LIMITED REPORT

Climate Change Adaptive Capacity of Forestry Stakeholders in the Boreal Plains Ecozone

Prepared for Government of Canada's Climate Change Impacts and Adaptation Program as part of the Project A1383

By

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CONTENTS

Chapter 1
Introduction

M. Johnston – Saskatchewan Research Council

The interior of central Canada is expected to experience greater impacts of climate change than many areas of Canada and the rest of the world (Field and Mortsch 2007). Impacts of particular concern to forest managers include increased frequency and intensity of fires (Flannigan et al. 2005), increased outbreaks of forest pests, both insects and disease (Johnston et al. 2006), increased frequency of drought leading to forest dieback, particularly on the southern fringe of the boreal forest (Hogg and Bernier 2005), and changes to growth and amount of harvestable wood volume (Johnston and Williamson 2005). These (and other) potential biophysical impacts are becoming more clear, although further detail is required before specific adaptation options can be identified (Johnston et al. 2006). In contrast, the effects of these impacts on forest management institutions and planning are poorly understood. Biophysical impacts are particularly important in the Boreal Plain Ecozone, as a significant portion of the economy of this region is resource based. It is clear that the forest industry, rural resource-based communities, and First Nations societies will be required to adapt. However, we currently have a limited understanding of the capacity of these human systems to adapt to future climate change. This has two important implications. First, it means that we do not have a basis for identifying and assessing sources of climate change vulnerability of social and economic systems in the forested regions of Canada's northern interior regions. Second, it means that we have limited information for policy development targeted at improving the adaptive capacity of forestry stakeholders in an area of the country that will be significantly impacted by climate change.

Objectives of the study

The principal objective of this study was to assess the adaptive capacity of the forest sector in the Boreal Plains Ecozone (BPE) of central Canada (portions of Manitoba, Saskatchewan and Alberta, see Fig. 1). This region encompasses the majority of commercial forest land in the prairie provinces and includes nearly all of the major wood processing facilities. For the purposes of this project, the forest sector was defined as forest management practitioners (in both industry and government), forest-dependent communities and forest-based First Nations. We were particularly interested in the stakeholders' perceptions of their adaptive capacity, as this strongly affects their recognition of risk and the likelihood that they will take action (Williamson et al. 2005).

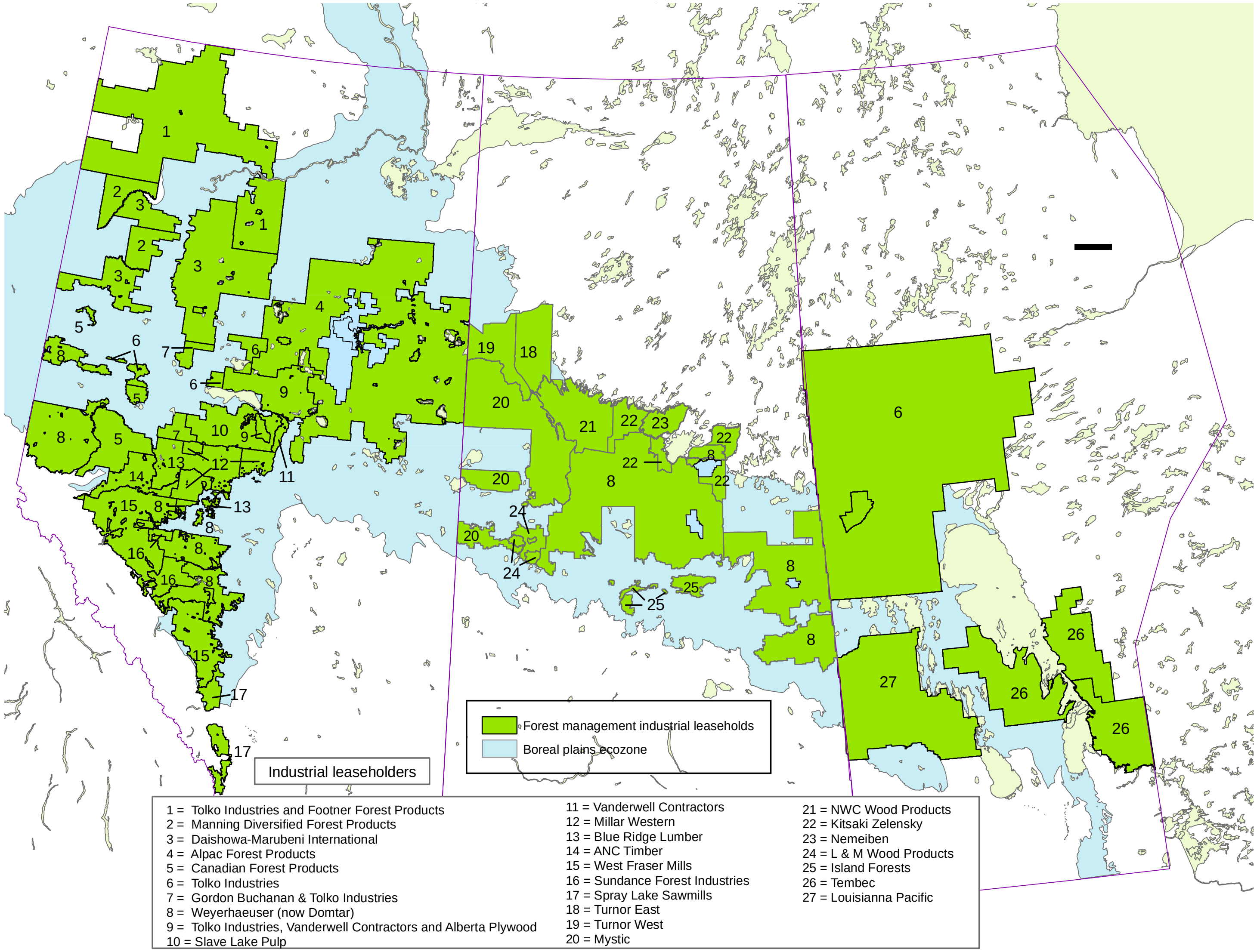

Figure 1. Location of Forest Management Agreements (green) in the Boreal Plain Ecozone (blue).

More specifically, we had the following research objectives:

- To develop a specific definition and measurement framework for assessing adaptive capacity of forestry stakeholders in the boreal plains ecozone.

- To obtain information in order to assess the adaptive capacity of large industrial leaseholders in the boreal plains ecozone (see Fig. 1). This would include the identification of barriers to adaptation in the forest industry.

- To integrate the research results on adaptive capacity of forest-based communities, based on results from an existing Model Forest/CCIAP research project (A1249) into the overall boreal plains ecozone assessment.

- To determine the adaptive capacity of First Nations in the boreal plains ecozone and to assess the extent to which traditional ecological knowledge confers increased adaptive capacity on aboriginal communities, particularly in respect of continued access to forest resources (e.g. caribou).

- To explore alternative models of resource governance that may confer increased adaptive capacity on forestry stakeholders.

Format of the report

Several authors contributed to this report, with each contribution being a more-or-less stand alone chapter. The report is structured as follows:

- Chapter 1 is a general introduction to the study as a whole.

- Chapter 2 provides an overview of the study area and a description of forest management in the BPE.

- Chapter 3 provides a review of climate trends and current and potential future impacts on the forest sector with specific reference to the concerns raised by stakeholders in our discussions.

- Chapter 4 provides a conceptual definition of adaptive capacity and adaptive capacity deficits for forest-based communities.

- Chapter 5 presents the results of our assessment of the adaptive capacity of forest based communities in the BPE, using data from the Canadian Government Rural Secretariat's Community Information Database with addition analysis and interpretation.

- Chapter 6 provides the results of discussions with a wide range of industry, government and NGO forest managers across the three provinces, with some additional information from discussions carried out in BC.

- Chapter 7 presents results of interviews with 13 CEOs and senior executives of forestry companies, many with operations across Canada. This chapter complements the previous one in providing the perspective of the strategic decision-maker as compared to the field-based forest manager in Chapter 6.

- Chapter 8 presents two case studies of aboriginal communities in which adaptive capacity was assessed by graduate students.

- Chapter 9 is a synthesis of the foregoing chapters and provides some general conclusions about adaptive capacity among forestry stakeholders in the Boreal Plains Ecozone.

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Chapter 2
The Boreal Plains Ecozone

M. Johnston – Saskatchewan Research Council

Bio-physical and socio-economic characteristics

The following description of the Boreal Plains Ecozone is adapted from the Canadian Council of Ecological Areas publication on the Terrestrial Ecozones of Canada (CCEA 2008).

The Boreal Plains Ecozone is part of the flat Interior Plains of Canada, a northern extension of the Great Plains of North America. The subdued relief consists of low-lying valleys and plains stretching across the mid portions of Manitoba and Saskatchewan, and continuing through almost two-thirds of Alberta. It covers 650,000 square kilometres, and includes parts of three watersheds: the Saskatchewan River; the Beaver River; and the Peace, Athabasca, and Slave rivers.

Forests cover 84% of the Boreal Plains and forestry has historically been one of the primary industries. Less than 20% of the land area is devoted to agriculture. Today, most of the ecozone is associated with the boreal forest. It is composed mainly of coniferous species including white and black spruce, balsam fir, jack pine and tamarack. Of the broadleaf trees, aspen is the most common, with birch in some areas. Fire has by far the strongest influence on structuring the landscape, determining species occurrence, age-class distributions and growth rates. In a typical year, more than one million hectares burn, despite increasingly effective fire suppression and prevention efforts. In particularly bad fire years, very large areas can be affected by fire. The largest area burned occurred in 1989, when over 4 million ha were burned in the prairie provinces. The forests are also affected by native insect pests and disease. Outbreaks of spruce budworm have affected extensive areas of spruce and fir forests. Other insects, such as the forest tent caterpillar, have defoliated trembling aspen stands. Secondary organisms, including other insects and fungi, often attack and kill trees weakened by defoliation or drought.

The characteristic soils are grey Luvisols, developed in loamy conditions under a forest canopy. Lakes and wetland areas, such as sloughs and marshes, are areas of rich vegetation. In poorly-drained areas, extensive bogs have developed.

Development accelerated greatly after 1870, when the Hudson's Bay Company surrendered its charter and sold Rupert's Land, which included the entire Boreal Plains Ecozone, to Canada. As a means of securing the area from potential expansion of the United States, Canada encouraged land development. Much of the arable land was occupied in the years following the completion of the transcontinental railway in 1885, which also introduced coal mining. With the settlement of the prairies came demand for lumber. Nearly half the ecozone is occupied by productive forests. Logging was concentrated in the southern fringes and, by 1900, large sawmills were in operation.

Demand for petroleum products early in the 20th century led to the discovery of the substantial oil and gas reserves in Alberta, where they have been a focal point of the economy for the last 50 years. More recently, oil and gas has become an important component of Saskatchewan's economy as well. In Manitoba, hydro-electric power is the dominant energy source.

Today, only about 700,000 people, many of them relatively young, live in the ecozone. Despite rapid urban development over the past two decades, just 40% live in major cities. Most municipalities are relatively small compared with those of the Prairie Ecozone.

The most recent major development is the increased use of forests. Between 1951 and 1991, forest harvests increased by 82%. Agriculture has also become a more visible influence. Farmland has increased by 8% over the last 20 years, but still occupies less than 10% of the Boreal Plains. Agricultural activities are dominated by wheat, pasture and rangeland.

The economic structure of the ecozone reflects a relatively high dependence on the service sector, which employs 65% of the labour force, and the primary industries. Over the past century, much of the ecozone has been put to use harvesting natural resources. Forestry was historically the dominant industry but recent economic declines have reduced its importance. Other resource industries include agriculture, oil and gas development, hydro-electric power generation, fisheries and mining. The First Nations of the ecozone are tied tightly to traditional places of spiritual significance and ancient burial grounds. They use the ecozone's forests as both their home and workplace. Wildlife is particularly valuable to those who rely on hunting, trapping, and fishing as a primary source of food.

Most of the major rivers have their origin in the Rockies. These rivers flow east across the ecozone and are the products of rainfall, snowmelt and glacial runoff at their headwaters.
The climate of the Boreal Plains Ecozone is determined by its location in the heart of North America. The Rocky Mountains to the west block moisture-bearing winds from the Pacific. The result is short, warm summers and long, cold winters. The annual precipitation, approximately 450 mm, is greater than the evaporation rate, resulting in surplus moisture of up to 100 mm near the southern edge of the ecozone and up to 300 mm in the northern and foothills regions.

Forest regulators and the forest industry

Forest resource management in Canada falls under the jurisdiction of the provincial governments. In the BPE, managed forest crown land totals approximately 36 million ha, of which about 24 million ha is in Alberta and 6 million ha in both Saskatchewan and Manitoba (Natural Resources Canada 2008). Most of this land is allocated to forest companies through Forest Management Agreements (FMA). The FMAs are contractual agreements between the company and the provincial government that grant rights to harvesting and also require certain forest management activities to be undertaken by the company: forest regeneration, protection of water quality and fish habitat, submission of forest management plans, etc. Generally FMAs are based on a 20-year planning cycle and are usually renewed every 10 years. The provincial governments maintain ownership of the land while the company has the right to annually harvest a given volume of wood, usually based on requirements of the wood processing facilities associated with the FMA (pulp mills, saw mills, etc.). There are approximately 25-30 FMAs in the BPE as shown in Figure 1. Note that this map represents the overall allocation of harvesting rights in the BPE; at any given time forestry operations may or may not be active depending on market conditions, weather restrictions and disturbance events (forest fires, insect outbreaks, etc.). The forest products industry in the BPE (i.e. within the provinces of AB, SK and MB) generated revenues of approximately $8 billion and employed about 30,000 people in 2007 (Natural Resources Canada 2008).

First nations

Several hundred aboriginal reserves and communities occur in the BPE. The aboriginal population of the prairie provinces is shown in Table 1.

Table 1. Total and Aboriginal population in the prairie provinces

Province	Total population	Aboriginal identity population	% Aboriginal
Manitoba	1,133,515	175,395	15.5
Saskatchewan	953,850	141,890	14.9
Alberta	3,256,355	188,365	5.8
Total	**5,343,720**	**505,650**	

Much of the landbase allocated for forest management in the BPE overlaps with aboriginal communities' traditional lands. Opportunities exist in these areas for aboriginal employment and other economic benefits from the forest sector. On the other hand, threats to traditional landuse activities such as trapping may result from forestry activities. In order to address these issues, aboriginal communities have been calling for increased participation in forest resource management decision-making. Most forest companies in the region have established various forms of co-management agreements with aboriginal and non-aboriginal communities to foster collaborative decision-making. Olsson et al. (2004) define co-management as:

> "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing."

Co-management can take many forms but generally consists of a committee of community stakeholders that meet periodically with the forest company to review operational plans and to identify their concerns regarding the impacts of management activities. The concept of co-management is consistent with giving local residents a stronger voice in resource management decision-making, and will promote adaptive capacity as they become more involved and develop expertise in resource management. However, problems have arisen as co-management has been implemented. Members of co-management boards may lack expertise, have language difficulties or simply not have time to participate (Castro and Neilsen 2001). Governments or large forest companies are often guided by political or economic forces far from the local forest community and either will not or cannot implement the advice and direction give by the co-management group (Castro and Neilsen 2001).

Other values

Several other resource extraction industries are important in the forested regions of the BPE. Oil and gas activities, especially in northern Alberta, affect large portions of crown forest land. Diamond exploration is moving rapidly toward full production in the Fort a la Corne area east of Prince Albert SK. The world's largest uranium industry is in northern Saskatchewan, and oil sands mining, extraction and upgrading is a multi-billion dollar industry in northern Alberta and is under development in northern Saskatchewan. These developments may have significant environmental impacts on the forest and local First Nations communities. Several forestry and oil and gas companies have begun to use an approach called Integrated Landscape Management in which collaboration on road development and other activities minimizes the activity footprint on the landscape (Natural Resources Canada 2007).

The BPE is internationally known for high-quality recreation opportunities, including world-class trophy fishing, hunting and back country canoeing. Many First Nations and Metis communities occur in the BPE, where residents undertake a wide range of traditional land use activities such as hunting, fishing, berry picking, medicinal plant gathering and others.

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Chapter 3
Climate Trends and Current and Potential Future Impacts on the Forest Sector

E. Wheaton – Saskatchewan Research Council

Considerable progress has been made in the last decade in the understanding of climate science and in projecting possible future changes in climate (Solomon et al. 2007). This progress is especially important to regions such as the Boreal Plains Ecozone because changes in such mid-continental northern regions are projected to be among the largest and most rapid changes globally. The Boreal Plains Ecozone is the study area considered here. The communities of the Ecozone are fairly dependent upon the resources of the region, and thus are sensitive to changes of that ecozone driven by climate change. This combination of sensitivity and significant climate change tends to produce high potential vulnerability in the study area communities. Awareness of climate change and using climate change information in decisions begins to increase the capacity to adapt and decrease vulnerability. The importance of improving the knowledge of current and future climate change in the boreal forest and the implications of these changes are emphasized by the mounting evidence that many of the projected impacts of changing climate on the northern forest sector are already visible (Furgal and Prowse 2008). These findings are wake-up calls or alerts to increasing adaptive capacity.

The objective of this chapter is to provide an overview of recent information about future possible climates. The information is tailored to be relevant to the Boreal Plains Ecozone and its stakeholders, where possible. This ecozone is the study area chosen for this project. Warren and Egginton (2008) remind us that stakeholder engagement is a critical first step in assessing vulnerability. This project has accomplished this step and this chapter continues that progress by using the stakeholder concerns as a guide towards climate scenario information updates. The authors also state that vulnerability assessment requires an understanding of both biophysical and socioeconomic processes. The foundation of such an assessment requires an understanding of how climate is likely to change, as addressed in this chapter.

The structure of the chapter includes descriptions of the objective (above), guiding methodology, climate-related topics of concern as indicated by stakeholders, as well as discussions of relevant climate variables, of future related climate change, and the certainty and uncertainty of these projections. Conclusions and recommendations follow.

Methods

Discussions were held with selected stakeholder groups and notes were taken based on these discussions. The stakeholders were selected from industrial leaseholders and government departments. Further description of the methodology regarding the stakeholder discussions is described in subsequent chapters. The discussion notes are critical to this chapter as they were used to determine the climate-related topics of most concern and/or interest to stakeholders. The link with these issues and climate variables aid in the determination of the climate conditions relevant to the stakeholders' concerns. The adaptation measures needed to deal with the impacts are affected by the nature of the impacts, including type, as well as temporal and spatial scales. Therefore the variables are also important to the adaptation management of the forest.

This approach of using information from stakeholders to direct and/or inform the pathways of the climate change research appears to be rare, but is being used by the Institutional Adaptation to Climate Change (IACC) study (Diaz and Gauthier 2007). This approach is in contrast to the more traditional approach of determining and discussing the main climatic variables provided by the climate change scenarios as a first step.

The steps used in this chapter include:

- Document the climate-related topics, including impacts and adaptations in the stakeholder discussion notes.
- Estimate the priority or level of relevance or concern based upon the number of discussion notes that mention the impacts and comments in the notes. Organize the main topics by priority
- Determine the climate variables that affect the main topics in step one. This determination is accomplished through expert judgment and confirmation in the literature and discussion notes, as possible
- Provide a brief description of these climate variables from recent literature describing existing climate change scenarios of the future. Include those using Global Climate Models (GCMs), Regional Climate Models (RCMs) and downscaling procedures. Emphasize results for the study area.

Climate-related topics identified by stakeholders

The stakeholder discussion notes were reviewed in order to determine the climate-related topics of importance or concern to the stakeholders. Many impacts were discussed by the stakeholders, so an indicator of the importance or priority of the impact was needed. Several related topics were grouped together for improved organization of the topics and for brevity. An example is winter and summer access to the forest for different activities, including harvesting. A simple indicator was used to accomplish prioritization of the importance of the impacts. The indicator was the number of discussion notes mentioning the issue. For example, "one" indicates that the topic was mentioned in only one set of group discussions. A total of six sets of stakeholder discussions were held, so "six" designates the most commonly mentioned set of topics and may be considered the top priority topic, by this method. Table 1 lists topics organized by priority, along with the main climate variables affecting the topic, comments and knowledge gaps, comments from the discussion notes, and the priority indicator.

Table 1 Climate impacts and adaptation topics documented in the stakeholder discussion notes. Priorities of the impacts, relevant climate variables for the impacts and comments are included. *Priority is indicated by the number of discussion notes (out of six) that describe the impacts. Impacts are listed in the order of priority indicator.

