, of the University of British Columbia, presented a study on water management and climate change in the Okanagan and Columbia regions of southern and southeastern British Columbia. The Okanagan region is highly dependent on irrigation for agriculture. It is expected that under future climate conditions, the length of the growing season will increase. There is also a growing population in Kelowna and Vernon, and these combined stresses are beginning to create difficulties for the management of water in this region.

A group at AAFC developed a water demand model for agriculture. At the same time, another group studied stream-flow hydrology for a number of creeks in the Okanagan region. Scenarios were brought to water managers in the region in order to begin a dialogue on adaptation. Managers were asked, "What if this were the new hydrograph for your irrigation system, for your municipal system and for your fisheries habitat?" and "What adaptation options would you prefer?" The water managers suggested a number of options: some structural measures, such as building dams at higher elevations to increase storage, and some social measures, such as purchasing water licences. Stakeholders identified the implications of some of these choices. Some would involve high costs, some might have side effects on fisheries, and some might involve restricting individual development choices. This study gave insights on how we might connect global science to local decision-making.

Further work is now being done to link climate scenarios with hydrologic scenarios (water demand and supply; irrigation) and scenarios of land-use change (expansion of cropland or urban lands) through this century. In addition, the study is examining the role of local institutions in proactive water management. It is also investigating the costs of certain adaptation options, including more widespread use of metering, and building expanded reservoir storage or pumping water from Okanagan Lake to higher elevations. The findings will be used to initiate a dialogue on regional water management with water managers and water users throughout the region.

Witnesses agreed that it is extremely difficult to obtain funding for integrated approaches. Dr. Steve Lonergan, from the University of Victoria, suggested that while Canada has some of the best climate researchers in the world, their impact is being diffused because not enough concerted effort has been made to get them together through funded partnerships in integrated research.

2. Areas of Research

During their discussions with the Committee, researchers and industry groups proposed a number of areas where additional knowledge is essential. This section briefly presents the four topics that received the most attention from the witnesses: refinement of national and regional models, examination of water resources, more detailed studies of the effects of climate change on agriculture and forestry, and developing better understanding of what farmers and forest managers think about climate change.

The first area concerns the development of models. Witnesses stated that current models have a broad resolution. This is because thus far only global models have been developed – and these global models are being used to study local effects. For example, they do not take features such as the Great Lakes and the Rocky Mountains into account. Trying to downscale the output to look at the effects of climate change in a small area, however, increases the level of uncertainty. But with a North American model, for instance, there will have greater accuracy about what we can expect for Saskatchewan. Therefore, there is a clear need for climate data sets at a spatial scale that is useful for agriculture and forestry. Dr. Nigel Roulet, from McGill University, also pointed out the need to reduce the uncertainties that are embedded in the models. He suggested that social scientists work with climate modelling and carbon modelling researchers to try to assess socio-economic impacts, and to include adaptation options in the models.

Water is the second topic of interest for research. Changes in precipitation patterns will modify the water supply; changes in land-use, and longer growing seasons, will affect water demand. The combination of these factors will increase water management difficulties, a prospect that highlights the need for more integrated research on water availability and management. Furthermore, as conflicts over water use are likely to become more common, Dr. Byrne (who is involved in the Water Institute for Semi-Arid Ecosystems) suggested that integrated research on water should be funded independently to allow researchers to focus on the subject without concern about offending interest groups.

The CFA and other witnesses recommended that AAFC undertake a comprehensive study of the effects of climate change on Canadian agriculture. This research will give farmers a better understanding of what to grow, what practices will be suitable, and what insects, pests or weeds are more likely to affect their crops. To date such studies have been done piecemeal, covering only a few regions and a few crops. A systematic assessment would create a better understanding of the effects and adaptation options available to Canadians.

A similar study on forests should also be undertaken. The Forest Products Association of Canada (FPAC) pointed out that the industry cannot do much without a more detailed understanding of the likely impact on forests. The FPAC suggested developing a good monitoring system to track what is happening in our forest systems. Studies would focus on the technical aspects of adaptation, and it is mostly the responsibility of governments and research organizations such as universities to provide that information.

According to Dr. Christopher Bryant, of the Université de Montréal, it is impossible to understand adaptation fully if we study only the biophysical impacts of climate change and the technical aspects of adaptation; these, however, are the areas where Canada invests the most research funds. While our current research capacity is oriented towards assessing how crops are sensitive to different climatic changes, this is only a small part of understanding how producers can deal with climate risks. Currently, the knowledge base on adaptation is lacking simply because there has been little effort to understand what individual farmers and rural communities know, and what adaptation options are available to them. Dr. Smit listed a number of topics that need to be examined, such as the current vulnerabilities in the agri-food sector, the effectiveness of existing risk management strategies, and the incorporation of climate-related risks in management practices. Studying such topics would require a different research approach: researchers would have to learn from the experience of producers – including woodlot owners – rather than only modelling adaptation options in the research labs.

In addition to highlighting the four areas indicated above, the Committee wishes to stress that research on climate change should not be emphasized over research addressing other aspects of agriculture and forestry. In fact, much of the latter research – such as development of crop and tree varieties, soil and water conservation practices including micro-irrigation and fertility research, and intensive forest management practices – produces information that is applicable to adapting to climate change, even though it is not specifically being done for that purpose.

3. Fostering Research

While a consensus exists for more targeted funding for integrated research, witnesses proposed many different ways of reaching that end. The following paragraphs present the four options that witnesses suggested for fostering Canadian research on impacts and adaptation: enhancing government research capacity, facilitating partnerships, targeting research at universities, and creating a national climate change research centre.

The federal government must show leadership in fostering research. Canada can count on a wide variety of scientific, technical and policy expertise, both in governments and universities, in engaging what are probably the most challenging environmental, social and economic problems that it has ever faced – those arising from climate change and accelerated global warming. In that context, NRCan plays a decisive role in assuming the lead domestically on climate change and adaptation. NRCan can count on many world-class scientists for providing relevant information and knowledge on the multiple facets of the issue. Its expertise covers earth sciences, energy, forests, minerals and metals. As key participants in climate change research, the Canadian Forest Service and other sectors of NRCan, along with all members of the Canadian forest community, provide tools that will help to find ways to take advantage of climate change, when possible, and to reduce its effects, when necessary.

The forestry industry strongly believes that undertaking basic science on the impact of climate change on Canadian forests is the responsibility of government, while applying that science and exploring how forestry techniques should change is more the

responsibility of industry. Although the Committee agrees to some extent with this statement, it believes nevertheless that both the forest industry, and the government, must be active partners in research on ecosystem changes, considering their involvement into the long-term planning of forestry operations.

Certainly, some fundamental research remains to be done on the issue of climate change; and since long-term research requires long-term commitment, some witnesses recommended that the scientific capacity of our governments be enhanced. Federal and provincial government research capacity could be improved through an increase in human resources and funding for ongoing activities (A-base funding) dedicated to climate change impacts and adaptation in agriculture and forestry.

Another strategy would be to facilitate partnerships between research organizations, and to strengthen the capacity of universities to assist industries and rural communities through research into adaptation. National granting councils and special government funds such as the Climate Change Action Fund should be encouraged to increase their funding for integrated research on vulnerabilities and climate adaptation in the agriculture and forest sectors.

The Water Institute for Semi-arid Ecosystems (WISE) in Lethbridge is an example of partnership between federal, provincial, academic, and private sector organizations, including the University of Lethbridge, AAFC, Alberta Environment, and the Alberta Irrigation Projects Association. WISE brings researchers together on strategic and interdisciplinary research. The Semi-arid Systems Research Collaborative is a research network comprising researchers from various disciplines located in seven universities and the major provincial and federal government research centres in the four western provinces. It creates a virtual centre that links expertise from various research bodies. Strategic investment in such partnerships was also suggested for climate change; a Network of Centres of Excellence on climate change, for example, would foster partnership and integrated research.

Dr. Peter Duinker, a professor at Dalhousie University and manager of C-CIARN Atlantic, suggested the creation of funded chairs, a special position that would carry a low teaching load and a high research obligation, to entice our best researchers into the field of climate adaptation. Furthermore, he suggested the establishment of graduate student research awards to increase the existing capacity among professors across Canada to engage in impacts and adaptation research. According to Dr. Duinker, establishing a funded research chair and four or five student research awards in each of the six C-CIARN regions would cost only $1.8 million per year – a minimum of $200,000 for each funded chair and $20,000 to $25,000 for each student award. This initiative would create an important network and foster much-needed research activity on impacts and adaptation.

Other witnesses suggested that the synergies of having significant numbers of people in one locale are also very positive. Speaking from his own experience, Dr. James Byrne, from the University of Lethbridge, mentioned that despite having colleagues in the same

city for several years who have much in common on climate change, they do not get a chance ever to work together because they are too busy with other responsibilities. Dr. Ned Djilali agreed that current funding does not address the key notion of critical mass, and that dispersion of resources is less effective since it entails much higher expenses. Dr. Weaver also stated that many scientific advances happen because connections are made spontaneously when researchers have the opportunity to be in the same place at the same time. He suggested the creation of a central facility, a national institute with researchers from various disciplines working on climate change in an integrated manner. The Hadley Centre for Climate Prediction and Research, the main U.K. research centre on climate change, was praised many times for the quality of its research. When asked about the reasons for this success, officials from the Centre suggested two factors: the centralization of numerous specialists in different fields in the same location, and stable funding from the government. They compared their situation to that of other countries, where there is often more than one centre and where the expertise is often external to the centre and has to be brought in from other institutions.

While there are different approaches, the Committee thinks they can and do complement each other. A centralized agency could conduct research on models and the biophysical effects in collaboration with AAFC and the Canadian Forest Service, or research institutions such as WISE. This approach could bring a national focus to climate change and generate knowledge from country-wide studies on agriculture, forests and water resources. On the other hand, adaptation strategies are specific to locations and to settings. Therefore, research on adaptation could be conducted primarily by regional research networks or research chairs, etc. The Committee wishes also to emphasize that sustained funding is imperative to generate effective and relevant long-term knowledge.

Summary

Increasing research efforts in impacts and adaptation will improve our understanding of the biophysical and economic effects, the vulnerabilities of agriculture, forestry and rural communities, and successful adaptation options and strategies, particularly at the local level. Although increasing the funding for research is part of the solution, it will not be enough; solutions to foster research could rather focus on building the research capacity.