Impacts and adaptation topics	**Climate variables of relevance (examples)**	**Comments and knowledge gaps**	**Comments from discussion notes**	**Priority indicator for impacts***
Timber supply, forest ecosystem response and cumulative impacts on all values	Temperature, precipitation, radiation, wind and other variables affecting growth and productivity	Cumulative climate change impacts may be the most uncertain impact	Timber supply is a critical issue	6
Forest regeneration, risks to establishment, germination, growth and survival of forests and plantations	Extended droughts (e.g. water scarcity, low precipitation and/or high temperatures, low stream flows)			6
Forest fires	Fire weather, e.g., high temperatures, droughts, lightning	Uncertainty is an issue	Many impacts include salvage, access, etc. Weather extremes are a main concern because of the management problems	6
Reduced access in summer and winter Site disturbance	Intense precipitation, high soil moisture, storm frequency, longer summers. Warm winters, shorter winters, excess snowpack, less frozen ground		The many effects include harvest, inventories, delivery schedules, mill production are affected. Roads for communities are also affected, especially in winter	5
Reliability/ uncertainty of climate projections	Scenario improvements and information about probabilities		Climate change is less understandable than other issues. Impacts could be positive or negative	5
Insect activity, e.g. outbreaks	Temperature, precipitation, etc.	Mountain pine beetle for example. What other catastrophic events should be considered?	- Insects may be an even more important dynamic than higher temperatures and severe storms - Salvage is affected	5
Biodiversity, e.g. impacts on endangered species and species at risk, invasive species	Temperature, precipitation, etc.		For example, impacts on caribou, shifting of species	5

Impacts and adaptation topics	Climate variables of relevance (examples)	Comments and knowledge gaps	Comments from discussion notes	Priority indicator for impacts*
Management issues, regulations, best practices, and standards of operation, land use planning, competitiveness, integrated management capacity, policies	Temperature, precipitation, etc	A tertiary effect moderated through primary effects. Many of the major issues for forest management have a climate change link	Management questions, e.g., optimum combination of spruce and aspen	4
Genetic issues and tree breeding	Temperature, precipitation, etc.	What genetic traits would be most suited to deal with climate change impacts?	What is the genetic adaptation potential of various species?	3
Cumulative effect on thresholds for radical forest ecosystem changes	Rate and magnitude of change in relevant variables, effects on extreme events	Thresholds for dieback, for example		2
Blow-down	Extreme winds, e.g. tornados			2
Impacts on specific species and differential vulnerability, e.g. black spruce, white spruce	Temperature, precipitation: simulation modeling for specific stands			2
Regional and decision relevant information, improved access to information and expertise re climate change		Climate change information for more local scales and more appropriated for decision making is needed		2
Competing land uses	Climate- land use capability for other industries, e.g. agriculture			1
Carbon cycle	Temperature, precipitation, effects on nutrients			1

The climate impacts mentioned by the most numbers of discussion notes (6) were timber supply (and cumulative impacts, etc.), forest regeneration, and forest fires. The next most commonly mentioned topics were access to the forest (in both winter and summer), biodiversity, uncertainty of climate projections, and insect activity. The third most relevant category of climate sensitivity, according to this method, is a set of management issues. The next most commonly mentioned issues included genetic issues, specific species, radical forest ecosystem changes, blow-down, competing land uses, carbon cycle, and regionally relevant information. Even though these later issues and possibly others were mentioned less often, these additional impacts may be considered more or perhaps even less important as the numbers of discussion groups were increased or the types of stakeholders changed.

Biophysical impacts on the northern forest sector as commonly noted in the literature include forest productivity changes, increased disturbances, northward ecozone shift, effects on different species, ecosystem changes (Lemmen and Warren 2004, Sauchyn and Kulshreshtha 2008). Most of these impacts are in common with those noted by the stakeholders (Table 1). Ogden and Innes (2007) found that the most important research needs to assist decision making identified by forest practitioners (in the Yukon and Northwest Territories) included understanding the impacts of climate change on the characteristics of insect outbreaks and forest fires, as well as net impacts on forest growth and productivity. They found that the climate change impacts perceived by forestry practitioners as having significant impacts included (in order of importance): forest insect outbreaks, extreme weather events, forest fires, lifestyles, land values and land-use options, length of winter road season, economic opportunities, and forest carbon budget. In comparison, insect problems were considered to be of secondary importance to several other topics using the methods of this chapter.

Relevant climatic variables and characteristics

Next it is important to ascertain which climate variables are most important drivers of the topics mentioned in the previous section. Then the future possible trends and variations of these climate variables can be considered. Climate variables that appear to be relevant to the stakeholders' list of topics were generated based on the literature and included in Table 1. Many of the impacts are driven by effects of temperature and precipitation, and extremes of those variables, such as intense precipitation. These basic variables are the first-order drivers of climate impacts and indices of changes in weather extremes (Sheffield and Wood 2007).Variables may be used directly as indicators of impacts, or indirectly through impact simulation. We begin the next section with a description of the future temperature and precipitation climates. These are the foundational variables underpinning many of the expected impacts and some of those already occurring.

Combinations of these variables that produce extremes such as drought are also important to impacts and are presented. Other variables, such as extreme winds that cause blow-down of trees, are also relevant. Variables or indices derived from temperature and/or precipitation are used in impact assessment. These include thermal indices such as growing degree-days, season lengths, and forest fire severity indicators.

Some characteristics, as distinct from variables, of climate scenarios are also important to stakeholders. These include scale-suitable information and descriptions of the uncertainty or confidence in climate scenarios. Other climate variables affecting impacts, but not in the stakeholder discussions should be considered in further work, especially for sensitivity studies of their relative importance. These variables may include cloud cover, solar radiation, storm tracks, etc.

Scenarios of future temperature and precipitation

Information regarding projections of future climates of the Prairie Provinces and the world has been provided by several recent references including Sauchyn and Kulshreshtha (2008) and IPCC (2007). Barrow et al. (2004) provide "state of the science" information not only regarding future climates and extremes, but also past climates. A main advantage of using Global Climate

Models (GCMs), as used by these reports, for example, to develop climate scenarios is that they are the only tool for estimation of changes in climate due to the increased greenhouse gases for a large number of climate variables in a physically consistent method (Carter et al. 2000). We use such data to describe the future possible climates of the Boreal Ecozone.

Scatterplots and maps of seasonal and annual changes in temperature and precipitation are provided by Sauchyn and Kulshreshtha (2008). Temperature and precipitation are among the main climatic inputs to one of the impacts of frequent concern, such as forest growth and wood supply, fire and insect activity. Scatterplots and maps are among the main tools used to describe scenarios. Scatterplots are used to compare variations among climate models. Maps are provided to assess geographical variation across the study area. These scenarios were derived from experiments using seven GCMs and several IPCC emission scenarios (Nakicenovic and Swart 2000).

Time evolution of change through three future periods

Climate change scatterplots (Figure 1) for the forest region of the Prairie Provinces show the simulated changes in mean seasonal temperature and precipitation for three future periods, the 2020s, 2050s and 2080s (Sauchyn and Kulshreshtha 2008). A useful question to ask for impact assessment is: are the future changes within the realm of natural variability? The plots demonstrate that all models, with few exceptions, forecast climates that lie outside the range of natural variability even for the earliest period of 2020s. This means that the type of climate change projected will be beyond what the stakeholders have experienced during the baseline period of 1961 to 1990. This also means that the impacts and adaptations would likely be outside the range of this past experience, especially of thresholds of ecosystem impacts are exceeded, for example. These findings provide information for the concern or interest expressed by the stakeholder discussion groups regarding radical forest ecosystem changes, or tipping changes that could be encountered with large and/or rapid climate changes (Table 1).

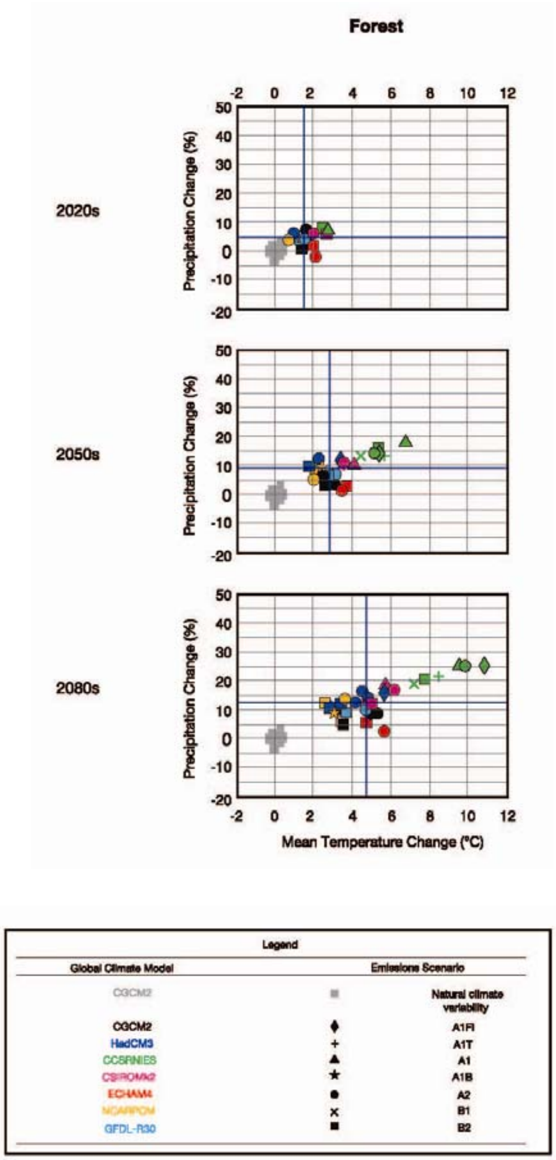

Figure 1 Projected changes of mean annual temperature and precipitation for the forest region of the Prairie Provinces for the 2020s, 2050s and 2080s (Sauchyn and Kulshreshtha 2008). The grey squares indicate the 'natural' climate variability simulated by a long control run of the Canadian Coupled Global Climate Model, Version 2 (CGCM2), with no change in forcing over time. Blue lines represent median changes in mean temperature and precipitation derived from the suite of scenarios.

Confidence in GCM results is highest for the first 30 year averaging period of the 2020s and lowest with the 2080 period (Warren and Egginton 2008). Comparison of the scatterplots for the three periods to 2080s also is an indicator of confidence or certainty of results. The GCM experiments are highly clustered, showing good agreement for the 2020s and even the 2050s. This indicates the consistency of these results for annual temperature, precipitation across several different GCMs and emission drivers. The results have clearer separation from the pack in the 2080s, especially for the Japanese model.

Another indicator of increasing confidence in these near-term projections is that the global average temperature increases are similar to the observed values of about 0.2°C per decade (IPCC 2007:12). Geographic patterns of observed and simulated values are also similar. Patterns of simulated future changes show close agreement for many climate experiments. They consistently show greatest warming over land and for most high northern latitudes, and least warming over the Southern Ocean and parts of the North Atlantic Ocean (IPCC 2007:15). These patterns also have broad consistency with many characteristics of other observed changes besides temperature, e.g. storm tracks (e.g. IPCC 2007:16). These consistencies also strengthen confidence in the projections.

Annual temperature increases range from about 1°C to nearly 3°C, with a median change of almost 2°C for the 2020s (Sauchyn and Kulshreshtha 2008). Small changes in the average may result in quite large to record changes in the extremes. Annual precipitation for the 2020s ranges from a decrease of a few percentage points to an increase of over 5%. Changes in both annual values increase considerably to the 2080s to upper values of 50% increases in annual precipitation and about 11°C increases in annual temperature. Projections for temperature are more reliable than for precipitation as the former is less variable in time and over area, and thus more easily simulated. Changes in annual values are likely more reliable than changes in seasonal values, however, changes in seasonal and smaller increments of time are more appropriate than annual values for understanding impacts.

Seasonal comparisons

Seasonal changes in temperature and precipitation exhibit much more scatter and thus variability than the annual changes. Much of the projected increase in temperature and precipitation is expected for the winter and spring seasons for the forest region. This pattern implies that the impacts may be much more pronounced for these seasons and changes will be more noticeable then. Median changes for winter in the 2050s are more than 12% precipitation increase and almost 4°C temperature increase (Figure 2). Spring results are a median change for precipitation of almost 15% and over 3°C temperature increase. Fall shows little change in median precipitation, but with a wide range from a 10% decrease to almost 25% increase. Summer results for precipitation are an important indicator of possible droughts and/or excess soil moisture. Summer has a temperature increase of near 3°C, but is the only season to show a decrease in precipitation with a median decrease of 5%.

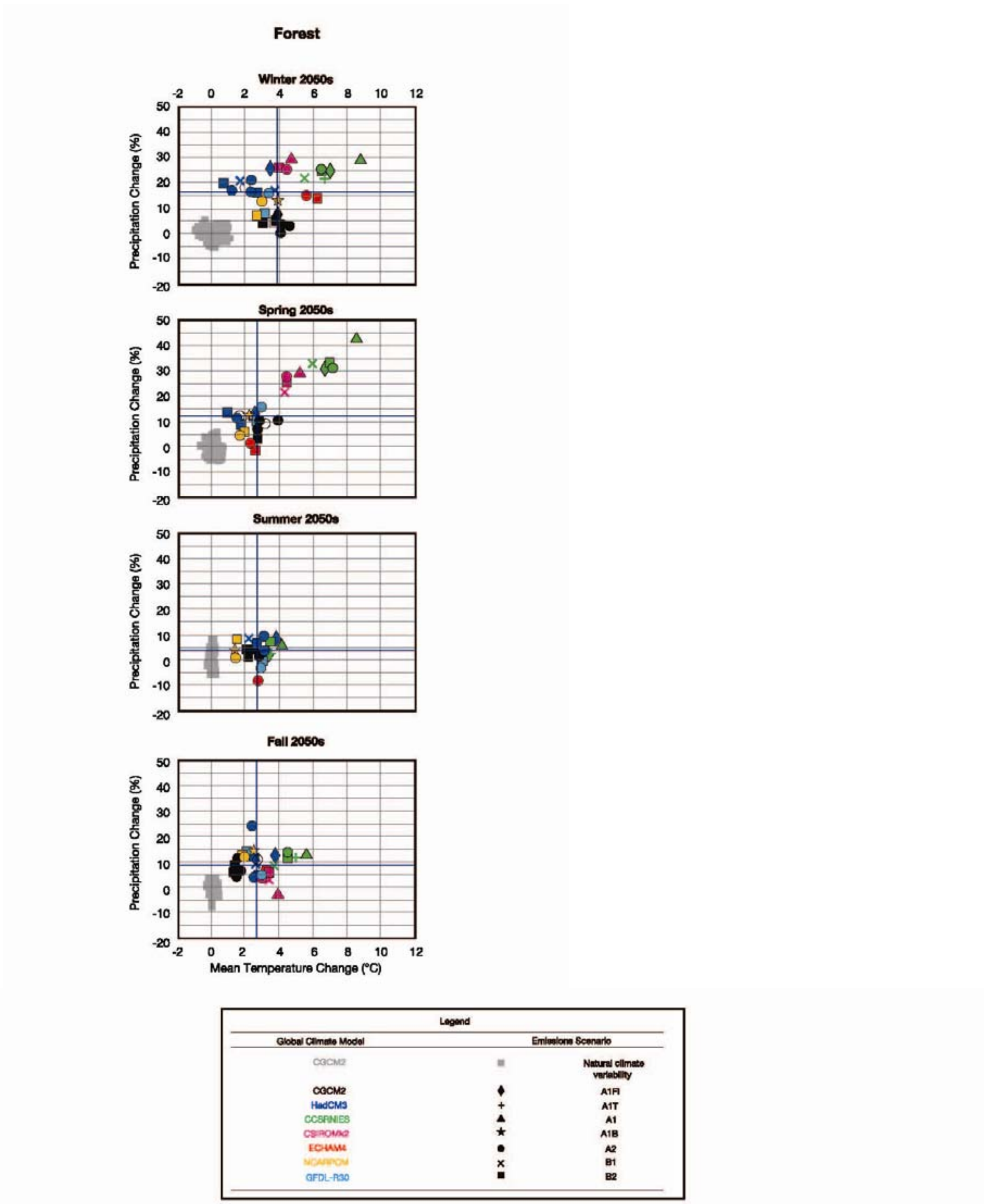

Figure 2 Projected mean seasonal changes of temperature and precipitation for the forest region of the Prairie Provinces for the 2050s. (Sauchyn and Kulshreshtha 2008). The grey squares indicate the ‘natural’ climate variability simulated by a long control run of the Canadian Coupled Global Climate Model, Version 2 (CGCM2), with no change in forcing over time. Blue lines represent median changes in mean temperature and precipitation derived from the suite of scenarios.

Geographical patterns of climate change

The GCM results are available only at a coarse spatial resolution of hundreds of kilometers. For example, the range of resolution for the 15 GCMs participating in the IPCC Fourth Assessment is from coarse (e.g. 4x5° for the GISS-AOM) to medium (e.g. 2x2.5° in GFDL) to finer (1.4x1.4° in CCSM3) (Wang 2005). This is especially a limitation for areas of complex topography and land/water cover. These limitations are not substantial for the study area because of the relatively lower relief and relatively homogenous land cover. However, this limitation can be dealt with by a process termed "downscaling" designed to provide much finer resolution. Common approaches to downscaling to provide climate scenarios are dynamical and statistical. The use of a high-resolution climate models, or regional climate models (RCMs) is the dynamical downscaling. Statistical downscaling methods are popular as they are easier to use and computationally less demanding. Two examples of this method are the Statistical Downscaling Model (Wilby et al. 2002) and the LARS weather generator (Semenov and Barrow 2002). Price et al. (2004) use the downscaling method, ANUSPLIN, to downscale GCM output of several climate variables from four models at 10 km resolution for North America. They find this interpolation method to work well and list several advantages compared with other downscaling methods.

Regional Climate Models (RCMs) are a powerful means of providing improved spatial resolution and they are evolving rapidly. However, their results are limited to a few GCMs and emission scenarios. Therefore, they cannot be considered to encompass a full range of plausible futures (Warren and Egginton 2008). This is a reason for the wider use of GCM scenarios.

The greatest warming and largest precipitation changes on an annual basis are projected for the north and east of the Canadian Prairie forest region, with the south and east having the least warming and some decreases in precipitation (Figure 3). Increases in precipitation are larger for the forest than the grassland region of the Prairies (Sauchyn and Kulshreshtha 2008). Geographical variations for the seasons and for extreme climate events should be examined for greater relevance to climate impacts.

Figure 3 Projected geographical changes in a) mean annual temperature and b) mean annual precipitation for the Prairies in the 2020s, 2050s and 2080s showing minimum, median and maximum projections of changes (Sauchyn and Kulshreshtha 2008)

Future scenarios of other climate variables

Droughts and Aridity

One of the greatest threats for forests is increased aridity (Henderson et al. 2002). This conclusion is confirmed by Hogg and Bernier (2005) who state that the main challenge for future management and conservation of forests is the likelihood of more severe droughts. Hogg et al. (2008) examined the effects of the severe drought of 2001-2002 on trembling aspen (*Populus tremuloides* Michx.) in Western Canada. They showed that moisture was the most important factor affecting stand-level growth, dieback, and mortality during 2000-2005. A more than two fold increase in stem mortality and a 30% decrease in regional stem growth occurred during and following the drought. Climate change impacts on forest characteristics such as productivity is a critical issue, especially in already drought-prone areas. Scientific assessment confirms that "More intense and longer droughts have been observed over wider areas since the 1970s…Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought." (IPCC 2007: 8).

One of the first studies that analyzed potential changes in drought under future global warming characterized by persistence in severe soil moisture deficits using multiple models and scenarios is by Sheffield and Wood (2007). They compare soil moisture results for future climate models driven by the SRES B1, A1B and A2 emission scenarios with the results from pre-industrial control and eight Atmosphere-Ocean coupled GCMs. They investigate the possible future changes in drought by analyzing soil moisture and drought characteristics over global land areas, excluding Antarctica. They consider uncertainty in regional climate change by using data from many climate models and for three future emission pathways.

The models used by Sheffield and Wood (2007) replicate the estimates of large area drought occurrence fairly well, but the longer term (more than 12 months duration) droughts are over-estimated. The future projections show decreases in soil moisture globally for all scenarios with a doubling of the area of severe soil moisture deficits and frequency of short term (4-6 months) droughts from the 1950s to the2090s. Droughts longer than a year are estimated to triple in frequency. Changes in extremes of climate and hydrological impacts are found to be more detectable than changes in their means. This finding is consistent with several other studies that estimate drying over the interior of northern hemisphere continents over the next century, especially in the summer (e.g. Wetherald and Manabe 1999, 2002; Gregory et al. 1997, Burke et al. 2006). The conclusion of the latest IPCC report (Meehl et al. (IPCC) 2007: 783) was "In a warmer future climate, most Atmosphere-Ocean General Circulation Models project increased summer dryness and winter wetness in most parts of the northern middle and high latitudes. Summer dryness indicates a greater risk of drought."