B. Communication

> **"I want to emphasize […] that adaptation is not just a question of getting the science right; it is also a question of engaging the stakeholders. It is a question of awareness and understanding. It is a question of political will, and I do not mean just at the federal and provincial level, but also at the municipal level."**
>
> *Dr. David Pearson, Chair, Canadian Climate Change Impact and Adapt Research Network Ontario*[23]

According to a study published by AAFC in March 2003, one-third of agricultural producers believe that climate change is nothing to be concerned about. A slightly

[23] Standing Senate Committee on Agriculture and Forestry, Issue No. 4, 2nd Session, 37th Parliament, Ottawa, December 5, 2002.

smaller proportion (30%) believes climate change will have a positive effect, while 26% believe the overall impact will be negative. Mr. Jean-Louis Daigle, of the Eastern Canada Soil and Water Conservation Centre, noted that the situation has evolved over recent years and that more farmers than previously are now ready to hear about adaptation. Given the importance of other immediate issues such as commodity prices, contracts, and safety net programs, it is understandable that the long-term effects of climate change are not currently a priority for farmers. Many of them, however, are already integrating different strategies into their farm practices, often due to the last two or three years of devastating droughts or rains.

The forest industry acted on climate change very early on. The industry's current GHG emissions are 26% below the 1990 level, while production has increased by 20%. On the other hand, although it recognizes the importance of the potential impact of climate change on the industry and forest-based communities, the industry has taken a "wait and see" approach, arguing that no-one knows exactly what will happen. Dr. Dan Smith, a professor at the University of Victoria's Tree-Ring Laboratory, mentioned that on northern Vancouver Island the forest industry is planning for crop rotation cycles of 500 years; however, it is not taking into account the climate changes that are likely to occur, and is assuming that the same conditions will apply.

Because scientific information is complex by nature, communicating it has been a common concern at all the public hearings. How do we pass the information on to farmers, the forest industry, and rural communities to enable them to take appropriate adaptation measures? Since the long-term effects of climate change are not currently a priority, the question of timing, and the type of message to deliver at a specific time, will be important in any communication strategy.

1. A Clear Message at the Right Time

Since there are still uncertainties regarding the precise effects of climate change on a scale that is relevant for farmers and forest operators, the key message is that climate change is real and impacts are likely to happen. It is very confusing, if you are not a climatologist, to hear one day that climate change is a real thing, and to be told differently another day. The first step should be to convey a consistent message balancing the benefits and risks that are likely to result from climate change. For example, the objective of this Committee study is to raise awareness that climate change has the potential to affect rural Canada significantly. The Committee does not want to sensationalize the issue and needlessly scare the public; nevertheless, we would be remiss if we were to ignore the clear message from witnesses that Canada is soon likely to face much greater changes than it has experienced in the last hundred years. It is valid to be concerned about the future.

As the research community refines our understanding, the message will evolve to provide more meaningful information for business decisions in rural Canada. Taking the agricultural sector as an example, Dr. Mendelsohn from Yale University suggested that revised long-term climate forecasts be issued on a decadal basis. That is, every decade researchers would try to provide a clearer picture of what Canada's climate will look like

over a given period, and relate this knowledge to farming opportunities and risks. This could be done by continually updating both our knowledge and the information that is communicated. For instance, since it is difficult today to adequately predict what the agricultural sector should do in 2050, it might be more relevant to make such predictions in 2030 or 2040. Furthermore, farmers are already used to dealing with uncertainty. They cannot be sure of conditions in next year's growing season, let alone in several decades; nor can they confidently predict prices, trading policies or demand. Nonetheless, they have to make their decisions and investments in light of those unknown variables. Climate uncertainty is part of the other risks that they must manage.

2. A National Communication Strategy

Although it was mentioned that scientists from the University of Guelph and the University of Saskatchewan have been effective in sharing their results with the agriculture industry, researchers recognized that the public communication phase generally comes last after research and teaching. In contrast to land grant universities in the United States, universities in Canada do not have extension faculty members.

Dr. Burton linked the farming community's lack of awareness of the effects of climate change to the limited extension capacity within the provinces. The capacity for extension services to deliver information to farms and producers has been severely curtailed over the last 20 to 30 years. The Eastern Canada Soil and Water Conservation Centre, for example, has only four people attempting to cover Eastern Canada in terms of communicating with producer organizations. In the forest industry, the Canadian Association of Woodlot Owners noted that with the elimination of the federal-provincial forestry agreements in the mid-1990s, most provinces cut back or cancelled their forest extension staff. While some have restored the programs, others did so only partially while still others did not at all.

Some witnesses suggested the following strategies to ensure effective communication between the research community and stakeholders:

- the establishment of specific extension groups that will help keep the researchers involved;
- more discussion forums for producers and forest operators about climate change challenges; and
- additional resources for education and awareness programs.

While extension services address industry needs, reaching out to rural communities is another aspect that must be examined. Like many witnesses, the Committee thinks that with climate change, "the buck stops in communities." Those who will live with the effects of climate change and must deal with it, such as municipal councillors, the farming community, and the forest industry, are often not engaged in discussions with researchers. Furthermore, many of the research projects that are undertaken do not have an immediate relevance for the stakeholders.

In addition to the conventional view that the information must flow from researchers to the industries and communities, the Committee recognizes that it is equally important that the research community learn from producers, the rural population, and aboriginal people. The research community will thus be able to incorporate better knowledge on matters such as how farmers currently deal with risks, and how local communities make water management decisions. This two-way flow of information and knowledge will ensure that research into adaptation is better rooted in local contexts.

The Climate Change Impacts and Adaptation Research Network has, as one of its goals, the objective of bringing researchers together with decision-makers from industry, communities, and non-government organizations. In November 2002, C-CIARN Ontario held a large workshop that focussed on communities. The workshop dealt with impacts and adaptation potential for four areas: ecosystem health, human health, water resources, and infrastructure. One hundred people attended; about one-quarter of those were municipal employees, while others were representatives of non-governmental organizations (NGOs) and researchers from universities and government. C-CIARN Forest held a workshop in Prince George, B.C., in March 2003, at which small communities were represented along with environmental groups, the forest industry, First Nations, consultants, provincial and territorial governments, research organizations, and the Canadian Forest Service.

As C-CIARN is a relatively new entity, these examples are just a beginning; but they are the kind of discussions that need to be encouraged between researchers and stakeholders. Mr. Peter Johnson, of C-CIARN North, also suggested that we need to find different and more effective ways of developing our relationships and talking with rural communities, particularly in the North, where one must be a part of the community for some time in order to understand it.

The decline in extension services, and the challenge of going into rural communities strongly suggest the need for a national communication and public outreach strategy that will focus on rural communities and their economy, including agriculture and forestry. This strategy will be a key step in assisting rural communities, farmers, and forest operators to plan for adaptation to climate change.

The Committee thinks that a single, monolithic communication plan may not be adequate to reach rural communities. Rather, Dr. Bryant recommended a process by which people work in communities, interact with farmers, woodlot owners and municipal employees, and bring them together in small groups. This could be done by revitalizing extension services, and using the various networks within the farming community at the provincial and local levels.

Regionally based groups, including producer organizations, the “clubs agro-environnementaux” in Quebec, soil conservation groups (such as the Eastern Canada Soil and Water Conservation Centre), the PFRA, and others, all have networks. If the key people in these networks believe in the importance and relevance of certain ideas or information, it is then relatively easy for them to communicate with a large and broad-based proportion of the rural population. It is also important to have more than one point

of entry into a given region, because some organizations may focus more on some sectors than others at certain times, or farmers may be members of organizations that do not always share their concerns. As Dr. Bryant put it, there is an enormous wealth of resources on the ground that we could use to communicate more effectively with the farming community. A good understanding and use of the various networks within a given region will enable a fairly rapid diffusion of information within the agricultural community.

As for the message, it will be important to provide some guidance to the various organizations. This may mean emphasizing not only the importance of climatic change, but also the importance of getting farmers and other decision makers to undertake strategic planning processes that build on dealing with uncertainty and change.

In addition to the mechanisms to reach out rural communities, rural Canadians must also be able to find their information themselves. The use of the Internet in rural communities is more and more popular but telecommunications infrastructures are not always adequate (party lines, access to Internet by phone line only, etc.). The access to broadband technology is therefore essential to each community. The Committee wishes to reiterate the following recommendation it made to the Government of Canada in 2002:

The government partners with private companies to ensure that 100 per cent of Canadians have access to high-speed Internet services by following a plan like Supernet in Alberta and connecting all public institutions. [24]

Furthermore, the Committee wishes to reiterate the importance of heightening the urban public's awareness of the positive economic and social contributions that rural Canada makes beyond food and timber production. A component of this national strategy should, therefore, target urban Canada. Implications for the farm community and rural Canada in general will affect everyone in the country. For instance, there will be more demands on water resources; and the Committee does not want rural Canada be left behind when centrally based policy makers decide who has legitimate demands on our water. It is crucial that the rest of the country recognize the importance of adaptation in rural Canada.

> In its report *Canadian Farmers at Risk*, tabled in June 2002, the Committee recommended that:
> **The federal government work with farm organizations in developing a powerful communications campaign to ensure that all Canadians appreciate farmers' economic and social contributions to our society.**

Summary

Because of the complexity of this issue, communication will be the key to enable rural Canada to adapt to climate change. Planning for adaptation is preferable to only reacting to the effects, therefore a communication strategy will bring the message to rural Canada

[24] *Canadian Farmers At Risk*, Report of the Standing Senate Committee on Agriculture and Forestry. June 2002. 1st Session, 37th Parliament. Available at http://www.parl.gc.ca/37/1/parlbus/commbus/senate/com-e/agri-e/rep-e/rep10jun02-e.htm.

that climate change is real, and that it is time to start thinking about our vulnerabilities and ways to increase our resilience. The communication strategy should include the revitalization of extension services and use existing networks within rural communities to ensure that current information is effectively distributed. The access to broadband technology is also essential to rural communities to enable rural Canadians to actively search the information by themselves.

C. Government Policies and Programs

> **"One of the problems about adapting is that we realize that there may be nothing we can do about adapting right now, other than just being aware of the likelihood of this happening."**
>
> *Mr. Brian Stocks, Senior Research Scientist, Forest Fire and Global Change, Natural Resources Canada*[25]

Government programs and policies such as farm income programs, tax credits, and insurance regulations significantly influence agricultural and forestry practices, and how these sectors react to specific stresses or situations. It is, therefore, an area that needs to be examined closely. A general goal of government policies should be to encourage the adoption of opportunities to adapt to climate change, or at the very least to avoid preventing the adoption of such opportunities.

1. Specific Programs to Encourage Adaptation

Economists who appeared before by the Committee recommended that the government create a framework to allow farmers and forest operators to respond to signals. In the agriculture industry, this would entail allowing farmers to make adjustments as they see fit and, as they see the climate changing, allowing them to make the necessary changes in their operations. In the forest industry, it would mean ensuring that concession agreements are not written so rigidly that, if conditions change in the future, the licensees could not operate differently from their present practices. Other witnesses suggested that in order to adapt proactively to climate change, the agriculture and forest industry require longer-term incentives that would counter the short-term ones provided by competitive markets. This would also help to make those industries more aware of the benefits of planned adaptation.