Sheffield and Wood (2007) define drought as an extended period of anomalously low soil moisture. They characterize the duration, intensity, severity and area of drought. Although they estimate future drought for large regions of the globe, results from the study area can be indicated by using results for Western North America (WNA) and Northeast Canada (NEC). WNA shows increases in drought statistics, but has large variation among scenarios, indicating higher uncertainty in the results. The regional time series of the frequency of short term droughts shows a steeper increase through time for WNA as compared to NEC. The Drought frequencies show large increases, especially for those longer than a year, for regions such as WNA with changes elsewhere relatively smaller. They found that the same mechanisms are operating to increase drought statistics as suggested by several other authors. These include decreasing precipitation as the primary forcing, with increased evaporation driven by higher temperatures as an exacerbating agent.

Bonsal and Regier (2006) completed a first-order assessment of future drought occurrence over southern Canada. Their results are relevant for the south portion of the study area. Their drought modeling approaches included the Standardized Precipitation Index (SPI) and the Palmer Drought Severity Index (PDSI). The SPI is a simpler index that only considers precipitation and the PDSI is more complex as it incorporates a water balance approach using precipitation, potential evapotranspiration, antecedent soil moisture and runoff. All the climate scenarios projected considerable increases in temperature and generally small increases to annual precipitation over southern Canada. These higher temperatures result in greater evaporation and more severe droughts. Droughts increase dramatically in both spatial extend and severity with the effect of increasing temperatures. Results indicate that future droughts may frequently exceed the worst droughts on record. The authors warn that information regarding large-area general atmospheric circulation and future precipitation is less certain than estimates of future temperature. The nature of future droughts is a knowledge gap.

Estimation of future changes in soil moisture poses more difficulties than for temperature and precipitation, but some progress is occurring. Wang (2005) examined the impact of greenhouse gas warming on soil moisture and found that the GCMs are consistent in predicting summer dryness and winter wetness in part of the northern middle and high latitudes. A wide range of response in soil moisture values is attributed to the differences in land surface parameterization. This source of uncertainty is partly addressed by using an ensemble approach. Another source of uncertainty is the very limited observational data set of soil moisture. The climate variable most commonly used to represent soil wetness levels is the soil moisture content (in mm). In the northern high latitudes, the average of all the models shows a decrease of soil moisture despite the significant increase in precipitation. This direction is consistent with the relatively large potential evaporation increase during warm seasons. That is, the increased potential evaporation driven by the higher air temperature outweighs the impact of precipitation increase. Drought appears to be primarily due to enhanced evaporation in a warmer world. This effect is documented by other researchers, e.g., Manabe et al. (2004). It is important to note that even though temperature increases are more certain, the models are now highly consistent in predicting both the direction and magnitude of precipitation changes. This consistency is better for winter than summer.

Barrow et al. (2004) point out that water storage and runoff in regions of frozen soil moisture, such as the study area, remain outstanding challenges in GCMs. This means that soil moisture information from GCMs must be considered with caution. However, as mentioned elsewhere, improvements in land surface schemes are improving the simulation of liquid and frozen soil moisture.

Observed changes in drought show that some of the projected changes are already occurring and perhaps the GCMs are under-estimating the rate of change. Droughts have shown an increase in intensity and duration since the 1970s on a global basis (Dai et al. 2004). Heat waves have also increased in frequency. Changes related to drought found by Vincent and Mekis (2006) include more extreme warm nights and days and decreases in the mean amount of daily precipitation for Canada. Actual evapotranspiration rates have increased in most parts of Canada in the last 40 years. The northwest forest region shows a slight increase of evapotranspiration. In drier areas, the water available for evaporation tends to limit this increase (Fernandes et al. 2007).

Wind Speed, Storms, Intense Rainfall, and Atmospheric General Circulation

Barrow et al. (2004) map and describe future possible changes in mean sea level pressure and wind speed across Canada. They use the Canadian CGCM2 model with A2 and B2 emission scenarios for the 2050s. The resulting pattern of mean sea level pressures across Canada and along both coasts results in a higher pressure gradient across the country. Resulting wind speeds increase in the order of 5 to 10% across the study area and across the entire country, with the largest increases in the north. The seasons of largest increase appear to be winter and spring for the study area.

Evidence for long-term changes in the large-scale circulation of the atmosphere has been documented. These changes include a pole-ward shift and strengthening of the westerly winds. The increased strength of the westerly winds is a major factor in the observed winter changes in storm tracks and related patterns of precipitation and temperature trends at mid to high- latitudes (Solomon et al. IPCC 2007). Several future changes are projected. “Extra-tropical storm tracks are projected to move pole-ward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century.” (IPCC 2007:16). “The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour (IPCC 2007:8). Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s (IPCC 2007). Evidence is insufficient to determine the existence of trends in small storm events such as tornados, hail and lightning (IPCC 2007:9).

Uncertainty/ certainty of climate change projections

The confidence indicated by the clustering of GCM experiments was discussed earlier. This section further describes sources and nature of uncertainty and certainty or reliability of climate change scenarios. By using a wide range of GCMs and emission scenarios, much uncertainty can be captured and reduced. The range from wetter/cooler to hotter/drier scenarios can be selected from these experiments to more fully reflect the range of possible futures than arbitrarily selecting a few experiments that may not describe this range. Barrow and Yu (2005) take this approach to provide a range of scenarios for the Alberta Vulnerability Project.

Uncertainty varies according to many factors, including the climatic element, geographical region (i.e. topographical complexity, water bodies), and scale (regional to global). Uncertainty is greater for variables such as precipitation and wind than for temperature. Uncertainty is greater for regional than for global scales. Also, GCMs do not provide information at the local scale relevant for many stakeholders. However, as discussed above, several methods for downscaling to the appropriate scale are available and provide appropriate results.

The climate system is very complex and a challenge for understanding. Some of the most important of the uncertainties in the scientific understanding of the climate system include: aspects of the role of clouds, the cryosphere, the oceans, land use and the couplings between climate and biogeochemical cycles (IPCC 2007). An area of considerable advance is the quantification of direct aerosol radiative forcing. Many atmospheric models now include all aerosol components that are considered significant. It is also very important to be able to simulate feedback effects on climate, including those of snow and ice, water vapour, and clouds. Water vapor changes represent the largest feedback and are now better understood than at the time of the earlier IPCC assessment report of 2001. However, cloud feedbacks remain the largest source of uncertainty (IPCC 2007:12).

GCMs have improved considerably in the last decade or so and are better able to simulated observed climates. The considerable progress since the IPCC Third Assessment Report (TAR) (Watson and the IPCC Core Writing Team (2001)) is based upon new and more comprehensive data, more sophisticated data analyses, and improvements in the understanding of processes and of model simulation. “The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence* that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m^{-2}”. The term “very high confidence” represents at least a 9 out of 10 chance of being correct (IPCC 2007:3). They go on to report that “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level” (IPCC 2007:5). Also “Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns” (IPCC 2007:10).

The IPCC (2007) screened 24 climate models and seven met their criteria for use. Table 2 lists these models by acronym along with the modeling centre, emission scenario, and grid cell size. Model projections of climate change account for external forcing from natural and human sources, including greenhouse gases, aerosols, and solar irradiance. However, internally generated natural variability was not included. This is a source of uncertainty in most climate projections that is being addressed by researchers such as Smith et al. (2007). They used a newly developed Decadal Climate Prediction System, based on the Hadley Centre Coupled Model, version 3 (HadCM3) for predicting decadal changes including natural variability. Internal variability will continue to partially mask the global warming signal for the next few years, but the climate will continue to warm as the signal becomes more dominant.

Table 2 Summary of characteristics of some main climate models; the country of origin, SRES simulations available, grid cell size and dimensions of the area. Output was available from the IPCC Fourth Assessment Report (IPCC 2007) for all models except the HadCM3 from the Third Assessment Report (Watson and IPCC Core Writing Team 2001) at the IPCC Data Distribution Centre (http://www.ipcc-data.org/) and Program for Climate Model Diagnosis and Intercomparison (http://www-pcmdi.llnl.gov). (adapted from Lapp et al. 2008)

Climate Modeling Centre	Model	SRES Simulation	Grid Cell Size (degrees)
Canadian Centre for Climate Modelling and Analysis **Canada**	CGCM3 (T47)	A1B*, A2*, B1*	3.75^{o} x 3.75^{o}
	CGCM3 (T63)	A1B,A2,B1	2.81^{o} x 2.81^{o}
Met Office Hadley Centre **UK**	HadCM3	A2*, B2 (TAR)	3.75^{o} x 2.55^{o}
National Institute for Environmental Studies **Japan**	MIROC3.2-MEDRES	A1B*, A2*, B1*	2.8125^{o} x 2.8^{o}
Geophysical Fluid Dynamics Laboratory **USA**	GFDL 2.0	A1B, B1	2.5^{o} x 2.0^{o}
Max-Planck-Institut for Meteorology **Germany**	ECHAM5-OM	A1B,A2,B1	1.875^{o} x 1.87^{o}
Australia's Commonwealth Scientific and Industrial Research Organization **Australia**	CSIRO-MK3.0	A1B,A2,B1	1.875^{o} x 1.87^{o}

*More than one experiment was carried out for these emission scenarios.

Considerations of changes in variability are important to document uncertainty and certainty of future changes. There appears to be few assessments of future projected changes of variability of various climate elements. Price et al. (2004) provide one of these and find that the higher emission scenario (SRES A2) gives an increase in variance in seasonal temperatures and the lower emission scenario (B2) gives a decrease for 2061-2090 compared with 1961 to 1990. Changes in variance of seasonal precipitation have little consistency, but interannual variability in spring precipitation increases. They used GCM output from four climate models with the SRES emission scenarios A2 and B2.

Meehl and Hibbard (2007) document some of the updates of and recommendations for the next generation of atmosphere-ocean general circulation models (AOGCMs, i.e. Atmosphere-Ocean coupled Global Climate Models (GCMs)). These new components represent areas of uncertainty that are being addressed in this next generation of climate-Earth System modeling. The authors provide several examples of new components being considered for incorporation in the first generation Earth System Models (ESM) in AOGCMs to encompass chemical and biological aspects of the Earth System. ESMs simulate processes in the climate system involving main components of atmosphere, ocean, land and seas ice, including forcings and feedbacks. These improved and/or new components include carbon cycle, dynamic vegetation, aerosols and chemistry and such as:

- Impacts of land use change, land management, and wild-land fires
- Representation of ocean biology processes
- Strategies for biogeography and successional processes
- Representation of the indirect effect of aerosols. (An example of ongoing research and thus uncertainty here is the ice phase cloud-aerosol interactions)
- Interactive ice sheet models

These improvements represent a crucial period of climate model development beyond the traditional global coupled model components of atmosphere, ocean, land surface and sea ice.

Conclusions

Society needs to focus on adaptation because of the reality that Canada's and the Earth's present climate is different from that of the recent past and will continue to change in the future (Warren and Egginton 2008). Sauchyn and Kulshreshtha (2008) state that "we have options, but the past is no longer one of them." Several of these trends for the future are clear and well established. Canada is projected to warm faster than most other regions in the world throughout the current century. Within Canada, regions such as the south-central prairies and northward through the Boreal Plains Ecozone will warm the most (Lemmen and Warren 2008).

This chapter documents the many concerns and interests expressed by stakeholder groups about climate change impacts and how to deal with them. These topics include changing timber supply and forest ecosystem response, forest regeneration, reduced access, disturbances such as forest fires, biodiversity, many management and policy issues, cumulative effects and enhanced information. These issues were used to frame, present, and describe current and emerging information about climate change scenarios.

Recommendations

This type of approach using stakeholder-identified issues to frame the work regarding climate change scenarios is rare. Therefore many improvements are possible and several recommendations can be made, including specific ones documented earlier. A first recommendation is to improve the methods used. This includes the determination of priority of the issues, the identification of the specific climate variables and their quantities that affect the impacts. The information was limited to six sets of stakeholders because of time constraints, and should be extended.

Other questions to use to frame further work include:

1) Climate information for decision making: What is the role of climate change information for improving adaptive capacity and reducing vulnerability? How can this role be enhanced?
2) Reducing exposure to extreme events. What adaptive capacity is most important for dealing with and preparing for extreme events? Which sets of adaptive capacity come into play in the short, medium and longer term? Which are more effective and practical in reducing vulnerability? Which extreme events have priority in terms of cost and damage, for example? Extremes are critical to consider for improved adaptation to climate. Also, "It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent." (IPCC 2007:15).

3) Other sectors: This project focuses on the forest sector and forest management. Several other economic sectors are located in the ecozone. They are being and will continue to be affected by climate change. These sectors include mining, tourism, water management, health and mitigation. This approach of impacts-relevant assessments of possible climate futures should be taken for other sectors. What are the best ways to build better adaptive capacity and what are the priorities?
4) Export and trade: Forestry is a leading export sector. Therefore the likely impacts of climate change on forestry in competing countries and the effects of climate change on international trade need to be monitored and assessed. The biggest export market is the United States (Bruce and Haites 2008), so climate change effects on that country would be a priority to consider.
5) Climate impacts and adaptations as well as interactions: the links between climate and topics of concern such as fire, insects and diseases, blow-down, carbon sequestration, for example, require further research. How effective are various adaptations at reducing negative impacts? How well does the adaptation portfolio contribute to sustainable development of the resource and the communities?

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Chapter 4
The role of economics in reconstructing adaptive capacity assessment approaches in climate change vulnerability assessment

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This paper identifies and discusses two areas where economics can inform and enhance current approaches for determining and interpreting adaptive capacity in the context of climate change vulnerability assessment. First, the paper proposes a complementary construct; namely adaptive capacity deficits. Different human systems have different levels of adaptive capacity and these differences are natural. Differences in adaptive capacity can arise because of differences in demand (or utility), and/or differences in supply (or cost). Therefore, the subjective determination of adaptive capacity as being high or low (as is the current practice in higher level vulnerability studies) does not necessarily infer low or high vulnerability. A more direct approach is to determine where circumstances result in socially inequitable and/or economically sub-optimal[1] investment in adaptive capacity resulting in adaptive capacity deficits. An adaptive capacity deficit occurs when actual supply is less than the socially optimal supply of adaptive capacity services in particular social contexts (the efficiency argument) and/or where a particular level of adaptive capacity is socially unacceptable (the equity argument).

A second area where economics can contribute to current approaches is by more directly incorporating properties affecting the adaptive capacity of economic systems into broader adaptive capacity constructs. The current focus of adaptive/community capacity approaches is mainly on social determinants and social systems. However, local economies will also be impacted by climate change and the response of economies and their inherent capacity to adapt will have a significant effect on the overall adaptive capacity of integrated social and economic systems. However, features and properties of economies that affect their capacity to adapt (e.g., amount of intervention in private markets, economic diversity, substitutability of inputs, short vs. long term adaptive capacity) are generally not included in current constructs. For example, in the case of private goods, unencumbered and appropriately structured private competitive markets adapt autonomously and efficiently, and therefore in cases where there is intervention in private good allocation, there may be opportunities to increase adaptive capacity by reducing this intervention (e.g., reducing subsidies, tax incentives/penalties, reducing public ownership, modifying regulation). At the same time, private markets are inefficient relative to some kinds of goods and services (e.g., public goods, common property goods) and for some kinds of markets (e.g., monopoly, oligopoly, etc). Moreover, interventions may be necessary where there is a need

[1] Socially sub optimal refers to cases where the marginal social cost of one additional unit of adaptive capacity is not equal to the marginal social benefit.

for income redistribution. And so in cases where climate change exacerbates market inefficiencies, there may be a requirement for less private markets and more regulation and intervention. Here again, economics can play a role in determining where increased private markets can have a positive effect on adaptive capacity and where there is a need for more intervention and regulation. The need for redistributing income to address inequities in the distribution of adaptive capacity is a social policy question. Nonetheless, economics can inform decision making by identifying the most efficient way to increase adaptive capacity to more equitable levels across systems.

Current constructs for adaptive capacity assessment

The IPCC defines adaptive capacity as: "…the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate" (IPCC 2001). Although this definition is relatively straightforward, there are multiple constructs about how adaptive capacity (and community capacity) are conceptualized, applied, and measured. Current constructs can arguably be grouped into two broad categories: the *general approach* and the *community capacity* approach.

General approach

The Intergovernmental Panel on Climate Change Third and Fourth Assessment reports adopt, for lack of a better term, *a general approach* to adaptive capacity assessment to support vulnerability assessments. The general approach relies on the use of determinants (i.e., it is primarily a bottom-up approach). This approach is general in the sense that it is not theory based and it is not tied to any particular disciplinary field. It is also general in terms of feasibility of application across a broad range of social spectra and contexts.

In the IPCC's Third Assessment Report (TAR), Smit and Pilifosova (2001) suggest that economic resources, technology, information and skills, infrastructure, institutions, and equity constitute the key determinants of adaptive capacity. Numerous authors have proposed additional and/or alternative measures and indicators of adaptive capacity. Adger et al. (2004) for example suggest that specific indicators of adaptive capacity could include: wealth, inequality, educational commitment, isolation of rural communities, quality of basic infrastructure, political influence, willingness to invest in adaptation, and various environmental sustainability measures.

The Fourth Assessment Report (FAR) (Adger et al. 2007) reflects a growing literature on adaptive capacity and presents a more comprehensive and sophisticated approach for adaptive capacity assessment. The method, frameworks, approaches, and concepts described in the FAR move toward the community capacity approach outlined in the next section. For example, the FAR states: "The capacity to adapt is dynamic and influenced by economic and natural resources, social networks, entitlements, institutions and governance, human resources, and technology." (Adger et al 2007, pg 719). The FAR summarizes their assessment of adaptive capacity as follows: "In summary, empirical research carried out since the TAR has shown that there are rarely simple cause-effect relationships between climate change risks and the capacity to adapt. Adaptive capacity can vary over time and is affected by multiple processes of change. In general, the emerging literatures show that the distribution of adaptive capacity within and across societies represents a major challenge for development and a major constraint to the effectiveness of any adaptation strategy." Chapter 17 of the FAR concludes by identifying limits and barriers to adaptation. They identify (1) physical and ecological limits, (2) technological limits, (3) financial barriers, (4) informational and cognitive barriers, (5) social and cultural barriers as key areas that may limit adaptation. Limits or barriers to adaptation can also be viewed as determinants of adaptive capacity (i.e., more of a particular item implies higher adaptive capacity).

The *general approach* to adaptive capacity assessment is useful because it has broad applicability and it is practical, straightforward, and intuitive. It leads to assessment and measurement approaches that are feasible, tractable for policy analysis, and intuitive for non social science specialists. The general approach for adaptive capacity assessment can result in policy relevant assessments of current capacity to adapt and potentially about the adaptive capacity requirements of systems. The main drawback of this approach is that it is not theory based. It is, therefore, difficult to interpret whether current adaptive capacity is socially optimal – and if not why. Another drawback of the general approach is that there is inconsistency in application, lack of comparability across studies, and because there is a lack of underlying theory there is a lack of consensus about the proper set of indicators (Adger et al. 2007). Finally, there is no recognition of interrelationships between determinants, no acknowledgment of which determinants are the most constraining, and analysis that adopts the general approach generally does not consider how adaptive capacity and adaptive capacity requirements might be impacted by future climate change.

Community capacity

The *community capacity approach* is based on the notion that communities have access to resources and assets that enhance their general capacity to adapt to, and deal with, shocks and stresses. The community capacity approach is also bottom-up in nature. Donoghue and Sturtevant (2007) assess various social science constructs of community capacity used recently in ecosystem assessments in the US. They find that the various constructs are similar but that they also vary in some fundamental ways.

Beckley et al. (2002) describe an approach for assessment of community capacity. Borrowing from Kusel (2001), they define community capacity as "the collective ability of a group (or community) to combine various forms of capital within institutional and relational contexts to produce desired results or outcomes" (Beckley et al. 2002 pg 7). Forms of capital (i.e., determinants of adaptive capacity) include:

- Natural capital: natural resources and environmental services such as clean air and water
- Human capital: skill, education, and health of individuals that contribute to the skill base and economic performance of the community
- Economic capital: local industrial base, physical infrastructure such as roads and buildings, financial capital such as organizational budgets and household savings
- Social capital: the relationships between and among community members that contribute to collective action.

Various authors allude to other forms of capital. For example, Flora and Emery (2006) include cultural and political capital as determinants of community capacity.