The Committee was told that NRCan and Environment Canada are primarily responsible for identifying measures and programs in support of the goals and objectives of climate change management. Currently, however, NRCan believes that implementing incentives or regulations based on our present level of understanding would be premature. According to the department, NRCan has not yet completed the research necessary to enable it to make specific policies to assist the natural resource-based sector in adapting to climate change, such as incentives, long-term tax measures, or promotion of investment in adaptation-related innovation. As research results begin to indicate where

[25] Standing Senate Committee on Agriculture and Forestry, Issue No. 16, 2nd Session, 37th Parliament, Ottawa, May 6, 2003.

adaptive actions can make a difference, the government will look at actions that may be needed, such as incentive-based regulations to help the forest and agriculture sectors adapt. For these two sectors, the federal government will need to work closely with provincial governments in developing any such actions.

2. Incorporating Climate Change into Existing Programs and Policies

Government programs such as crop insurance already influence adaptation undertaken by producers. Current policies may, in fact, either hinder or encourage adaptation efforts. For example, insurance promotes certain behaviours. During the Committee's last trip to Western Canada, members were told that farmers in some areas base their cropping decision on the return they can expect from crop insurance. On the other hand, crop insurance has been a popular option to mitigate some problems associated with climate variability. Dr. Barry Smit suggested that a high priority be given to considering climate change risks in existing programs. Such actions would fall under the category of "no regret" policies, i.e., measures that provide benefits regardless of whether climate change occurs.

With respect to farm safety net programs, Dr. Cecil Nagy, from the University of Saskatchewan, said it is currently difficult to say whether these programs will be able to respond to climate change problems over the long term. A number of questions need to be answered, including:

- Will safety net programs encourage farmers to take advantage of the adaptation options that are available?
- Will safety net programs limit or support farmers in using available adaptation options?
- In terms of funding over the long term, are the current programs designed to meet the challenge that climate change will present?
- Can these programs be adapted as necessary to new conditions?

To illustrate this point, Dr. Nagy used the example of new crops. If a crop is no longer viable for a given region, it is important to determine whether farmers will be allowed to switch crops without losing the benefits of their current farming programs. In designing crop insurance, one should then consider a mechanism to identify new crops as being suitable for a region and to add them into the crop insurance coverage.

AAFC's current development of the Agriculture Policy Framework (APF) provides an excellent opportunity to incorporate climate change adaptation into Canadian agricultural policy. Through production insurance, the new Net Income Stabilization Account (NISA) programs, and tax deferral designations,[26] the APF provides business risk management options. The renewal portion of the APF will address the issue of training, and assistance in dealing with changes. As details of the APF at the time of this study are still unknown, witnesses could not tell the Committee the degree to which the Framework provides for climate change adaptation.

[26] Tax deferral is a measure that can be applied to allow farmers who sell part of their breeding herd due to drought conditions to defer tax on a portion of the sale proceeds to the following year.

With respect to the forest sector, Dr. John Innes, from the University of British Columbia, mentioned that provincial regulations currently hinder some adaptation responses to climate change. Regulations on seed transfer in British Columbia, for example, require that seed from within a certain area be planted at a particular point. If seed is planted near Prince George, it must originate from near Prince George and not from much further south. Dr. Innes mentioned that the regulations have been relaxed a little in recognition of the climate change issue, but they need to be relaxed further.

British Columbia is currently in the process of reviewing and introducing new forest legislation. Some witnesses questioned the provinces' ability to introduce changes enabling adaptation to future climate conditions, simply because the people who are designing these policies may not be aware of many of the climate change issues. C-CIARN Forest suggested that Canada's provinces and territories be encouraged to develop forest management legislation and policies that are consistent with the reality of climate change, and to create a framework and culture through which climate change adaptation is possible and encouraged.

In addition to the legal framework that underlies sustainable forest management practices, markets are having a growing effect on forest practices through demands for forest certification. C-CIARN Forest suggested that certification standards for environmentally friendly products from forests be required to incorporate adaptation to climate change in order to remain relevant, and be flexible enough to accommodate adaptive strategies proposed to deal with the reality of climate change. Therefore, national forest certification bodies should be encouraged to include climate change adaptation as one of the objectives around which standards are developed.

There are many other areas for "no regret" policies that the Committee wishes to underline:

- While the Meteorological Service of Canada is currently undertaking a reorganization of its activities, it should consider adequate coverage of the Canadian landmass with climate and weather stations. Monitoring climate and ensuring adequate weather forecasting systems will be our first line of defence to mitigate the possible effects of climate change.
- Municipalities will have to bear a lot of the adaptation efforts, yet they may not have the capacity to do it. It will be important to ensure that municipalities do have the capacity to increase the resilience of their infrastructures in areas likely to be affected by climate change, such as wastewater treatment.
- Climate change could also be taken into consideration in the creation and management of protected areas. The Sierra Club of Canada suggested the creation of north/south corridors along which species can migrate to new habitat.

While addressing climate change, these measures would also serve other purposes. Creating a mechanism to permit the rapid inclusion of new crops in crop insurance programs would not only address the effect of climate change, but would also accommodate the case of a new crop being developed through research – independent of new climatic conditions. The creation of protected north/south corridors would also

allow Canada to meet its objective of completing a representative network of protected areas. A systematic look at policies through a climate change "lens" will make our industries, ecosystems, and communities less vulnerable to climatic changes, while also helping them to adapt to other stresses.

Summary

Public policies and programs must not prevent industries and communities from pursuing available adaptation options. Climate change considerations must be incorporated into government policies and programs where appropriate. Public policies such as farm income safety nets, tree plantation programs, and policies concerning water and protected areas, to name just a few, will have to be designed to cope with climate change risks. A systematic review of existing and new programs could be implemented to assess whether climate change risks are being considered.

CHAPTER 9:
CONCLUSION – LESSONS LEARNED

> **"Climate change is ultimately a social issue, not a scientific one, and it is a major public policy issue. We have created the problem, or at least we have increased the rate of climate change, and we must deal with the impacts."**
>
> *Dr. Dave Sauchyn, Coordinator, C-CIARN Prairies.*[27]

Climate change will affect all Canadians to some extent, and it will significantly affect rural Canada, both positively and negatively. There is sufficient evidence to conclude that the global warming trend observed in the last century is caused primarily by human industrial activity, namely, the emission of greenhouse gases such as CO_2. This warming trend is likely to continue at a rate unprecedented in human history; it will have consequences at a regional level on temperature, precipitation patterns, winds, and the frequency of extreme weather events.

The Kyoto Protocol is currently the only public policy tool available at the international level to help deal with climate change. As climate change is a global problem, there is a need for international coordination; but by itself the Kyoto Protocol will not curb, let alone reverse, the warming trend. Stabilizing the concentrations of greenhouse gases in our atmosphere at a level that will avoid dangerous consequences for humanity entails measures far beyond those called for under the Protocol. Significant reductions in greenhouse gas emissions would require our energy systems to shift from fossil fuel to low-carbon-content fuel such as hydrogen – the *decarbonization* of the energy system. At the same time, the mitigation of this warming trend must go hand in hand with adaptation to the effects of climate change. While the energy system goes through the decarbonization process, and our climate responds to decreasing levels of greenhouse gases in the atmosphere, we will have to adapt to new climatic conditions.

Because the warming effect will be amplified at high latitudes, circumpolar countries such as Canada will be particularly vulnerable. In fact, some effects are already being felt in the northern part of the country. It is therefore important that Canada develop its own expertise, as it will not be able to take advantage of the experiences of other non-circumpolar countries such as the continental United States. Those countries, rather, may look to Canada for guidance in adapting, as they will likely feel the effects later.

Although longer growing seasons and warmer temperatures have the potential to increase the productivity of Canadian agriculture and forestry, those benefits could be offset or exceeded by effects such as reduced availability of water, new pests, and increased weather variability. Regions will feel a variety of effects; some areas will see net gains,

[27] Standing Senate Committee on Agriculture and Forestry, Issue No. 6, 2nd Session, 37th Parliament, Ottawa, February 4, 2003.

others will lose. Moreover, the impact of climate change on the rest of the world will also have implications for Canada's agriculture and forest sectors. Many prices are determined by world markets, meaning that the economic effect on these two sectors in Canada will depend also on how Canadian productivity may change relative to the rest of the world. In the end, it is how Canadian farmers, forest operators, rural communities and Canadians living in urban areas adapt and react that will determine the real impact of climate change.

Farmers are already innovative and adapt to various stresses such as variations in weather, trade policies, and commodity prices. Farmers in Western Canada are adopting or expanding certain practices, such as not tilling their soil, in order to protect their topsoil during droughts, keep moisture in the soil, and reduce the amount of greenhouse gases being released into the atmosphere. The expected increase in weather variability, however, may be of even greater concern for farmers than changes in average conditions, because it is more difficult to adapt to changes in variability. Events such as the drought in 2001, which affected all provinces, have made farmers, the forest industry, and rural communities realize that they are vulnerable, and that they must begin to adapt to new climate scenarios.

An important area of vulnerability will be our water resource. Changing climatic conditions will affect the water supply through different precipitation regimes. While some adaptation options might alleviate potential shortages, other options, such as irrigation, will directly affect the demand. Water affects all industries in rural Canada – agriculture, forestry, fisheries, tourism – and these industries will have to compete for the resource with urban areas. More than any other aspect of the issue, finding solutions to potential water-related conflicts arising from climate change will have to involve all levels and sectors of society.

It is still too early to clearly identify effective adaptation measures that should be taken. Those measures will have to fit local conditions, but our knowledge of climate change is not yet refined enough to predict its local effects. Nevertheless, there is room for government action in the following areas:

- Research: Increasing research efforts in impacts and adaptation will improve our understanding of the biophysical and economic effects, the vulnerabilities of agriculture, forestry and rural communities, and successful adaptation options and strategies.
- Communication: A national communication strategy will bring the message to rural Canada that climate change is real, and that it is time to start thinking about our vulnerabilities and ways to increase our resilience. The communication strategy should include the revitalization of extension services and use existing networks within rural communities to ensure that current information is effectively distributed.
- Government Policies: It is important that public policies and programs do not prevent industries and communities from pursuing available adaptation options. Climate change considerations must be incorporated into government policies and programs where appropriate. Public policies such as farm income safety nets, tree plantation programs, and policies concerning water and protected areas, to name just a few, will

have to be designed to cope with climate change risks. A systematic review of existing and new programs could be implemented to assess whether climate change risks are being considered.

"No regret" public policies in these areas can provide net benefits regardless of climate change, because they would address vulnerabilities associated not only with climate change but also with many other stressors that our industries and communities already face. More focussed research, communication and far-sighted government policies can together create a framework that will enable farmers, forest operators and rural communities to mitigate the risks and realize the opportunities associated with climate change.