Social scientists have also studied specific determinants of community capacity frameworks in considerable depth. For example, social capital is generally viewed as an important determinant of community capacity. Social capital refers to the interrelationships and networks of individuals, organizations, and community leaders (Matthews 2003). Networks are defined in terms of size, density, and diversity and they can take different forms (e.g., bonding, bridging, and linking) (Franke 2005). Social capital provides individuals and groups with access to information and resources that they might not otherwise have access to. Thus, social capital contributes to the ability of individuals and communities to deal with shocks and to adapt and adjust to change generally (Matthews 2003; Franke 2005) and to climate change in particular (Adger 2003).

The benefits of social networks for individuals includes information (health, employment, financial, technology, travel), emotional support, financial support, finding employment, having a place to stay in time of crisis, assistance with vehicle repairs or home renovations, looking after children, taking care of pets, etc. Social capital also exists at higher levels. For example a community's collective social capital is measured in terms of numbers of organizations in a community, number of members in these organizations, and the level of interconnections between organizations (Franke 2005). Also, community leaders have social networks that may benefit the overall community. A high level of social capital in a community contributes to adaptive capacity because it supports collective action by the community. It also contributes to actions or decisions being taken that contribute to overall community health and well-being. Socially pathological events or circumstances that constrain the ability of a human system to invest in social capital to normal levels or that break down existing social capital (e.g., a serious conflict, something that results in division and a breakdown in trust within a community, racism, injustice, inequities, increased conflict within the community) can result in decreases in social capital below normal or socially optimal levels.

Perception of climate risk contributes to the willingness and preparedness of individuals to adapt to climate change (McDanials et al. 1996; O'Connor et al. 1999). Thus, the ability to accurately perceive climate risks is required for socially optimal investment in adaptive capacity while misperception of climate risks can result in bad choices and potentially increased vulnerability[2]. The assessment of perceptions of climate change risk contributes to vulnerability assessment in two ways. First, perception of local risks provides new information that complements technical risk assessments because such perceptions may be based on local observations that are not detected by science based/technical risk assessments (Reference). Second, there are often features or characteristics of climate related risks and/or risk perceivers themselves (i.e., individuals, communities, or policy actors) that may result in underestimation or overestimation of climate change risks (Slovic 1987; Slovic 2000; McDaniels et al. 1995; Khaneman et al. 1982). Davidson et al. (2003), Stedman et al. (2004), and Williamson et al. (2005) consider these factors in the context of forest-based communities and forestry actors in Canada. Underestimation of risk may result in inappropriate or insufficient adaptation causing individuals and communities to be relatively more vulnerable because of failure to take actions or measures

[2] As will be noted an individual who has less than full information and/or who has processed the information available with a biased result will likely make suboptimal choices. Thus, lack of access to full information and/or biased processing results in irrational expectations, underinvestment in capacity and adaptive capacity deficits which in turn contributes to a vulnerable individual.

that would have mitigated some of the negative impacts. Thus, underestimation of risk may contribute to underinvestment in adaptive capacity and increased vulnerability[3].

Processes of adaptation and investment in adaptive capacity itself are controlled by institutional and organizational factors that determine how assets (or stocks of capital) are generated and used to produce various outcomes. Adaptation and investment in adaptive capacity can be enhanced or constrained by institutions (Adger and Kelley 1999). Therefore, a potentially important contributing factor for climate change vulnerability assessments of forest-based communities is the identification of weak, inefficient and/or out of date institutions (Adger and Kelly 1999). Institutions constitute the set of rules, customs, norms and standards that guide economic, social and political choice and behavior. They define property rights and responsibilities, and guide or bound decisions by individuals, households, firms, government agencies, land-owners and organizations. In a climate change context, institutions provide the incentives, rules, mechanisms, tools and means that will motivate and direct adaptation and investment in adaptive capacity. Institutions that are effective and efficient, and entitle individuals and groups to resources needed for adaptation, will contribute to the adaptive capacity. Conversely, institutions that do not optimally and efficiently provide individuals and groups with access to resources necessary for adaptation, and/or that do not provide sufficient autonomy to adapt in ways that are best suited to their particular requirements will constrain or reduce adaptive capacity (possibly at levels that are socially sub optimal).

Applying the community capacity construct in a vulnerability assessment context requires the assumption that community capacity approximates adaptive capacity. This is not unreasonable given that much of the writings of social scientists on community capacity is largely an extension of the factors identified in the general model of adaptive capacity. Moreover, the most recent IPCC FAR construct of adaptive capacity moves in the direction of the community capacity construct.

In general, the community capacity approach is more theory based than the general approach. The supporting theory for factors such as social capital and risk perception is relatively well established. The community capacity approach provides more structure and goes into more detail about the formation, use, and depreciation of the various determinants that contribute to capacity. It also directly refers to processes affecting the formation and utilization of adaptive capacity resources. The community capacity approach gives an enhanced understanding of adaptive capacity from the point of view of social processes and systems. As was the case with the general approach, there are some limiting aspects of the community capacity approach and these limitations are similar. First, although there is theory to support the ways that individual determinants contribute to capacity, there is a lack of a commonly agreed-to overarching theory about the correct mix of determinants. The result is multiple competing viewpoints, perspectives, and approaches. Another limiting aspect of the community capacity approach is that it is not behavioural in orientation. It does consider how investment in overall adaptive capacity contributes to agent objective functions, it does not consider relative prices and the optimal mix of determinants, and it does not consider budget constraints. Similar to the general approach, the community capacity approach is a bottom up approach and there is no criterion for determining

[3] As will be noted in a later portion of the paper underestimation of risk contributes to adaptive capacity deficits.

adequacy of current adaptive capacity in a particular human system. The analysis of adequacy is usually based on comparing the adaptive capacity of one system against another. Comparative assessments between systems are predicated on the assumption that communities with higher adaptive capacity are better off than communities with lower adaptive capacity. But this is not necessarily true because as will be shown in the next section there may be economically rational and socially justifiable reasons why human system A has invested less in adaptive capacity than human system B. A top-down approach is needed that integrates the general and community capacity approaches into a framework for determining where and why there is socially sub-optimal investment in adaptive capacity in particular human systems. Socially sub-optimal investment in adaptive capacity would result in adaptive capacity deficits and it is the existence of such deficits that contributes to vulnerability - not relative differences in adaptive capacity.

Adaptive capacity deficits

Viewed in an economics general equilibrium context adaptive capacity can be regarded as a service that is produced and consumed along with other goods and services that consumers demand. Consumers (e.g., individuals and households) demand adaptive capacity because it contributes in some ways to utility. Producers (who are in some cases also the consumer) create or supply adaptive capacity. Within a framework of general equilibrium, producers and consumers jointly determine the welfare maximizing levels of all goods and services (including adaptive capacity). Welfare is maximized where marginal benefit equals marginal cost for all goods and services and markets clear (i.e., supply equals demand). Therefore, assuming efficient markets and institutions and assuming rational and well-informed producers and consumers, then levels of adaptive capacity that are expressed in households, communities, and regions will be socially optimal.

One result of this perspective is that socio-economic systems may vary in the equilibrium levels of adaptive capacity that they possess and in the amounts and configuration of inputs that contribute to adaptive capacity. This is neither good nor bad. Nor does it necessarily imply higher or lower vulnerability. Differences in levels of adaptive capacity and the component parts of adaptive capacity can occur because of differences in what is socially optimal. Differences in what is socially optimal in turn might occur because of differences in requirements (or utility), differences in costs to consumers of obtaining or creating adaptive capacity (i.e., potentially differences in the cost of specific determinants), differences in income (i.e., budget constraints), and differences in the prices of other goods and services. This then begs the question of whether or not a relatively low level of adaptive capacity and/or differences in determinants compared to some other system support the conclusion that the system with lower adaptive capacity is more vulnerable. Differences between nations and across individuals and societies within a nation will occur but such differences do not necessarily infer differences in vulnerability. A better approach for identifying vulnerable systems is to evaluate whether a particular socio-economic system's capacity to adapt (to current and expected future change) is socially sub optimal resulting in an adaptive capacity deficit (i.e., marginal benefit of adaptive capacity ≠ marginal cost of adaptive capacity). The logical follow up question then is to determine where there is underinvestment (i.e., what determinant is affected) and why there is underinvestment.

Adaptive capacity deficits occur as a result of social, political, institutional, and economic factors that impair the ability of the socioeconomic system and/or individuals within the system to optimally invest in a determinant or a collection of determinants that contribute to adaptive capacity. Adaptive capacity deficits arise from an imbalance between the socially optimal supply of, and socially determined demand for adaptive capacity (Figure 1). The existence of an adaptive capacity deficit should be the criteria for vulnerability analysis. However, knowing that an adaptive capacity deficit exists is only partly helpful relative to vulnerability assessment. It is also important to identify what determinant is lacking (this is where the general and community constructs fit) and also what the barriers or impairments are that are contributing to low investment.

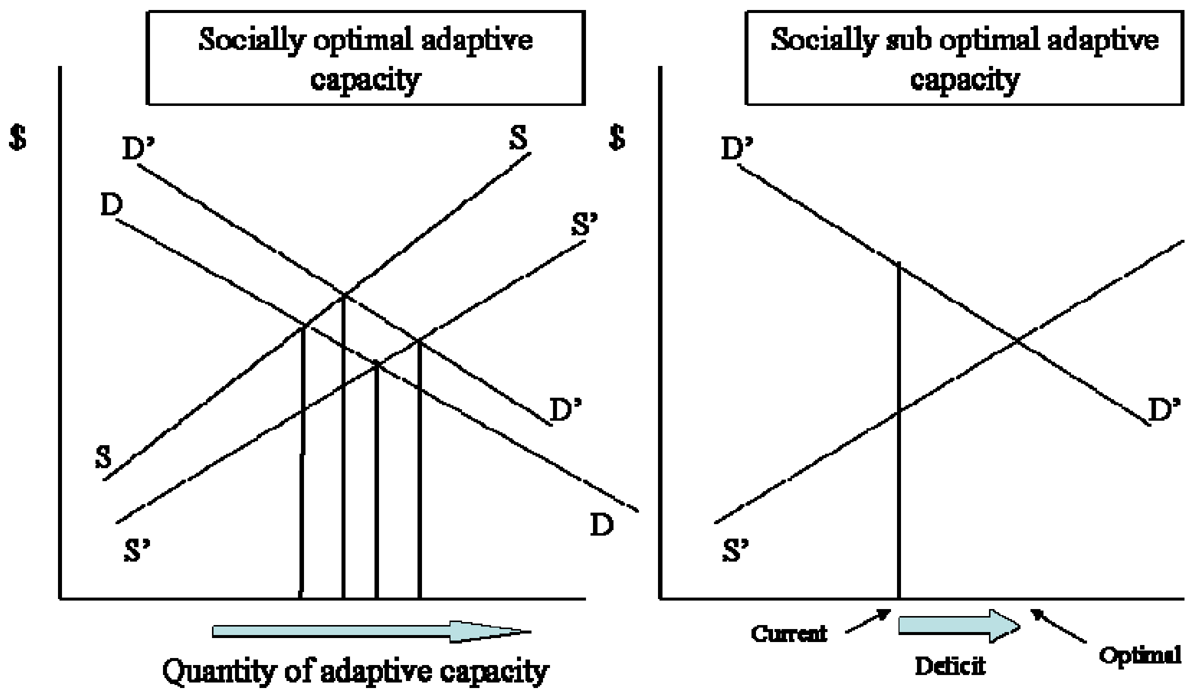

Figure 1. The case where adaptive capacity is optimal and unique and the case of an adaptive capacity deficit.

A possible methodology for identifying and interpreting adaptive capacity deficits in the context of vulnerability analysis would include the following steps. First, there is a need to assess aggregate adaptive capacity levels. Second there is a need to determine if an adaptive capacity deficit exists. Third, if an adaptive capacity deficit is identified, there is a need to determine where there is socially sub-optimal investment in a determinant(s) and why there is sub-optimal investment. This methodology is developed and illustrated in Williamson et al. (2008).

The first step is to evaluate current levels of aggregate adaptive capacity. On the supply side, adaptive capacity can be viewed as an output that results from combining factors of production (determinants) via some unknown production function. Viewed in this way, measures of adaptive capacity could hypothetically be constructed in three ways. One hypothetical approach is to consider the inputs (or determinants of adaptive capacity) and incorporate them into some production function and then derive adaptive capacity output. From a practical standpoint this approach suffers from the fact that adaptive capacity production functions are local and path dependent and generally not known (Yohe and Tol 2002). A second hypothetical approach is to consider adaptive capacity in aggregate and directly measure it as an output. The problem with the output approach is that adaptive capacity is not tangible and therefore cannot be directly measured. A third and somewhat more practical approach is to estimate aggregate adaptive capacity through proxies. Proxy adaptive capacity indicators are outcomes that are measurable and correlated to adaptive capacity (i.e., they reflect the degree to which a system is stable, functioning, healthy, and resilient). Proxy indicators infer the amount of adaptive capacity of a human system. Systems with low adaptive capacity may be more prone to large swings in the economy and/or in the local population. A system with low adaptive capacity may also display certain characteristics including high unemployment (indicating labor markets are unable to clear), low per capita income, high poverty rates, low levels of community involvement, and/or a lack of strong social ties to one’s community. As previously noted, low adaptive capacity does not necessarily equate to having an adaptive capacity deficit nor is it necessarily directly indicative of relative vulnerability. A partial list of proxy indicators of current adaptive capacity could include percentage change in population between two periods, average current income and average change in income between periods, rates of unemployment, incidence of low-income families, etc.

As a way of illustrating the difference between adaptive capacity and adaptive capacity deficits, consider the hypothetical case of a community with a level of adaptive capacity that is considered to be low compared to another community. It may be low for any number of valid reasons. For example it may be low because of decisions made by the local population and local leaders to maximize income and output instead of increasing adaptive capacity. It may be low because of a perceived lack of a need for higher adaptive capacity. Climate change may increase the demand for adaptive capacity but there is no reason to conclude apriori that community members have not already taken these expected changes into account in terms of building local adaptive capacity. As climate impacts in the local area occur, residents and firms will adapt and this adaptation may include moving to another location. However, if there are rigidities that are beyond the control of an individual and that prevent or impair that individual from making the adaptation choices that are in his/her best interest, then an adaptive capacity deficit may exist.

Estimating aggregate adaptive capacity through proxy indicators is only the first step. Once the level of adaptive capacity is estimated or inferred from the proxies the second stage of analysis is to determine if there are system failures resulting in socially sub-optimal investment in adaptive capacity in a particular social context. Sub-optimal investment in adaptive capacity results in adaptive capacity deficits. The determination of adaptive capacity deficits fundamentally comes down to a determination of the effectiveness of institutions, markets, culture, rules, norms, standards, conventions, traditions, and regulations in ensuring that the socially optimal adaptive capacity requirements of a system are in reasonable balance with supply. If it can be shown that these are not in balance, then it might be inferred that deficits (or surpluses) exist. Some factors that might result in deficits include:

- The existence of government intervention (e.g. regulation) in places where competitive markets would be more effective in allocating resources and vice versa
- Governance system failure (e.g., inefficiencies in the provision of government services and/or under provision of public goods such as health, education, protection services, etc.)
- Market failures
- Inequitable and socially sub-optimal distributions of income (e.g., through the tax system or income support programs)
- Unclear and inefficient property rights structures
- Rigidities in labor, capital, or natural resource markets that impair investment or limit movement and that result in underutilized capacity
- Factors that reduce the ability of individuals and households to relocate
- Irrational expectations (i.e., misinformed perceptions of risk), and/or
- Political or policy failures (i.e. policies, programs, regulations, legislation, that are not in line with public needs and values).

If it is determined that there are adaptive capacity deficits, then a logical next step for adaptive capacity analysis is to move toward a systematic assessment of where and why there is under-investment in determinants, where investment would provide the highest social return (i.e. is the determinant constraining and does it have a high shadow price), and how to reconfigure governance systems or provide incentives for investment in key factors. Many of the determinants in the general and community capacity approaches could be selectively looked at in this phase.

There are three main reasons why adaptive capacity deficits may emerge. First, if future outcomes differ from what people are expecting them to be, then systematic under and/or over investment might occur and adaptive capacity deficits (or possibly surpluses) may emerge. Second, adaptive capacity deficits can occur as a result of market, institutional, and political system failure again resulting in sub-optimal investment in adaptive capacity. Third, climate change itself can have feedbacks on adaptive capacity. For example, natural capital is considered to be a determining factor of adaptive capacity within the community capacity model. However, climate change can increase or decrease natural capital. Therefore, climate change itself can contribute to adaptive capacity deficits and surpluses. If under a given climate scenario adaptive capacity deficits are increasing while exposure and sensitivity are trending up – then populations may be faced with emergent vulnerability risk. Assessing the potential for emerging adaptive capacity deficits and emergent vulnerability risk may be a more meaningful approach to vulnerability assessment than the current static mainstream approaches.

The approach and questions described above would also apply to a forward-looking analysis of emergent adaptive and behavioral capacity deficits. However, a forward-looking analysis would also have to consider how adaptive capacity requirements might be expected to change. Key questions are: Will the adaptive capacity requirements change and why? Will the socially optimal supply of adaptive capacity services keep pace and if not why? What adaptive capacity factors are particularly constraining?

Adaptive capacity of economic systems

The second area where a stronger focus on economics is needed in order to better inform current adaptive capacity constructs is in the area of understanding and explaining factors or features that influence or affect the adaptive capacity of economic systems (Williamson et al. 2007). The general and community capacity constructs of adaptive capacity say very little about the role that higher-level economic system properties such as economic diversity might play relative to affecting the adaptive capacity of the socioeconomic system. However, diversity (as well as other properties such as flexibility) is an important characteristic of adaptive systems (e.g. see Gunderson and Holling 2002). For example, individuals who reside in communities where the economy is dominated by a single industry and/or a single mill – will have less capacity to adapt than individuals who reside and work in communities or regions with more diverse economies – particularly in cases where the primary resources that support the industry (or mill) is climate sensitive (such as the forest industry). A lack of alternative employment options limits the ability of wage earners to adapt and adjust to economic shocks. Specialized labour skills associated with a particular industry may further reinforce this lack of employment mobility (Davidson et al. 2003). Another factor that may constrain employment mobility includes inability to liquidate fixed capital assets (e.g. personal homes) in affected communities. In some cases a long established dominant industry within a single industry resource-based town may have an aging workforce and older workers may have difficulty relocating to new industries in the new knowledge economy.

The general and community capacity constructs of adaptive capacity also say very little about scale as a determining factor of adaptive capacity. However, scale can have a large influence on the capacities of socio-economic systems – particularly given recent trends toward agglomeration of industrial capacity, globalization, urbanization, etc. Smaller communities likely have a lower ability to attract the resources necessary to generate socially optimal adaptive capacity. Thus, adaptive capacity deficits may be more likely to occur in smaller communities than in larger communities.

In the case of the supply and demand of private goods and services, open and competitive free market economies have a higher capacity to adapt to change than closed, heavily regulated, and centrally planned economies. Flexibility, stability, and clearly understood ground rules are important properties in adaptive socio-economic systems. Competition provides a strong incentive and motivation for adaptation and ensures that agents are innovative and adaptive. Competitive free market economic systems are adaptive in the sense of being responsive, flexible, and relatively stable (i.e., a relatively low level of government intervention, minimal regulation, and clear ground rules for transactions between economic agents facilitates stability). Moreover, decisions about resource use and allocation occur autonomously in response to market signals as opposed to relying on bureaucratic central planning, government ownership, regulation, and or tax policy.

As noted, adaptive capacity can be viewed as the output of a production process. The assessment of adaptive capacity through the measurement of individual determinants has limits. The factors that generate adaptive capacity are interrelated through some type of underlying (but unknown) production function. Some factors may be complementary and some may be substitutes. Some factors contributing to the production of adaptive capacity may be easily substituted and for others it may be difficult to substitute inputs. Moreover, each input to the generation of adaptive capacity (or determinant of adaptive capacity) will either be slack (i.e. the particular determinant is not constraining) or it will have a shadow price (i.e. the amount of the determinant available is limiting with respect to the amount of adaptive capacity produced). Yohe and Tol (2002) point out that it is useful and important to identify which inputs for specific adaptation measures are most limiting relative to the successful and efficient adaptation measures.

The technologies used by industries and firms can have important implications for adaptive capacity in resource-based areas. Adaptive capacity does not only depend on the availability of new technologies. It also depends on the ability to adapt with existing technologies. Technologies vary in terms of the degree to which firms are able to substitute inputs when prices or availability of inputs change in response to climate change. Climate change may also affect the price of outputs. The ability of firms to adapt to demand changes while remaining in business will depend on cost structure, corporate culture, science capacity, innovativeness, scale, reversibility of capital investment, and regulations. These additional factors are seldom mentioned in the general and community capacity constructs of adaptive capacity.