APPENDIX A

DATE	WITNESSES
November 21, 2002	**From Environment Canada:** - Henry Hengeveld, Chief Science Advisor, Climate Change
November 26, 2002	**From Environment Canada:** - Norine Smith, Assistant Deputy Minister, Policy and Communications **From Agriculture and Agri-Food Canada:** - Alrick Huebener, Manager, Policy Development, Environment Bureau **From Transport Canada:** - Robert Lyman, Director General, Environmental Affairs **From Industry Canada:** - John Jaworski, Senior Industry Development Officer, Life Sciences Branch **From Natural Resources Canada:** - Neil MacLeod, Director General, Energy Efficiency - Paul Egginton, Executive Director, Climate Change Impacts and Adaptation Directorate
November 28, 2002	**From Natural Resources Canada:** - Gordon E. Miller, Director General, Science Branch, Canadian Forest Service - Paul Egginton, Executive Director, Climate Change Impacts and Adaptation Directorate - Donald S. Lemmen, Research Manager, Climate Change Impacts and Adaptation Directorate, Earth Sciences Sector - Darcie Booth, Director, Canadian Forest Service, Economics and Statistical Services
December 3, 2002	**From Agriculture and Agri-Food Canada:** - Gordon Dorrell, Acting Assistant Deputy Minister, Research Branch - Wayne Lindwall, National Program Leader for Environment - Michele Brenning, Director, Environment Bureau

- Phil Adkins, Acting Manager, Prairie Agroclimate Unit, Prairie Farm Rehabilitation Administration

December 5, 2002 **From the Canadian Climate Change Impact and Adaptation Research Network:**
- Aynslie Ogden, Manager, Northern Region
- Peter Johnson, Science Advisor, Northern Region
- David Pearson, Chair, Ontario Region
- Gérard Courtin, Professor Emeritus, Laurentian University

December 12, 2002 **From the Canadian Climate Change Impact and Adaptation Research Network:**
- Alain Bourque, Coordinator, Quebec Region
- Peter N. Duinker, Manager, Atlantic Region

February 4, 2003 **From the Canadian Climate Impact and Adaptation Research Network:**
- Dave Sauchyn, Coordinator, Prairies Region
- Stewart Cohen, Scientific Advisor, British Columbia Region

February 6, 2003 **From the Sierra Club of Canada:**
- Elizabeth May, Executive Director
- Martin von Mirbach, Director, Forests and Biodiversity

February 11, 2003 **From the Forest Products Association of Canada:**
- Avrim Lazar, President
- Jean Pierre Martel, Vice President, Sustainability

From the Canadian Federation of Woodlot Owners:
- Peter deMarsh, President

February 13, 2003 **From the National Farmers Union:**
- Cory Ollikka, Past President
- Janet Duncan

From the Canadian Federation of Agriculture:
- Geri Kamenz, Chair, Environment and Science Committee and Vice-President of the Ontario Federation of Agriculture
- Nicole Howe, Policy Analyst

February 18, 2003 **From the Canadian Foundation for Climate and Atmospheric Sciences:**
- Gordon McBean, Chair
- Dawn Conway, Executive Director

From McGill University:
- Nigel Roulet, Professor, Department of Geography

February 20, 2003

From the Agricultural Institute of Canada:
- Ed Tyrchniewicz, President
- Tom Beach, Acting Executive Director

From Ducks Unlimited Canada:
- Rhonda McDougal, Associate Scientist, Carbon Research
- J. Barry Turner, Director of Government Relations

February 24, 2003

From the Ecotourism Society of Saskatchewan:
- Joe Hnatiuk, President

From the Saskatchewan Association of Rural Municipalities:
- Neal Hardy, President
- Arita McPherson, Director of Agriculture Policy

From the University of Saskatchewan:
- Michael Mehta, Professor

From the Saskatchewan Research Council and Prairie Adaptation Research Collaborative:
- Mark Johnston, Senior Research Scientist

From Agriculture and Agri-Food Canada:
- Phil Adkins, Acting Manager, Prairie Agroclimate Unit, Prairie Farm Rehabilitation Administration
- Bill Harron, Project Leader, National Land and Water Information Service
- Gerry Steraniko, Manager, Operational Planning Division

From the Saskatchewan Environment Society:
- Ann Coxworth, Volunteer Program Coordinator

From Nature Saskatchewan:
- Silvia Lac, Volunteer
- Wayne Pepper, Representative, Saskatchewan Stakeholders Advisory Committee on Climate Change

From the University of Saskatchewan:
- Andre Hucq, Professor
- Roger D.H. Cohen, Professor
- Cecil Nagy, Professor

From the Western Canadian Wheat Growers Association:
- Mark Allan, Business Manager

From the Government of Saskatchewan:
- The Honourable Eric Cline, Q.C., Minister of Industry and Resources
- Gordon Nystuen, Deputy Minister, Saskatchewan Agriculture, Food and Rural Revitalization
- Bob Ruggles, Assistant Deputy Minister, Programs Division, Saskatchewan Environment
- Jim Marshall, Assistant Deputy Minister, Resources and Economic Policy, Saskatchewan Industry and Resources

From the Agricultural Producers Association of Saskatchewan:
- Terry Hilderbrandt, President
- Cecilia Olver, Vice-President
- John Clair, President, Saskatchewan Soil Conservation Association

February 25, 2003

From Natural Resources Canada:
- Kelvin Hirsch, Forest Research Officer, Northern Forestry Centre, Canadian Forest Service
- Brian Amiro, Research Scientist, Northern Forestry Centre, Canadian Forest Service
- David Price, Research Scientist, Integrative Climate Change Impacts Modelling, Northern Forestry Centre, Canadian Forest Service
- Tim Williamson, Sustainable Development Economist, Northern Forestry Centre, Canadian Forest Service