Firms are at the core of the economic system, because they purchase inputs, convert these inputs into products, and then market and distribute products to consumers. Firms operate within complex and rapidly changing economic milieus. At the firm level, adaptive capacity can be viewed as the ability of individual firms to respond (or adapt) to external forces and economic signals and remain in business. In the short term, business decisions are constrained by the fact that some inputs (such as a firm's capital stock) are fixed. The fixed nature of some inputs means that options for adaptation in the short run are limited. In the long term, all inputs (including capital) are variable and a different set of adaptation strategies might be possible. Thus, in assessing the adaptive capacity of firms, it is necessary to differentiate between short-run and long-run adaptation capacities. In the long-term, firms may respond to reduced prices and/or changes in resource costs and availability by shutting down and/or relocating, increasing plant size (assuming economies of scale exist), investing in new technologies, changing input proportions (i.e. substitution).

The differentiation between short run adaptive capacity (where some determinants are relatively fixed) and long run adaptive capacity (where all determinants are variable) may also be an extension worthy of further consideration. For example, in the short run factors and properties that affect adaptive capacity such as diversity, size, remoteness, natural capital, and isolation are relatively fixed. Other factors such as human capital, social capital, political capital, cultural capital etc might be considered as variable in the sense that individuals (and communities) have an opportunity to change the levels of these determinants in the short run.

Factor mobility is an important property of adaptive economies. The mobility of capital is a function of how well capital markets work. Labour mobility is a function of skills and portability of skills. The ability to change and modify land use is a function of the ratio of public to private ownership, and land use policies and regulations. Rigidities in factor markets can result in adaptive capacity deficits.

Summary and conclusions

In summary, economics provides structure and an integrating framework for adaptive capacity analysis. It provides a top-down approach to assessment that provides for more direct and less ambiguous interpretation and analysis. Subjective assessments of adaptive capacity as being low or high may not adequately inform vulnerability analysis. Moreover, the bottom-up general and community capacity approaches often produce ambiguous results. The assessment of current and/or potential future adaptive capacity deficits removes some of the vagueness and arbitrariness. The adaptive capacity deficit approach does require, however, the imposition of a more structured approach and it is more complex and less intuitive relative to the general and community capacity approaches. A second improvement from economics would be to introduce properties such as scale, economic diversity, remoteness, isolation, fixed, and variable factors into methods and approaches for assessment of adaptive capacity. A third improvement is to explicitly assess the relative degree to which local economies are market based, mixed, and/or centrally planned. Market based systems tend to have the highest capacity to adapt with respect to the allocation of private goods and services. There may, however, also be social costs and externalities associated with markets. And so, the efficiency and effectiveness of institutions in adapting to impacts on non-private goods and services is an important factor. Fourth, the economics approach leads to recognition that inputs that contribute to adaptive capacity are functionally interrelated. Some are substitutes (more of one may require less of another) and some are complements (more of one requires more of another). Moreover, some inputs may be more constraining than other inputs. Efforts to increase adaptive capacity (in cases where a deficit is identified) will be most efficient and effective if they focus on those inputs that are particularly constraining rather than making attempts to increase the levels of all determinants simultaneously (Yohe and Tol 2002). Finally, there is a fundamental distinction in economics between short run and long run analysis. In the short run some inputs to a production process are fixed (e.g., capital). In the long run, all inputs are variable. This distinction gives further definition to the concept of adaptive capacity in the form of distinguishing between short run adaptive capacity and long run adaptive capacity.

The suggested approaches introduced in this paper can be used to assess current adaptive capacity deficits as well as the potential for future emergent adaptive capacity deficits. Analysis of the potential for future adaptive capacity deficits requires an assessment of change in requirements and the ability of the socio-economic system to anticipate and meet the new demands. Climate change has a number of potential implications for adaptive capacity requirements of human systems in forest areas. Moreover, broader socio-economic trends such as globalization, urbanization, and the new knowledge economy also have important implications for the adaptive capacity requirements of residents of rural areas. It can be speculated that the combined effects will be that adaptive capacity requirements of rural areas will go up. At the same time climate change (as well as the previously mentioned trends) may be contributing to a downward trend in the supply of adaptive capacity services. For example, climate change may reduce the asset value of natural capital in some locations. Urbanization and globalization may result in increased outmigration of youth and highly skilled individuals and increasing difficulty in the ability to attract skilled professionals (e.g., doctors, scientists, engineers, etc). into rural areas. These are, however, questions that remain to be tested and answered.

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Chapter 5
Adaptive capacity deficits of human populations in the Canadian boreal plains ecozone: assessment and issues

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Introduction

This chapter evaluates whether or not there may be adaptive capacity deficits in the resident population in rural areas and in organized communities in the boreal plains ecozone in west central Canada. The population and local economies of northern rural forested areas such as the boreal plains ecozone and communities in these areas may be exposed to higher magnitudes of climate change impacts than other types of communities (Williamson et al. 2007). The potential for higher impacts does not automatically mean higher vulnerability. As noted in numerous manuscripts, vulnerability is determined by both the potential for impacts and by adaptive capacity. Chapter four, however, suggests there is a need to extend the concept of static adaptive capacity to consider adaptive capacity deficits (current and emergent). The occurrence of adaptive capacity deficits happens when there are failures in the ability of a local system to optimally match adaptive capacity requirements with availability. Therefore, if it can be shown that there is currently an adaptive capacity deficit, or if there is a high potential for emerging adaptive capacity deficits of households in geographic areas such as the boreal plains ecozones, then the population in these areas is prone to being more vulnerable than households in other social contexts that are not faced with capacity deficits. If on the other hand, there is no current deficit and there is no potential for adaptive capacity deficits to emerge (i.e., systems will anticipate higher impacts and will enhance adaptive capacity accordingly) then (assuming similar potential impacts) the vulnerability of these households is equal to households in other settings and therefore they may not be any more vulnerable than other types of human systems (even in cases where the stock of adaptive capacity assets is relatively low).

This paper has two main objectives. The first objective is to illustrate and test the concept of adaptive capacity deficits proposed in Chapter four. The second objective is to determine if adaptive capacity deficits exist, and/or if there is the potential for adaptive capacity deficits to emerge in human systems within the boreal plains ecozone in central Canada. If deficits exist or if there is the potential that deficits will emerge in the future, then this will be a source of vulnerability of human systems in the boreal plains.

A methodology for assessing adaptive capacity deficits

Current mainstream approaches for adaptive capacity assessment can be roughly grouped into two broad categories: general approaches and community capacity approaches. These two bottom-up assessment approaches are determinant based and they generally lead to conclusions that adaptive capacity is either high or low or that particular determinants are either high or low.

Moreover, human systems with relative low adaptive capacity are generally viewed as being relatively more vulnerable. However, differences in levels of adaptive capacity between individuals and between systems might be rational and justified and these differences do not necessarily mean that there are differences in vulnerability. A complementary approach may be to consider whether there are current or potential future adaptive capacity deficits (i.e., a disequilibria between the socially optimal amount supplied versus the amount being demanded). Adaptive capacity deficits could occur as a result of social, political, institutional, and economic factors that are somehow impairing the ability of the social system to optimally invest in adaptive capacity.

This paper illustrates and tests the approach proposed in Chapter four. The approach integrates concepts from the two current mainstream approaches within an economic framework. The objective is to determine if there is an imbalance between socially optimal supply and demand of adaptive capacity. If there is a socially sub-optimal supply of adaptive capacity then an adaptive capacity deficit results and it is the existence of the adaptive capacity deficit that leads to a system being vulnerable. The new framework is proposed as a complementary framework to the general and community capacity approaches.

A stepwise methodology for assessing adaptive capacity deficits is proposed. The methodology is summarized as follows.

Step 1: Evaluate aggregate adaptive capacity using proxy measures (as opposed to the determinant based approach as is the suggested in the IPCC Third and Fourth Assessment reports – e.g., see Smit and Pilifosova [2001] and Adger et al. [2007]). It is not possible to directly measure adaptive capacity. It may, however, be possible to infer levels of adaptive capacity using proxies (or combinations of proxies). Proxies are measures that are likely highly correlated with a regions adaptive capacity. All systems are subject to social, economic, and environmental change. Capacity to adapt should be correlated to social and economic outcome measures such as per capita income, stability of income, incidences of poverty, and rates of unemployment for the system. However, a relatively low adaptive capacity does not necessarily mean that the system is vulnerable. The base assumption for vulnerability assessment is that the supply of adaptive capacity (for individuals or in any particular human system) is in balance with demand and that there are no adaptive capacity deficits. A partial list of proxy indicators of current adaptive capacity could include % change in population between two periods, average current income, average change in income between the same two periods, incidence of low-income families, and rates of unemployment. The rationale for selection of these indicators is that communities are continually dealing with change and there should be a correlation between a systems adaptive capacity and socio-economic conditions, changes in conditions over time, and levels of under employment of productive assets.

Step 2: Assess the existence of, or potential for, adaptive capacity deficits. Adaptive capacity deficits can be characterized as a shortage of socially optimal[4] amounts of adaptive capacity resources relative to demand. Adaptive capacity deficits result from system failures in providing the socially optimal levels of adaptive capacity and/or from increased demand for adaptive

[4] Socially optimal is where the marginal benefit of the last unit of a good or service provided is equal to its marginal cost.

capacity and system failures in responding to the increased demand. The assessment should include a review of the economic structure of the system including an assessment of the degree to which competitive markets functioning efficiently and whether markets are playing a sufficient or insufficient role in allocating resources under conditions of change (i.e., is there too much or too little reliance on private sector markets in allocation of resources). Are there rigidities and/or inefficiencies in labor, capital, or natural resource markets that skew investment or limit movement of productive assets? A second requirement is to look at the governance system. Is there too much or too little government intervention? Are regulations and institutions efficient, flexible, and responsive to change? Is there strong, dedicated, and effective local leadership? Are incentives structured so as to provide for socially optimal investment in determinants of adaptive capacity? Are government agencies efficient? Is decision making democratic? Are decisions fair, just, and equitable? Are entitlements fairly and efficiently distributed? Are property rights correctly configured or are there perverse incentives relative to adaptive capacity services? A third requirement is to consider whether individual agents are rational, well informed and empowered to adapt. Questions might include: Does the public have sufficient information upon which to base decisions and are risks correctly perceived? Are the choices and decisions of agents rational relative to current and expected future risks? Are there social, economic, and cultural factors that reduce the ability of individuals and households to relocate when it is in their best interests to do so (i.e., individuals and households are better off in terms of income and/or well being as a result of relocation)?

Step 3: If it is determined that there are system failures leading to sub-optimal investment in adaptive capacity, then the next phase is to evaluate key determinants to identify where there may be insufficiencies, why there are insufficiencies, where investment would result in the highest social return, and/or what changes may be required in governance systems, institutions, and development strategies. There are a number of determinants and characteristics of systems that may contribute to low adaptive capacity (but not necessarily adaptive capacity deficits). Many of these are in the general and community capacity approaches noted earlier. In many cases, there are fixed characteristics of a particular system that contribute to low adaptive capacity but that are difficult to change in the short term. These include population size (i.e., smaller communities may have lower adaptive capacity), low economic diversity, remoteness, and isolation. In other cases, however, it may be that the barriers noted in stage two are resulting in socially sub-optimal investment in particular variable inputs to adaptive capacity. Understanding which inputs or determinants are adversely affected and where investment to increase a particular determinant would have the highest social return may be of use in addressing adaptive capacity deficits. Some of the higher-level groupings include human capital, social capital, political capital, cultural capital, natural capital, knowledge and information, income, income distribution, and infrastructure.

The method described above can also be used to assess the potential for future (or emergent) adaptive capacity deficits. Analysis of the potential for future adaptive capacity deficits requires an assessment of expected change in adaptive capacity requirements and the ability of the system to anticipate and optimally invest in adaptive capacity.

The boreal plains ecozone

The boreal plains ecozone stretches from the southeast corner of the province of Manitoba, Canada to the northwest corner of the province of Alberta (Figure 1). The region is largely forested. It is bounded on the south by aspen parkland forest and prairie and on its northern boundary by the boreal shield. There are a number of large forestry companies operating within the boreal plains ecozone, many of which operate under large area based leases (Figure 1).

The boreal plains ecozone is rural in nature. There are approximately 460 Statistics Canada census sub-divisions (CSDs) with populations less than 10,000 persons. Approximately 50 CSDs have populations of greater than 10,000.

There are two main categories of municipalities in the boreal plains ecozone. Unorganized and unincorporated municipalities are large areas with dispersed populations such as improvement districts and rural municipalities. We refer to these types of municipalities as rural areas. Towns and villages are more conventional communities with relatively concentrated populations. We refer to these types of municipalities as organized communities.

Determination of adaptive capacity deficits in rural areas

Adaptive capacity proxies

As noted, proxies of adaptive capacity are measures that are expected to be correlated with adaptive capacity. All systems are subject to social, economic, and environmental change. Capacity to adapt should be correlated to social and economic outcome measures such as per capita income, stability of income, incidences of poverty, and rates of unemployment for the system. A high rate of population change may be both a positive or negative indicator of adaptive capacity. On the positive side, a high rate of population change indicates mobility. On the negative side, a high rate of population change may be indicative of poor socioeconomic conditions locally resulting from generally low adaptive capacity. One way to consider whether population change is a positive or negative indicator of adaptive capacity is to consider the net socio-economic effects after migration has occurred. If migration results in an improvement in the overall economic situation and well-being of those that move (and of the two systems affected) then population change is a positive proxy measure of adaptive capacity. If, on the other hand, migration does not lead to net improvements in the systems affected (i.e., the system that is gaining new population and the system that is losing population) and to net improvements in the individuals that are relocating, then population change may be a negative proxy measure of adaptive capacity.

The selected proxies for assessing adaptive capacity in rural areas in the boreal plains are as follows[5].

- Average family income in 2001 (Figure 2)
- Incidence of low-income families in 2001 (%) (Figure 3)
- Full time employment change between 1996 and 2001 (%) (Figure 4)
- Unemployment rate in 2001 (%) (Figure 5)
- Population change between 1996 and 2001 (%) (Figure 6)

[5] The maps presented in the section are selected from Wittrock, V. 2008. Using the Community Information Database to determine community adaptive capacity. Saskatchewan Research Council. Publicaation No. 12306-1E08. Saskatoon, Saskatchewan – See Appendix ??

- Average family income change between 1996 and 2001 (%) (Figure 7)

Proxies for adaptive capacity of rural areas in the boreal plains are shown using maps. The information used to generate the maps is obtained from the Government of Canada/Rural Secretariat's Community Information Database (CID) (http://www.cid-bdc.ca/). The approach for generating adaptive capacity proxy maps was to overlay the boreal plains ecozone boundary on spatially represented data for specific indicators from the CID. A series of new maps (Figures 2 to 7) were created.

Figures 2 to 7 show that there are differences in adaptive capacity in rural areas across the boreal plains. Average family income in urban areas in the Prairie Provinces provides a benchmark for comparison purposes. The average family income in urban areas in the Prairie Provinces was about $ 66,400 in 2001 (Table 1). Figure 2 shows that average family income is low in south central Manitoba and in pockets along the southern border of the boreal plains ecozone in Saskatchewan and Alberta. This is a potential concern because it is along the southern border of the boreal plains ecozone that many of the more significant climate change impacts are expected to occur (e.g., increased drought, shifts in land use, etc.). Average family income is moderately low ($40,000 to $60,000) through much of portions of Saskatchewan and Manitoba in the boreal plains and in the north central portions of Alberta. Average family income along the Alberta east slopes and in the Fort McMurray area of northeastern Alberta is equal to or higher than average family income in urban centers.

Table 1. Adaptive capacity proxies for urban centres in the prairie provinces (2001)	
Average family income ($)	66411
Incidence of low-income families (%)	10.44
Population change (1996 – 2001) (%)	8.97
Unemployment rate (%)	5.26

The incidence of low-income families in urban centers in the Prairie Provinces is around 10%. The incidence of low-income families in rural areas in the boreal plains is generally higher throughout Manitoba, and in northern areas of Saskatchewan and Alberta (Figure 3). A relatively high incidence of low-income families indicates low adaptive capacity of social and economic systems. It also indicates a relatively high proportion of households in these areas with low adaptive capacity.

Figure 4 shows that full time employment decreased in a number of rural areas along the southern boundary of the boreal plains ecozone in Manitoba, through much of the northern portions of the boreal plains in Saskatchewan, and in the Peace River agricultural zone in north central Alberta. In an adaptive economy, a decrease in full time employment would be accompanied by a decrease in the labour force and it would not be associated with a significant increase in unemployment rates.

Table 1 shows that the unemployment rate in urban centers in 2001 was about 5.26 % in 2001. Figure 5 shows that the unemployment rate in rural areas is well above urban unemployment rates in northern portions of the boreal plains in Saskatchewan and Manitoba. A high rate of unemployment suggests that people are looking for jobs but not finding them. It may also imply that there are rigidities in the local labor markets that are preventing these markets from clearing. A persistently high rate of unemployment indicates low adaptive capacity of the economic system[6].

The average population change in urban centers on the Prairie Provinces between 1996 and 2001 was 8.97 %. Figure 6 shows that the population declined in the majority of rural areas of the boreal plains ecozone in Manitoba and Saskatchewan and increased in the majority of rural areas in Alberta. Population migration in this case is likely an indication of positive adaptive capacity. Economic activity is strongest in Alberta (due to oil and gas sector activity) and economic opportunity may be more plentiful in urban areas than in rural areas. Therefore, one would expect migration to occur. The fact that it does seem to be occurring is a positive signal. A combination of large economic disparities and low migration would indicate low adaptive capacity.

Average family income change was relatively uniform across rural areas of the boreal plains ecozone between 1996 and 2001 (Figure 7). Average family income increased across the majority of the region over the period. A few rural areas along the southern boundary of the boreal plains exhibited decreases in average family income. However, overall, the picture is one of relative stability and uniformity. This suggests a relatively high degree of adaptive capacity of the economy and of households in the boreal plains. The main hot spot (or area of low adaptive capacity) appears to be along the southern border of the boreal plain in Manitoba and Saskatchewan. This is an area that is likely to see the most dramatic changes from future climate change. Given significant increases in adaptive capacity requirements in this area - low adaptive capacity may be an indication of adaptive capacity deficits in these areas. These areas may, therefore, be vulnerable.

The analysis presented above suggests that adaptive capacity in rural areas is lower than adaptive capacity in urban centers in the Prairie Provinces. Moreover, adaptive capacity varies across rural areas. It is generally lower in northern rural areas and in rural areas in Saskatchewan and Manitoba. Adaptive capacity appears to be highest in Alberta. However, as noted, a difference in adaptive capacity between systems does not mean that one region is more or less vulnerable to climate change. The current level of adaptive capacity within a particular area may be the right level of adaptive capacity for that area. It may be that the costs of increasing adaptive capacity to a level that equals that of other areas are prohibitive. Or it may be that the local population has weighed the benefits and costs of current and future adaptive capacity requirements and they are satisfied with current levels (i.e., there is no excess demand).

Adaptive capacity deficits in rural areas
One indication of the presence of adaptive capacity deficits is if there is underemployment of resources. For example, persistently high levels of unemployment are indicative of adaptive capacity deficits in that labor markets are failing to clear. Figure 5 shows that northern portions of the boreal plains ecozone in Saskatchewan and Manitoba do have high rates of unemployment. Other than this measure, however, and without further evidence, there is no

[6] The unemployment rate presented here is a spot measure that shows the level of unemployment at the time the census was conducted. It does not, therefore, indicate the degree to which unemployment rates in the regions shown in table 1 are chronic.

reason to conclude that adaptive capacity deficits are currently prominent in rural areas in the boreal plains ecozone. There is no explicit evidence of market, governance, or social system failures or impediments that preclude optimal investment in adaptive capacity.

The absence of current adaptive capacity deficits does not preclude the possibility that deficits could emerge as a result of events associated with climate change combined with broader socioeconomic changes. Climate change is expected to be significant in the boreal plains ecozone. There will be ecosystem boundary shifts, changes in water levels, increases in extreme weather, and increased forest disturbances. There will be impacts on resource-based industries and on cultural activities. These changes will occur at the same time as other trends such as urbanization, globalization, and emergence of the new knowledge economy are increasing the requirements for adaptive capacity (Keskitalo 2008). Moreover, the Aboriginal population in the boreal plains ecozone is expected to be one of the fastest growing demographics in all of Canada. Thus, both climatic and non-climatic factors will contribute to an increased demand for adaptive capacity services. In theory, the marginal benefit of adaptive capacity will increase. If individuals and institutions and governance systems are efficient and if decision makers are rational then people will either relocate or increase the supply of adaptive capacity until marginal cost equals marginal benefit. If, however, people are not able to move or if institutions, norms, standards, traditions, and governance systems impair the optimal investment in adaptive capacity then adaptive capacity deficits will emerge. Moreover, given chronic nature and ever increasing rate of climate change, adaptive capacity deficits may potentially become larger over time. For example, climate change impacts are expected to vary from place to place. There may, therefore, be a need for local autonomy in decisions about resource use and management. This would contribute to an increase in local adaptive capacity. However, a trend toward more centralized institutions may actually limit the amount of autonomy, control, and power that local decisions makers have. Climate change can also have feedbacks in terms of potentially reducing an area's ability to supply an appropriate level of adaptive capacity services. For example if an area's natural capital is depleted as a result of climate change, the resources it has available for adaptation may decrease. Thus, rural areas in the boreal plains may be more prone to the future development of adaptive capacity deficits than larger urban centres.

Analysis of determinants in rural areas

As noted, there is no basis for drawing conclusions one way or the other about whether significant adaptive capacity deficits currently exist in rural areas in the boreal plains ecozone. A significant portion of the economy of rural areas in the boreal plains is resource based (agriculture, forestry, mining, energy) (Figure 8). The population is small and the economy has low diversity. Many areas are isolated and resident may have reduced mobility compared to members of larger centres. These are, however, fixed determinants of adaptive capacity that are difficult to change or modify in the short term.

There are also a number of variable determinants of adaptive capacity. Average family income in rural areas in the boreal plains was, on average, lower than in urban centres in 2001. Social capital, on the other hand, tends to be high in rural areas (see Table 2). People look out for each other, they help each other, and they generally trust each other. Indicators of human capital include the percent of the population with trade certificates and the percent of the population with university degrees. The percent of the population with trade certifications and university degrees in urban centres in the Prairie Provinces are 34 % and 13 % respectively. Figures 9 and 10 show that the percent of the population in rural areas with trade certificates is 11-20 % in much of Alberta and 0 – 10 % in large portions of Saskatchewan and Manitoba. The percent of the population with a university degree was in the 0 – 10 % range through most of the boreal plains ecozone. So it would appear that human capital indicators are generally lower in rural areas. However, it may be that high levels of education are not necessary in rural areas in the boreal plains.

Determination of adaptive capacity deficits in two case study communities

There are a large number of organized communities in the boreal plains ecozone. In many ways, each is unique. At the same time there are many similarities in terms of issues that pertain to adaptive capacity. This section evaluates current and potential future adaptive capacity deficits in two case study communities (La Ronge, Saskatchewan and Victoria Beach, Manitoba). The case study approach provides a way of assessing factors that may contribute to adaptive capacity deficits in other organized rural communities located in forested regions.

La Ronge, Saskatchewan

La Ronge is located approximately 240 km north of Prince Albert (345 km north of Saskatoon) in north central Saskatchewan (Figure 11[7]). According to the Statistics Canada Census of 2001 the town of La Ronge had a population of 2727 persons in 2001. However, this does not include the populations of two adjacent communities (The Lac La Ronge Indian Band, and the village of Air Ronge). The total population of the greater La Ronge area is around 6000 persons. A significant portion of the population in this area is Aboriginal.

La Ronge is a northern resource-based community, and also an administrative, government, services (e.g., retail, financial, professional, etc), educational, and health services center for northern Saskatchewan with government offices, a college, and a health centre located in the town. There is a significant export based wild rice producing industry associated with the town's economy. The community is the main service center for northern Saskatchewan with important links to resource industries such as mining and forestry (although forestry is not a significant industry in La Ronge). The community is situated on the shores of a large Canadian shield lake (Lac La Ronge). Tourism, outdoor-recreation based activities, and income injections from cottage owners also contribute to the local economy.

Adaptive capacity proxies

Proxies for adaptive capacity for the town of La Ronge are based on graphs that relate the value of adaptive capacity proxies for La Ronge compared to other non-urban Census Sub Divisions (CSDs) in Saskatchewan in 2001. Figures 12 to 15 show average family income, family poverty rate, the unemployment rate, and population change (1996 to 2001)[8]. Figure 12 shows that average family income in La Ronge is somewhat higher than the mean of average family income for other non-urban CSDs in Saskatchewan but lower than average family income in cities in the

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[7] Note this figure represents a 200 km × 200 km study area with La Ronge at the centre

[8] The middle dashed line in Figures 12 to 19 is the mean for all CSDs. The two outside lines are one standard deviation from the mean. In cases where the figure has an "L" this shows the position of La Ronge relative to other CSDs.

prairie-provinces[9] ($66,400). Figures 13 and 14 show that the family poverty rate and unemployment rate for La Ronge are higher than the mean for other rural CSDs and compared to cities (family poverty rate in cities was 10% and unemployment rate in cities was 5.2%). Negative population change in La Ronge is relatively high compared to other rural CSDs (Figure 15) and compared to cities in the prairie provinces (where population actually increased by 9% between 1996 and 2001). As noted previously, negative population change may actually be a positive indicator of adaptive capacity. These proxy indicators suggest that the La Ronge population has low to moderate adaptive capacity.

Adaptive capacity deficits
As noted in the methodology section, adaptive capacity deficits result from system failures in providing the socially optimal levels of adaptive capacity and/or from actual or expected increased demand for adaptive capacity and system failures in responding to, or in anticipating the increased demand. There are three key questions the answers to which would address the question of potential adaptive capacity deficits for La Ronge. First, is the local economy efficient and free from rigidities? Second, is the governance and social system efficient and does it provide optimal levels of and/or the correct incentive structure for socially optimal investment in adaptive capacity? Third, is there a possibility of emergent adaptive capacity deficits?

The first question pertains to potential impediments in the local economic system that might result in sub-optimal investment in adaptive capacity. The provincial and federal governments provide significant amounts of economic development funding into northern Saskatchewan. A question that could be asked is: Do these government programs skew investments and result in investment in uneconomic enterprises or is the funding provided to enterprises that are economically viable and that become self sustaining? There are likely examples of both. A significant level of intervention in economic development and in propping up uneconomic business enterprises reduces the adaptive capacity of both the local economy and the provincial economy. At the same time, well placed public investments (justified on the basis of economic efficiency or for distributional reasons) can result in the establishment of successful business enterprises that become economically sustainable. A useful approach for evaluating the adaptive capacity of the economic system is to consider financial performance indicators. Unfortunately there is a general lack of information about and/or previous analysis of financial performance measures for business enterprises in the town of La Ronge. An old study by Decter and Kowall (1993) suggested that businesses that are part of the Kitsaki Development Corporation (owned by the Lac La Ronge Indian Band and based in La Ronge) were profitable and that the company was a success story with respect to First Nations business development. The current Kitsaki Management Limited Partnership continues to be an economically strong and well managed business enterprise. However, in the absence of more specific information about the financial performance of the La Ronge economy, an alternative approach is to compare measures of financial performance for the overall Saskatchewan economy. Figure 16 provides indices that compare corporate profitability of firms in the national economy with corporate profitability of firms in Saskatchewan over the period 1962 to 2007. The rationale is that if the level and nature of intervention in the Saskatchewan economy is supporting uneconomic enterprises to a higher degree than in the overall Canadian economy – then this should be reflected in lower corporate profits. Figure 16 shows that in fact corporate profitability in Saskatchewan matches corporate

[9] Prairie-provinces include the provinces of Manitoba, Saskatchewan, and Alberta.

profitability at the national level over this period. Thus, the degree of public intervention in the Saskatchewan economy does not seem create adaptive capacity deficits – at least relative to the overall national economy.

La Ronge is considered to be the capital of northern Saskatchewan. There is a large government presence in the form of government offices providing services to northern residents. The significant government presence provides a relatively stable source of income for La Ronge. A stable income source contributes to higher adaptive capacity and lower likelihood of an adaptive capacity deficit.

There is a high level of local ownership of economic activity in La Ronge. The Lac La Ronge Indian Band (through Kitsaki Management Limited Partnership) is a significant business owner in the area. There is also local ownership through co-operatives and credit unions. Co-operatives have a long-standing history in Saskatchewan and remain an important part of the provincial and local economies. The essence of the co-operative concept is to provide a mechanism that allows people to work together to contribute to well-being and address issues like depressions, droughts, and economic downturns in a collective way. Co-operatives and credit unions are businesses that are owned and operated by the local population. They are used to market products and to provide consumer needs for goods and services for local populations. If there is a drawback to the current ownership structure of the La Ronge business sector it is that it relies on collective decision-making processes (e.g., First Nations Band Councils and Cooperatives are based on the principle of collective decision making). Collective management has many benefits, but one drawback is that it may reduce flexibility and responsiveness. La Ronge has a very diverse economy (see Figure17) and the economy is not dependent on a single large mill or a single sector. In fact, the economy has a low dependence on the resource sector in general (Figure 18). Nonetheless, high unemployment suggests that there is some rigidity in the local labor market. This may be an indication of a small adaptive capacity deficit.

The second question pertains to effectiveness of governance systems and social systems relative to their ability to generate a socially optimal level of investment in adaptive capacity. There is strong, independent, entrepreneurial, and dedicated leadership in the Lac La Ronge Indian Band and in the town of La Ronge. Moreover, there is a high level of cooperation and integration between the communities. This is an indication of effective local administration and therefore, lack of direction in local government is likely not a contributing factor to adaptive capacity deficits. The residents of greater La Ronge exhibit pride in their community. There is cultural tolerance and significant cooperation although some class, race, and gender divisions do exist (Findlay et al. 2008). The government offices in La Ronge deliver a wide range of programs. There may be some overlap and lack of coordination in these programs (Findlay et al. 2008) suggesting some inefficiency in government program delivery. However, this is likely a minor factor relative to adaptive capacity deficits in La Ronge.

The third factor pertains to the potential for emergent adaptive capacity deficits. Adaptive capacity deficits could emerge if 1) agents[10] are not rational, 2) demand for adaptive capacity resources increases (or is expected to increase), and 3) there are system failures in responding to

[10] Agents include consumers, investors, business owners, land owners, workers, or generally anyone who makes economic decisions.

actual or expected increases in demand for adaptive capacity resources. If local community members and firms are fully informed about potential future impacts and they have rational expectations (i.e., perceptions of risk and future changes are in line with actual risk and outcomes) then there is lower likelihood of adaptive capacity deficits to emerge as a result of climate change. A survey conducted for La Ronge residents indicated that climate change is a significant concern for area residents. Despite this relatively high level of concern, there are no visible institutional or local government actions in terms of planning or preparing for climate change impacts in La Ronge. This may be partly due to limited information about climate change impacts in the La Ronge area. There has been limited scientific analysis of how climate change may impact La Ronge. One of the questions asked in the survey was: Are governments providing adequate information about climate change at local scales. Only 2% of respondents to the La Ronge risk survey rated the information on climate change provided by provincial and federal government agencies as very adequate and more than half (54.5%) of the respondents rated the information on climate change as not adequate at all or not very adequate. So a potential factor that may contribute to emergent adaptive capacity deficits is lack of systematic analysis and information about climate change in the La Ronge area. It may be, on the other hand that a lack of action to prepare for climate change and/or to build adaptive capacity resources in anticipation of climate change is fully rational. La Ronge is at the northern limit of the boreal plains ecozone. Forests and tree cover will likely remain. Some environmental impacts from climate change are expected (e.g., more forest fires, warmer winters, potential changes in water levels with impacts on wild rice industry - note higher water levels reduce wild rice production). But the local population may senses that these potential impacts are not expected to dramatically increase adaptive capacity requirements.

Climate change may result in occasional hazards from extreme weather or forest fires. However, as will be mentioned in a later section on social capital, the population feels strongly that the community would come together in times of crises. From a science perspective there is no evidence to suggest apriori that climate change itself requires significant new investment in adaptive capacity (i.e., there is nothing to suggest that the scale of future impacts will exceed the capacity of La Ronge to adapt). In terms of the potential for future adaptive capacity deficits, there may be other forces that could result in increased demand for adaptive capacity resources. Globalization and other socioeconomic trends will likely have more pronounced implications relative to increased demand for adaptive capacity in the La Ronge area than climate change. For example, a growing and changing global economy could create new economic development opportunities and stresses on the La Ronge economy. However, as noted in Figures 17 and 18 the local economy is very diverse and it is not heavily dependent on resource industries (and therefore there is relatively low exposure to global resource industry markets impacts). There will also be a need to provide employment opportunities for the expected increased Aboriginal population and this will require new capital investment and technological innovation. La Ronge is somewhat remote. Attracting significant outside capital and skilled technicians and professionals to the La Ronge area may be a challenge. Economic development in the past has benefited from government programs. An increased level of programs in response to increasing demands may or may not be available in the future. Assuming it is not then lack of capital and availability of specialized skills for new technologies and products may be limiting and this combined with an expected increase in the Aboriginal labour force may result in adaptive capacity deficits. Countering this is the local presence of high levels of human capital (Figures

19 and 20), the entrepreneurial spirit of the local population, and a spirit of cooperation and collaboration (as exemplified by the presence of cooperatives and as is entrenched in First Nations governance).

In summary, with respect to climate change there is some potential for emergent adaptive capacity deficits due to a lack of information about climate change at a scale that is relevant to La Ronge. It may be that this lack of information poses a barrier to preparing and planning for climate change. With respect to other factors, the ability to grow the La Ronge economy to accommodate the growing Aboriginal population will require new capital investment, technological innovation, and human capital development. A continuation of economic development programs may be required to assist in attracting capital investment into the remote La Ronge region. A continued focus on development of human capital is required in order that La Ronge can be a receptor of new technologies. A continued and expanded focus on education (at all levels) and skills development for the growing Aboriginal population will help to mitigate emerging adaptive capacity deficits. At the same time it is important to acknowledge that rapid social and economic change can have negative socioeconomic consequences. Maintaining family ties, strong social networks, and protecting and preserving culture, traditions, and heritage is vitally important.

Victoria Beach, Manitoba

Victoria Beach is located north of Winnipeg on the shores of Lake Winnipeg (Figure 21). Victoria Beach is a resort community. Its permanent resident population is around 250 but the population balloons significantly in the summer to a population of around 10,000. The dwellings in Victoria Beach are mainly comprised of summer cottages owned by people (mainly from Winnipeg) who travel to the community in the summer months.

Victoria Beach has a strong association with its surrounding climate sensitive environments. Victoria Beach for example is located within a climate-sensitive forest and alongside a climate sensitive aquatic ecosystem (i.e. Lake Winnipeg). Significant change in these ecosystems has the potential for significant local impacts. This section discusses the adaptive capacity deficits in the context of Victoria Beach property owners.

Adaptive capacity proxies

The property owners and summer residents of Victoria Beach are in many cases high-income residents of Winnipeg who own property and cottages in Victoria Beach and reside there in the summer months. The information provided in this section was mainly obtained from two surveys provided to Victoria Beach property owners. The first survey was a survey to assess perceptions of climate change risk. The second survey was a survey to assess magnitudes of social capital.

Residents of Victoria Beach have one of the highest household income levels in Manitoba. The surveys of Victoria Beach property owners found that the most common household income bracket was $100, 000 or more, with 37.4% of respondents falling within this income bracket. Approximately 75% of respondents reported household incomes above $50 000. This is significant when considering that the median household income for Manitobans in 2001 was $41

661. The higher household income of the Victoria Beach population is an indication of very high adaptive capacity.

Adaptive capacity deficits

Victoria Beach does not have a formal economy, and its governance system is functioning efficiently. This suggests that there are no current adaptive capacity deficits. Similar to La Ronge, however, there is the potential for minor emergent adaptive capacity deficits due to lack of analysis, planning, and preparation. The relatively low level of preparedness may, in turn, be attributable to a lack of information about the timing and magnitude of local climate change impacts.

Adaptive capacity determinants

An important determinant of adaptive capacity is human capital. Respondents in the Victoria Beach surveys reported very high levels of educational attainment. Of those aged 20-64, approximately 62.3% indicated that they had a university degree. In 2001, approximately 19% of Manitobans aged 20-64 had a university degree. The comparatively large proportion of respondents in Victoria Beach with a university degree implies a high level of adaptive capacity.

People's perceptions and views about issues like climate change risk have an important influence on if, and how they will adapt to climate change impacts. A survey to assess Victoria Beach resident's perceptions of climate change risk was conducted between December 2006 and February 2007. The sample was 500 randomly selected Victoria Beach property owners. This sample was based on lists of residents and vacation home-owners supplied by the Rural Municipality of Victoria Beach. In the case of the risk perception survey, 196 completed questionnaires were returned. The Victoria Beach risk survey assessed a number of variables related to respondents' perceptions of risk. Of particular interest were respondents' answers relating to levels of concern regarding climate change, the adequacy of government information about climate change, sources of information about climate change and, finally, perceptions of climate trends over the past 20 years.

Approximately 82% of respondents indicated that they were either somewhat concerned or very concerned about climate change. Only 5.7% of respondents indicated that they were not at all concerned with climate change. Thus residents of Victoria Beach are aware of climate change and they are concerned about potential impacts to the community and to their own households.

In relation to the adequacy of government information regarding climate change, approximately 51% of Victoria Beach respondents indicated that they felt government (federal and provincial) information regarding climate change was either not adequate at all or not very adequate. Only 2% of respondents indicated that this information was very adequate. This suggests that people have a number of questions about climate change and that their need for information is not being completely fulfilled by governments. There may be a number of reasons for this result. One important issue is that although the quantity and quality of information about climate change is improving on a daily basis, there remains significant uncertainty about the magnitude and timing of impacts at local scales. The challenge for science and policy makers is to continue to reduce uncertainty about current and potential future climate impacts at community relevant scales and to develop programs that communicate new findings to communities in a timely manner.

When asked how climate change would affect the community of Victoria Beach, survey respondents expressed concern about the increased danger of forest fires, extreme heat in summer, water levels of Lake Winnipeg, and water quality issues. The prospect of hotter and drier summers appears to generate concern, as trees could be lost to drought or fire and recreation would also be affected. Interestingly, it was pointed out in survey responses that hotter summers could result in a larger population in summer months. Higher levels of preparedness for emergencies and related actions by the authorities were seen as important for preparing or adapting to climate change.

In summary Victoria Beach has high adaptive capacity (as indicated by the proxy of high average income). This is supported by the fact that the population is highly educated. Reliance on government programs is low and the population is highly mobile in the sense that they are not tied to Victoria Beach for their livelihoods. There is also a strong and committed local leadership associated with the Rural Municipality of Victoria Beach.

Social capital in La Ronge and Victoria Beach[11]

Social capital is an important determinant of adaptive and community capacity (Matthews 2003; Adger 2003). To our knowledge, there have been no studies of social capital in northern communities in Canada. This section reports on the results of social capital surveys administered to residents of La Ronge and Victoria Beach between June 2006 and January 2007. This section is provided as a separate section in order to provide a basis for comparison between the communities.

The level of participation and engagement by community members in community governance is an important indicator of social capital (Franke 2005). Voting behavior and interest in politics are measures of political engagement and commitment to the democratic process. Moreover, a high level of interest in democratic processes may be an indicator of preparedness to work with other members of the community to better overall social conditions in one's community. The results from the Victoria Beach social capital survey imply a relatively high level of political engagement. For example, the survey found that approximately 94% of respondents had voted in the January 2006 federal election. In contrast, the survey data obtained from respondents in La Ronge indicated relatively lower levels of political participation. For example, approximately 64% of the respondents in La Ronge reported voting in the same federal election. Although voter turnout in La Ronge is significantly lower than in Victoria Beach, La Ronge's participation rate was approximately equal to the overall national voter turnout. Participation in local politics in La Ronge was also lower than in Victoria Beach. Approximately 36% of La Ronge respondents regularly voted in regional or municipal elections. Moreover, only 58% reported being somewhat interested or very interested in local politics. In Victoria Beach, 78 % of respondents indicated that they always vote in municipal and regional elections and 82 % indicated that they are somewhat to very interested in local politics. These results indicate a very high level of political engagement from Victoria Beach residents and a more modest level of engagement from La Ronge residents. High voter turnout generally indicates that people are generally aware of, and interested in, what is happening in their surroundings and that they are not disillusioned. It may

[11] Thanks to E. Hyschka and S. Olmos (formerly of the Canadian Forest Service) for their contributions in data collection, tabulation, and analysis.

also be an indicator of people's preparedness to become involved in political processes and community wide initiatives to address climate change.