From Kalahari Management Inc.
- Carol Patterson, President

From Wild Rose Agricultural Producers:
- Keith Degenhardt, Director

From the Alberta Research Council:
- Daniel Archambault, Research Scientist

From the University of Alberta:
- Robert Grant, Associate Professor, Department of Renewable Resources

From the Canadian Climate Change Impact and Adaptation Research Network:
- Greg McKinnon, Forest Sector Coordinator
- Kelvin Hirsch, Forest Sector Scientific Director

From the Alberta Association of Municipal Districts and Counties:
- Bart Guyon, Vice-President

From BioGem:
- Grant Meikle, Vice-President
- Larry Giesbrecht, President

From the Métis Nation of Alberta:
- Rafique Islam, Sector Advisor
- Trevor Gladue, Provincial Vice-President
- George Quintal, Regional President
- Myles Arfinson, Economic Development Officer

February 26, 2003

From the University of Lethbridge:
- James Byrne, Professor

From the Federation of Alberta Naturalists:
- Cheryl Bradley, Member

From the Canadian Sugar Beet Producers' Association:
- Gary Tokariuk, Vice-President

From the Kainai Nation:
- Chris Shade, Chief
- Andy Blackwater, Elder
- Eugene Creighton, Legal Council
- Elliot Fox, Chair of Lands
- Rob First Rider, Director of Management of Lands

From Agriculture and Agri-Food Canada, Lethbridge Research Centre:
- Peter Burnett, Acting Director
- Henry Janzen, Soil Scientist
- Sean McGinn, Research Scientist

February 28, 2003

From Natural Resources Canada:
- Paul Addison, Director General, Pacific Forestry Centre, Canadian Forest Service
- Gary Hogan, Director of Forest Biology, Pacific Forestry Centre, Canadian Forest Service

- Caroline Preston, Senior Research Scientist, Pacific Forestry Centre, Canadian Forest Service
- Ross Benton, Research Office, Forest Climatology, Pacific Forestry Centre, Canadian Forest Service

From the British Columbia Agriculture Council:
- Steve Thomson, Executive Director
- Allan Patton, Director

From the Council of Tourism Associations of British Columbia:
- Petrus Rykes, Vice-President, Land and Environment Portfolio

From the University of British Columbia:
- John Innes, Professor, Department of Forest Resources Management
- Zoe Harkin, Graduate Student

From the University of Victoria Tree-Ring Laboratory:
- Dan Smith, Professor

From the North Central Municipal Association:
- Sue Clark, Executive Coordinator

From the University of Victoria:
- Andrew Weaver, Professor, School of Earth and Ocean Sciences
- Steve Lonergan, Professor, Department of Geography
- Ned Djilali, Director, Institute for Integrated Energy Systems (IESVic)
- G. Cornelis van Kooten, Professor, Department of Economics

From Agriculture and Agri-Food Canada:
- Denise Neilsen, Research Scientist, Pacific Agri-Food Research Centre
- C.A. Scott Smith, Head, Land Resource Unit, Pacific Agri-Food Research Centre

March 20, 2003

From Carleton University:
- Michael Brklacich, Professor, Department of Geography and Environmental Studies

From the University of Guelph:
- Barry Smit, Professor, Department of Geography

March 25, 2003	**From Yale University:** - Robert Mendelsohn, Professor **From the Massachusetts Institute of Technology:** - John Reilly, Associate Director of Research
March 27, 2003	**From Brock University:** - Mohammed H.I. Dore, Professor of Economics
April 1, 2003	**From the University of Toronto:** - Jay R. Malcolm, Associate Professor
April 3, 2003	**From Agriculture and Agri-Food Canada:** - Gilles Bélanger, Research Scientist, Crop Physiology and Agronomy - Samuel Gameda, Research Scientist, Soil, Water, Air and production Systems - Andy Bootsma, Honorary Research Associate
April 29, 2003	***By videoconference*** **From l'Université du Québec en Abitibi-Témiscamingue:** - Yves Bergeron, Industry Chair UQAT/UQAM in Sustainable Forest Management **From the University of Wyoming:** - Siân Mooney, Assistant Professor
May 1, 2003	**From the University of Washington:** - John Perez-Garcia, Associate Professor, Center for International Trade in Forest Products, College of Forest Resources **From the Nova Scotia Agricultural College:** - David Burton, Climate Change Research Chair **From the Eastern Canada Soil and Water Conservation Centre:** - Jean-Louis Daigle, Executive Director
May 6, 2003	**From Natural Resources Canada:** - Roger Cox, Biologist, Canadian Forest Service (Forest Health) - Brian Stocks, Senior Research Scientist, Forest Fire & Global Change

From the University of Montreal:

- Christopher Bryant, Chair, IGU Commission on the Sustainable Development of Rural Systems

May 8, 2003 ***By videoconference***

From the Hadley Centre for Climate Prediction and Research:

- Peter Cox, Head of Climate Chemistry and Ecosystems, Met Office
- Richard Betts, Senior Ecosystem Scientist, Met Office

APPENDIX B

OTHER WRITTEN SUBMISSIONS RECEIVED:

From Alberta-Pacific Forest Industries Inc.
- Shawn Wasel, Vice-President of Business and Fibre Security

From Simon Fraser University:
- Ben Bradshaw, Professor of Geography