In addition to examining political participation, the social capital survey also assessed the potential for collective action by communities. In particular it asked respondents to predict how they thought community members would respond if faced by a crisis or disaster (i.e., flooding or wildfire). Respondents in both La Ronge and Victoria Beach overwhelmingly indicated that they thought such a crisis would bring community members together to solve common problems. In Victoria Beach approximately 88% of respondents indicated agreement with this sentiment, and less than 7% indicated that they felt a community crisis or disaster would create divisions. In La Ronge, nearly three-quarters (72.4%) of the respondents indicated that the community would likely come together to solve common problems and just 15.5% indicated that a crisis or disaster would lead to divisions within the community. These results imply significant potential for collective action at the community level.

In terms of a potential disaster or crisis, the social capital survey also examined respondents' perceptions regarding government levels of preparation. Respondents were asked to indicate whether they felt that various levels of government would be prepared to respond in the event of a community evacuation (i.e., due to wildfire or flooding). In Victoria Beach 71% of respondents answered yes to this query. In La Ronge, 92% of respondents answered yes. This difference may be due to recent experiences of La Ronge residents to significant wildfires threats in the vicinity of the community.

Respondents were asked to indicate whether they would have an alternative place to go if they had to leave their home (e.g., due to some type of emergency). In Victoria Beach, approximately 94% indicated that they would have a place to stay outside of town (likely because most residents actually live somewhere else), while only 24.3% of respondents indicated that they had an alternative place to stay within the area of Victoria Beach. In La Ronge, the numbers were similar in terms of places to go outside the community, with approximately 89% indicating alternative accommodations would be available outside the community. However, a substantially higher proportion of respondents (approximately 57%) indicated that they could find an alternative place to stay within their own community. Thus community networks within La Ronge may be stronger than in Victoria Beach.

Two additional sources of information were used for the remaining measures discussed in this section. First, a similar social capital survey was conducted in Vanderhoof, BC. The results of the Vanderhoof survey provide another data point for comparison. Second, the Statistics Canada General Social Survey on Social Engagement (Statistics Canada, 2003) provides comparable information aggregated at the national level.

The development of social capital within a group is facilitated by trust among the members of the group (Matthews 2003). Trust, is also a product of participation in groups. Therefore, the degree to which people feel that others can be trusted may be an indicator of social capital in that higher levels of trust contribute to investment in social capital. According to the General Social Survey, 52.8% of Canadians feel that people can be trusted. In the study communities of La Ronge, Vanderhoof, and Victoria Beach the percentages of respondents who either agreed or strongly agreed with the statement 'most people can be trusted' were 50.7%, 56.2% and 74.3%, respectively. Thus, levels of trust in people in general are high in Victoria Beach and approximately equal to the national average in La Ronge.

Membership in organizations is an indicator of social capital (Franke 2005). Table two shows that approximately two-thirds of Canadians are involved in one or more organizations. The most common type of organizations were sports or recreation (28.7%), union or professional (24.9%), cultural, educational or hobby (17.7%), religious (16.7%), school or community (16.5%), service clubs (7.9%), and political parties or groups (4.7%). In the three study communities of La Ronge, Vanderhoof, and Victoria Beach, sports or recreation organizations were the most common – with, respectively, 46.6%, 51.9%, and 54.1% of respondents indicating being involved in such organizations. Involvement in unions or professional associations was more common in La Ronge (32.8% of respondents) than in Vanderhoof (27.3% of respondents) and Victoria Beach (24.3% of respondents). Involvement in arts/crafts/hobby groups was high in all three communities (30.5% in La Ronge, 22.6% in Vanderhoof, and 29.7% in Victoria Beach). Involvement in church groups was less common in La Ronge (20.3% of respondents) than in Vanderhoof (36.4% of respondents) or Victoria Beach (32.4% of respondents). Involvement in neighborhood associations was also much less common in La Ronge (12.1% of respondents) and Vanderhoof (12.8% of respondents) than in Victoria Beach (31.5%).

Based on a preliminary assessment, it might be suggested that social capital is somewhat higher in Victoria Beach than La Ronge but La Ronge is close to being on par with the national average. Victoria Beach scores are significantly higher than La Ronge in the areas of political engagement and trust. La Ronge scores were lower than Victoria Beach but roughly equivalent to the national average for these two variables. In terms of organization involvement, the two communities are roughly the same. Victoria Beach residents have higher level of involvement in some types of organizations while La Ronge residents have higher levels of involvement in other types of organizations.

Table 2. Involvement of residents of La Ronge, Vanderhoof and Victoria Beach in organizations

	La Ronge	**Vanderhoof**	**Victoria Beach**	**General Social Survey**
Sports/recreation	46.6%	51.9%	51.4%	28.7%
Union/professional	32.8%	27.3%	24.3%	24.9%
Arts/crafts/hobby[12]	30.5%	22.6%	29.7%	17.7%
Church	20.3%	36.4%	32.4%	16.7%
Neighbourhood[13]	12.1%	12.8%	31.5%	16.5%
Service	15.5%	10.53%	9%	7.9%
Friendship centre	19%	4.5%	8.1%	n.r.

[12] The 'comparable' type of organization reported in the General Social Survey is "cultural, education, or hobby" organization; in the three community surveys, educational organizations were a separate category – with participation levels not reported here.

[13] The 'comparable' type of organization reported in the General Social Survey is "school, community, etc" organization; in the three community surveys, school or educational organizations were a separate category – with participation levels not reported here.

Political	19%	6.2%	10.8%	4.7%

Summary and conclusions

This chapter shows that the conclusions reached through assessment of adaptive capacity levels and the conclusions reached by analyzing adaptive capacity deficits may be quite different. Generally, the adaptive capacity of human systems in the boreal plains is lower than that in urban centres (at least based on the proxy indicators presented here) but this is mainly a consequence of social and economic circumstances and not the result of systematic impairments in the ability of these systems to optimally invest in adaptive capacity (given their individual circumstances). Thus, differences in adaptive capacity between rural areas and urban centres or across rural areas and communities do not necessarily mean that these systems are differentially vulnerable. In fact it may be that the reason why adaptive capacity is lower in places like La Ronge compared to cities is that the cost of providing adaptive capacity services is higher. In terms of understanding vulnerability to climate change, a more useful approach is to assess the extent to which there are currently adaptive capacity deficits or the potential for adaptive capacity deficits to emerge.

A second purpose was to assess whether, in fact, there are current or potential future adaptive capacity deficits for human systems in the boreal plains ecozone. The analysis considered the potential for adaptive capacity deficits in both rural areas and in two case study communities. The analysis suggests that current adaptive capacity deficits in rural areas and in resource based communities are relatively low. However, there is a higher likelihood of emergent adaptive capacity deficits. Climate change impacts are expected to vary from place to place. There may, therefore, be a need for local adaptation and for transfers of authorities and autonomy in a way that allows individuals, firms, and resource managers to more effectively adapt to local changes[14]. The actual trend, however, may actually be in the opposite direction. A trend toward more centralized institutions may limit the amount of autonomy, control, flexibility, and power that local decision makers in rural areas and in rural communities have. Climate change can also have feedbacks in terms of potentially reducing an area's ability to supply an appropriate level of adaptive capacity services. For example if an area's natural capital is depleted as a result of climate change, the resources it has available for adaptation may decrease.

A key factor contributing to emergent adaptive capacity deficits is that broader socio-economic trends such as globalization, urbanization, and the new knowledge economy may work in tandem with climate change to increase the overall adaptive capacity requirements of residents of rural areas and rural communities in the boreal plains. At the same time climate change (in tandem with other trends) may be contributing to reduced supply of adaptive capacity. For example, climate change may reduce the asset value of natural capital in some locations. Urbanization and globalization may result in increased out-migration of youth and highly skilled individuals and increasing difficulty in ability to attract skilled professionals (e.g., doctors, scientists, engineers, etc) into rural areas. The above changes may require restructuring, downsizing, and possibly decommissioning. These changes will likely increase the demand for adaptive capacity in the future (possibly more so than in urban centres). The economic response should be to increase investment in adaptive capacity. However, in general there are significant knowledge gaps about

[14] For example, changed circumstances may require land-use change and/or conversion of natural capital into other forms of capital (e.g., manmade capital). Currently, communities have relatively limited power and authority relative to these types of decisions at local scales.

local impacts on natural resources and decision makers generally have insufficient information about future climate change effects upon which to base decisions. There are, in some cases, mobility constraints for residents in rural areas and a general lack of local autonomy on how best to manage local natural resources. Thus, rural areas and many rural communities in the boreal plains may be more prone to the future development of adaptive capacity deficits than larger urban centres.

As noted, emergent adaptive capacity deficits in rural areas and in rural communities may arise as a result of a general lack of information and knowledge about climate change effects at local scales. Surveys of residents of the two case study communities indicated that they are concerned about climate change. At the same time, they have not developed plans or strategies to deal with or prepare for climate change. A potential reason is that there is a lack of information about climate change and climate change impacts at locally relevant scales. This may not only be a barrier to adaptation it may also contribute to emergent adaptive capacity deficits in rural areas where there are close ties to climate-sensitive resources.

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Figure 1. The boreal plains ecozone of central Canada and large area based forest management agreements.

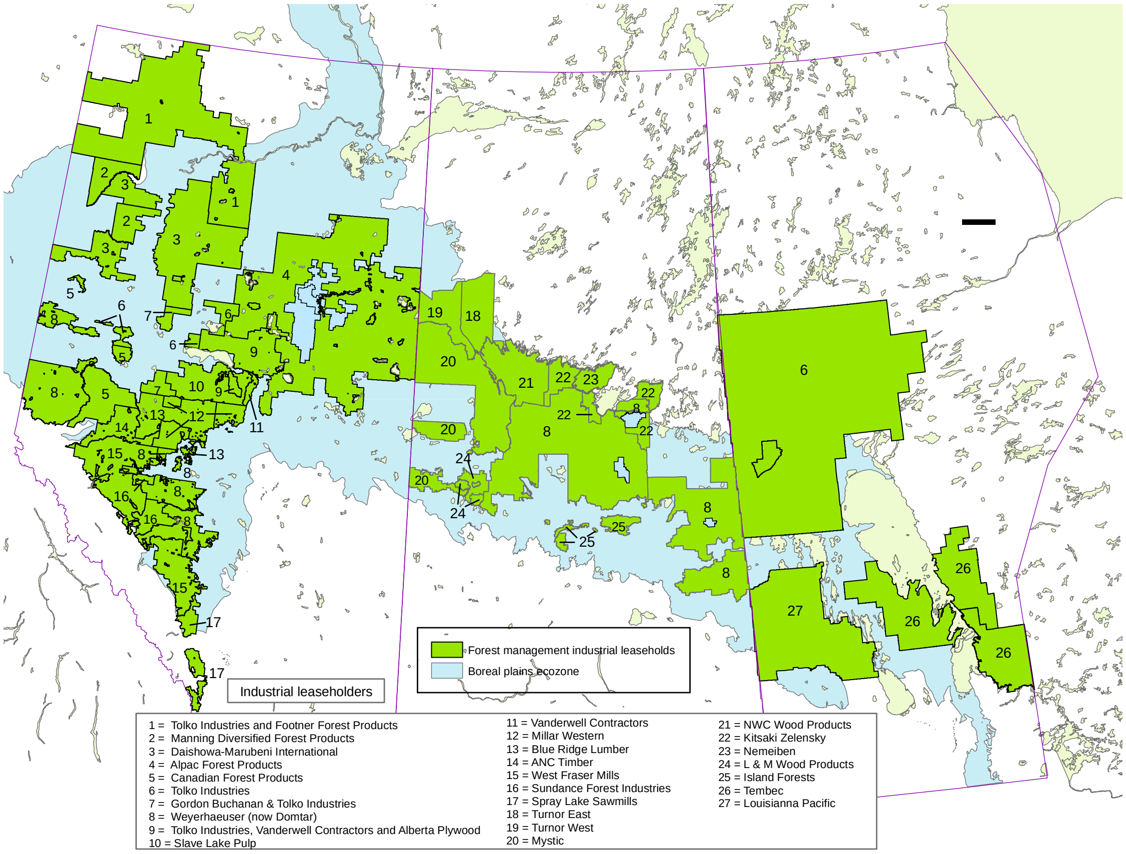

Figure 2. Average family income in rural areas in the boreal plains ecozone in 2001 (source Statistics Canada and Rural Secretariat Community Information Database)

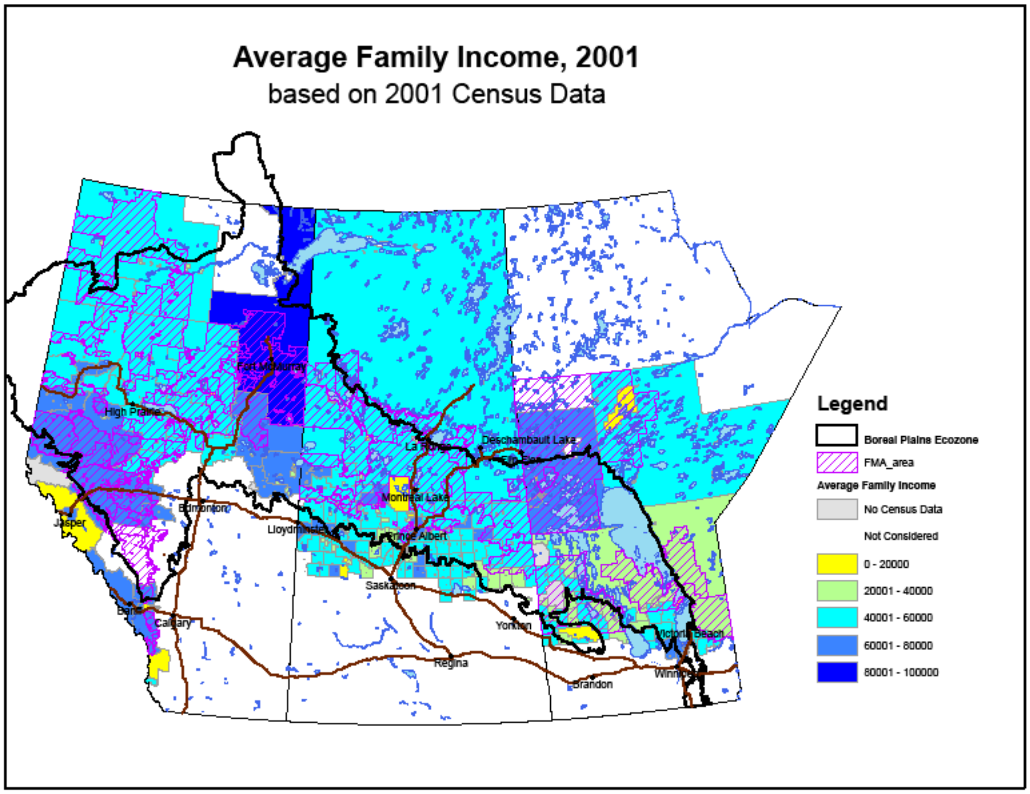

Figure 3. Incidence of low-income families in 2001 (%)

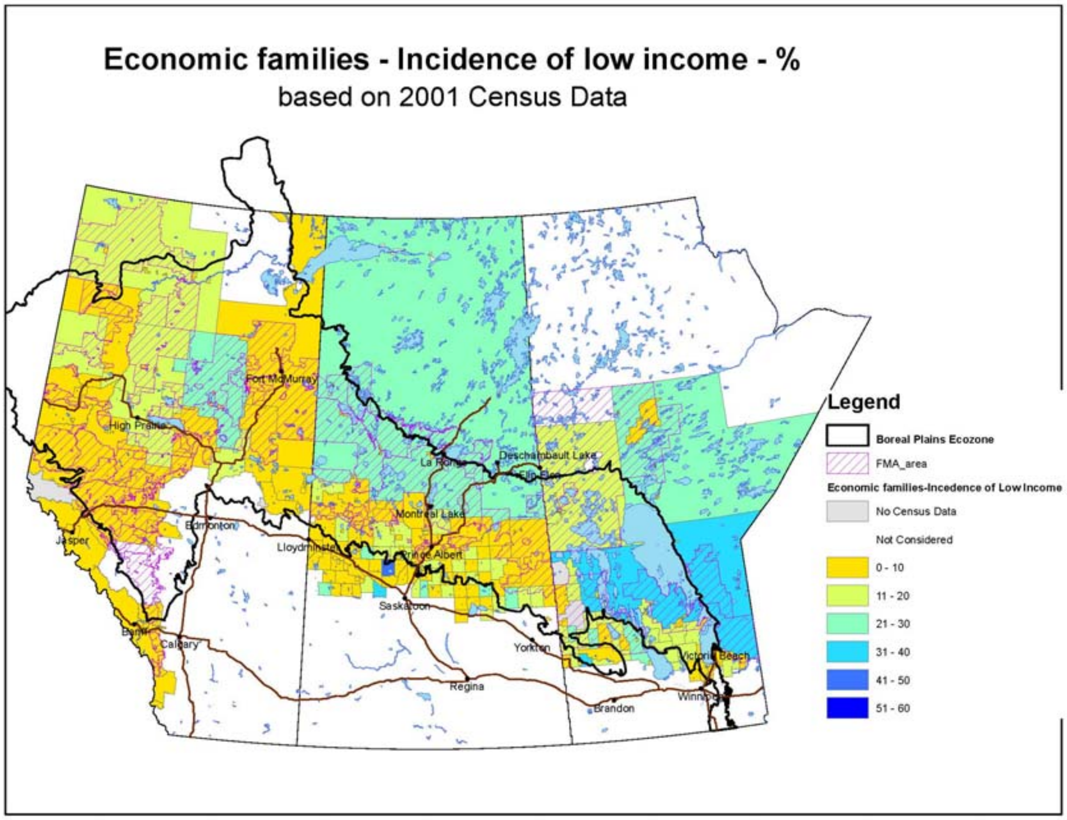

Figure 4. Full time employment change between 1996 and 2001 (%)

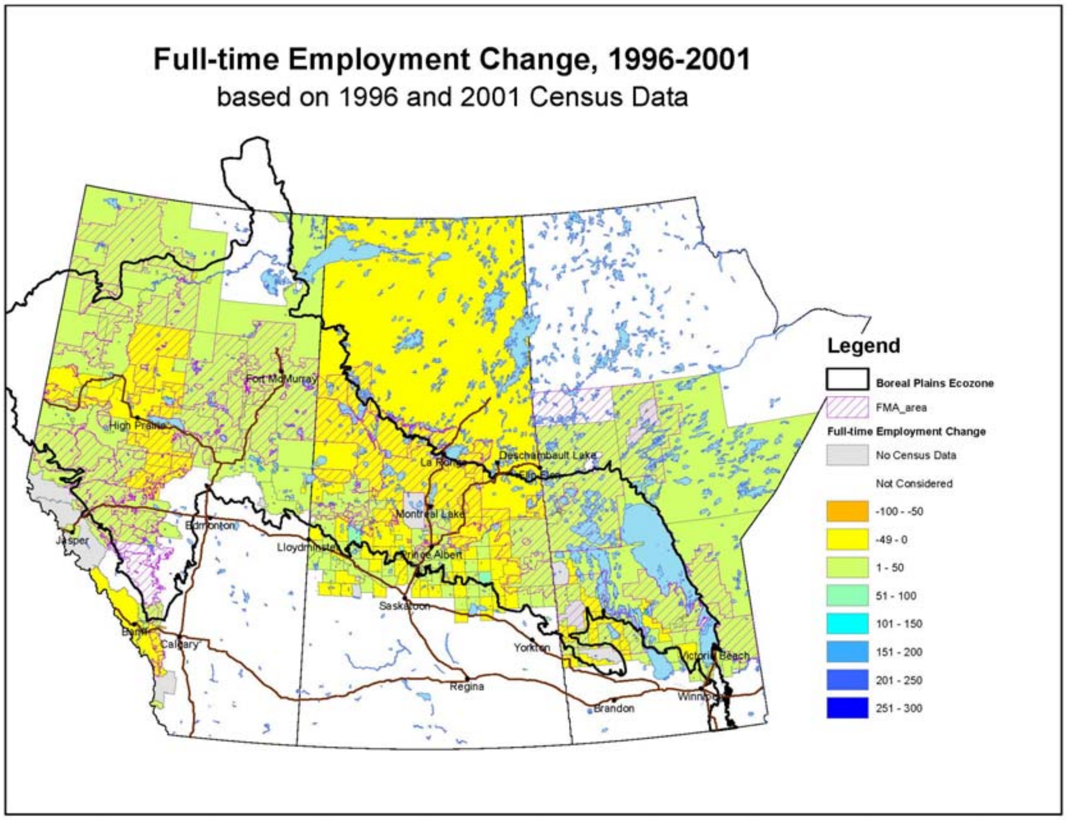

Figure 5. Unemployment rate in 2001 (%)

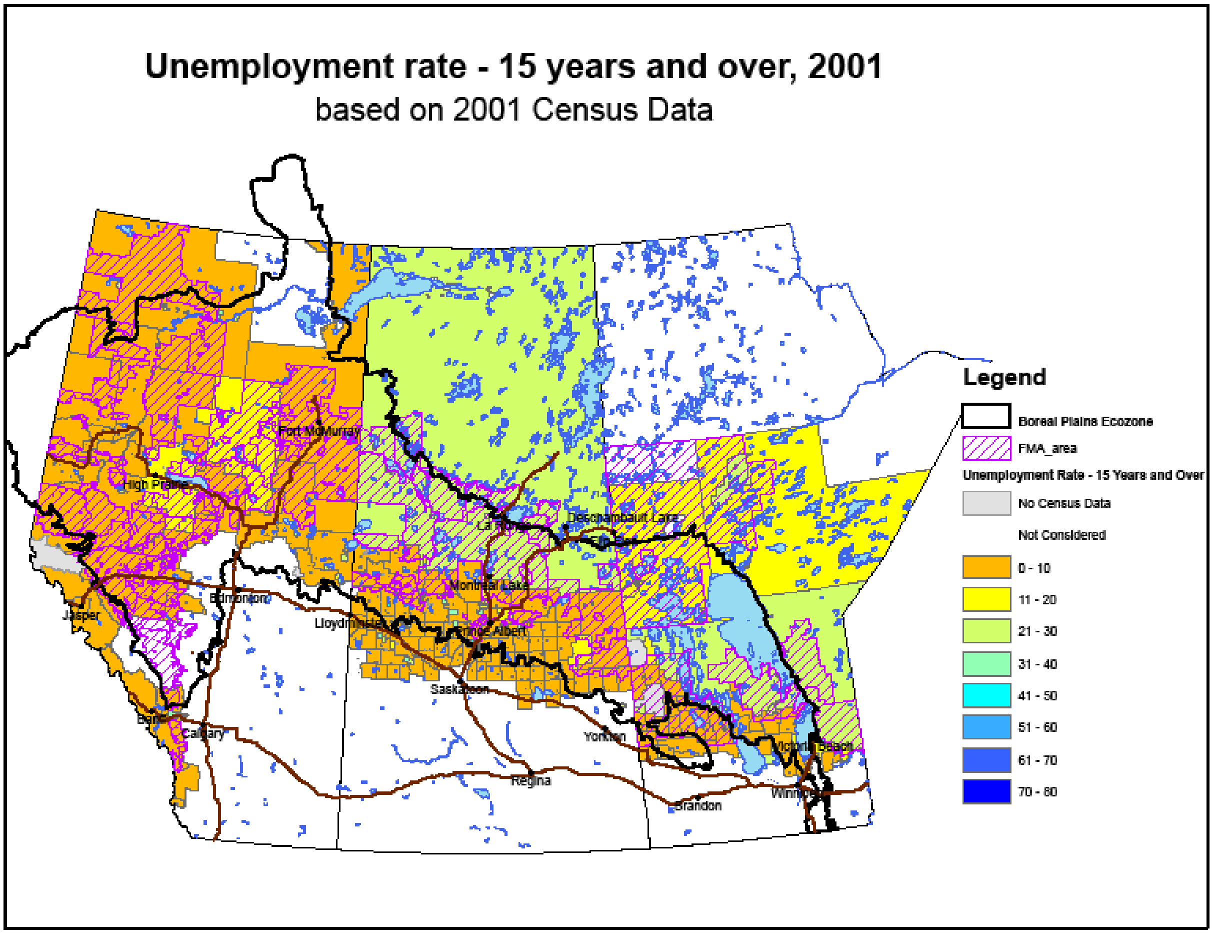

Figure 6. Population change between 1996 and 2001 (%)

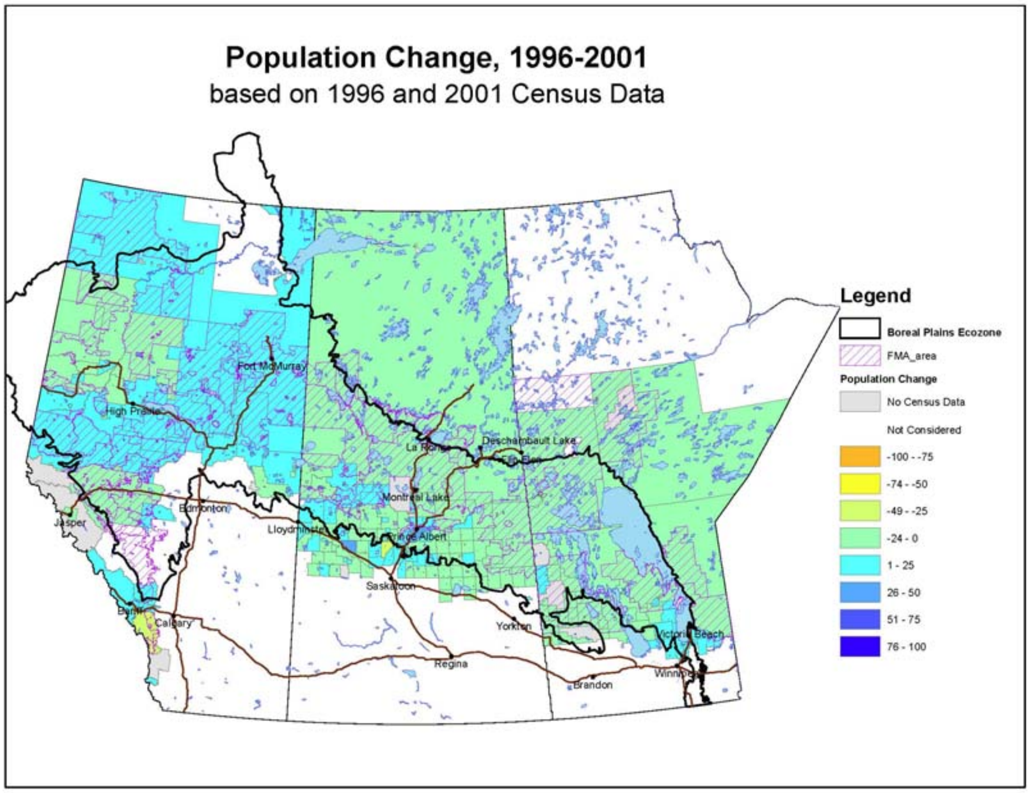

Figure 7. Average family income change between 1996 and 2001 (%)

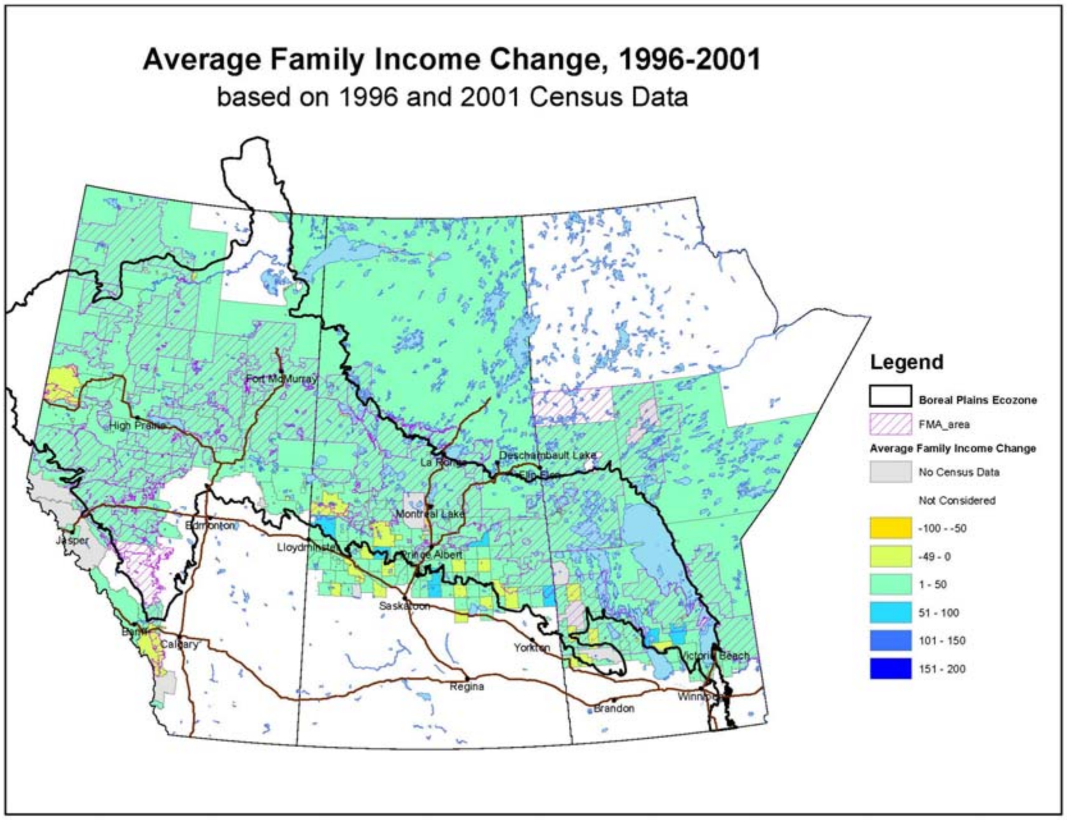

Figure 8. Structure of the economy of rural areas in the boreal plains

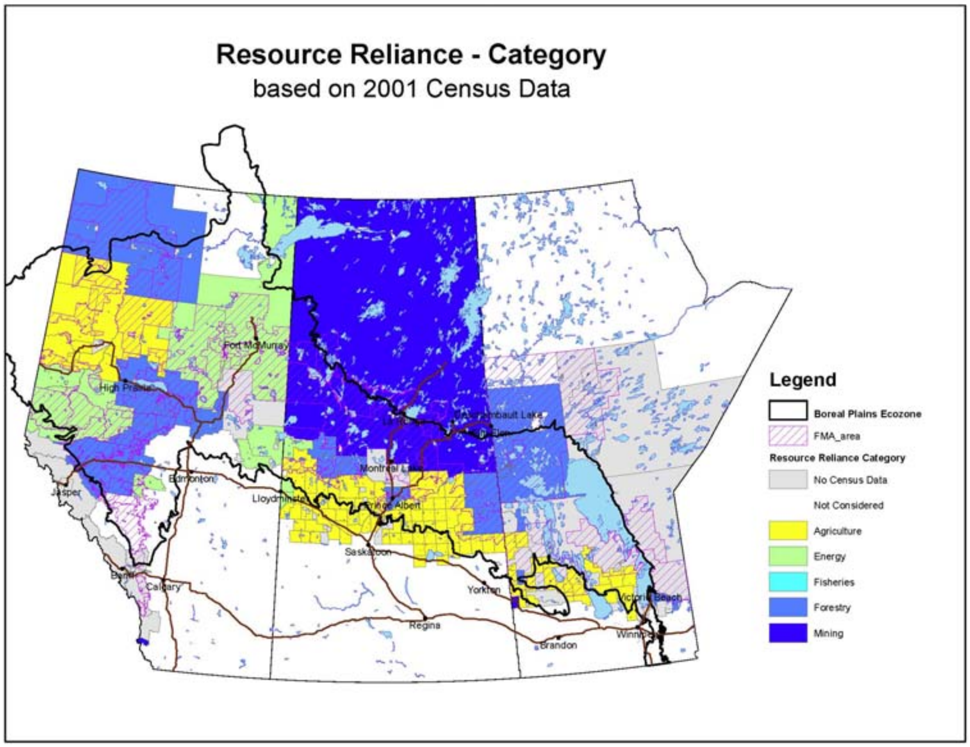

Figure 9. Percent of the population with trade certificate

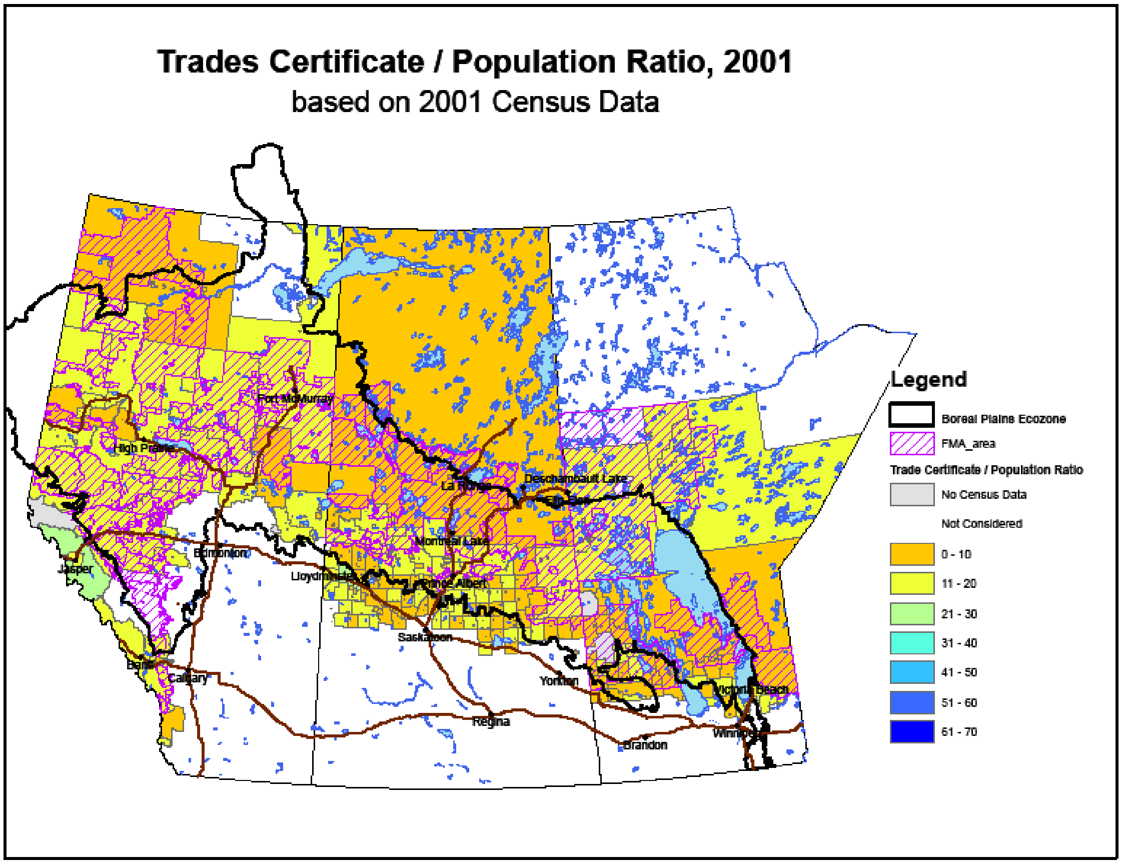

Figure 10. Percent of population with university degree

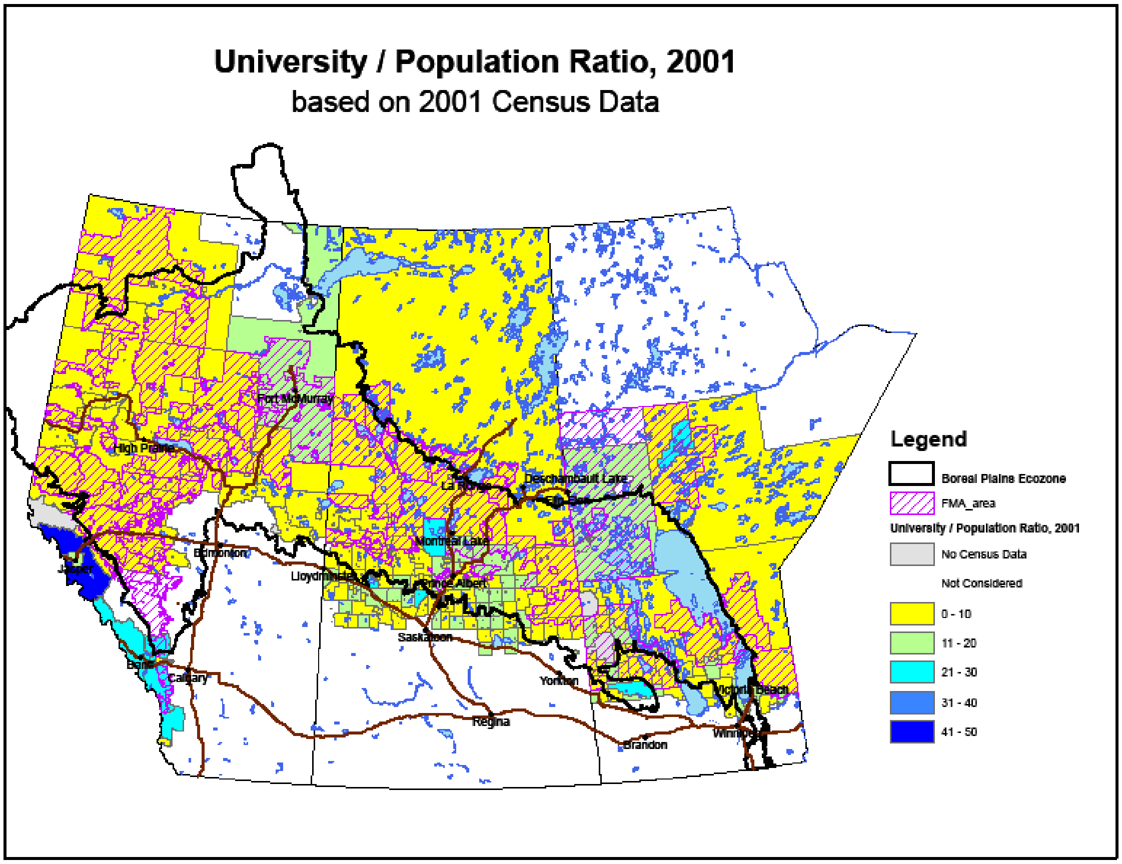

Figure 11. Location of the La Ronge study area

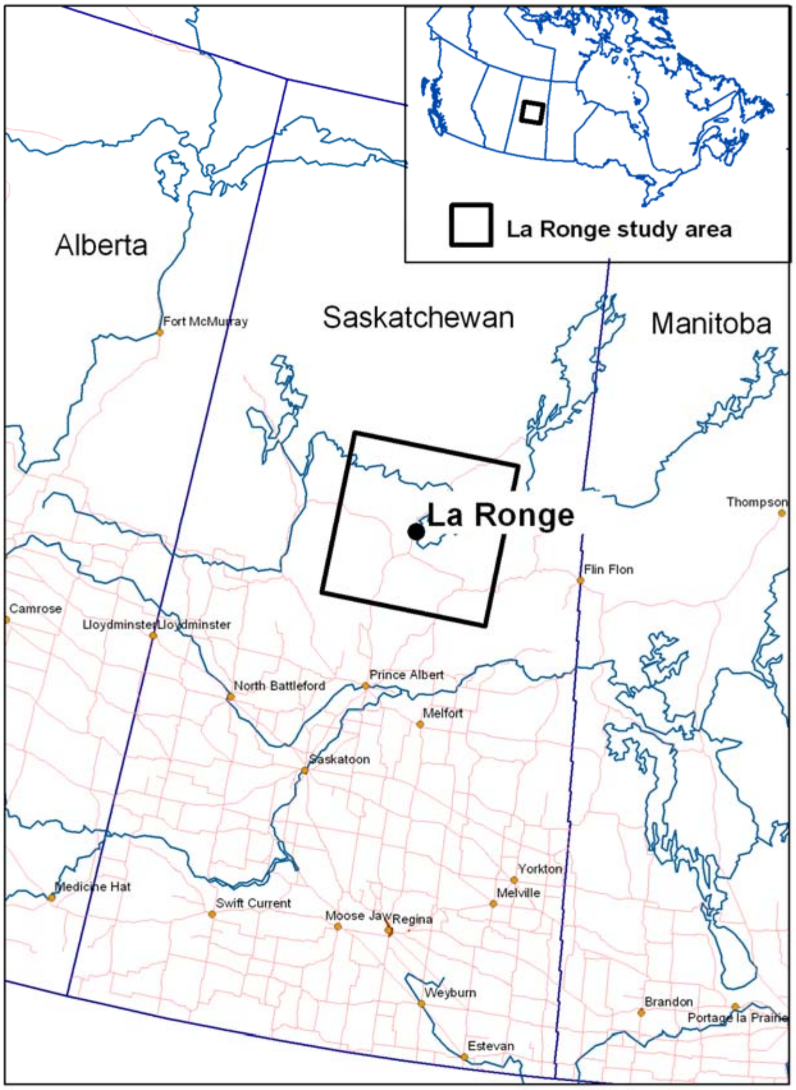

Figure 12. Average family income in 2001
(Average family income in cities in the prairie provinces = $66,400)

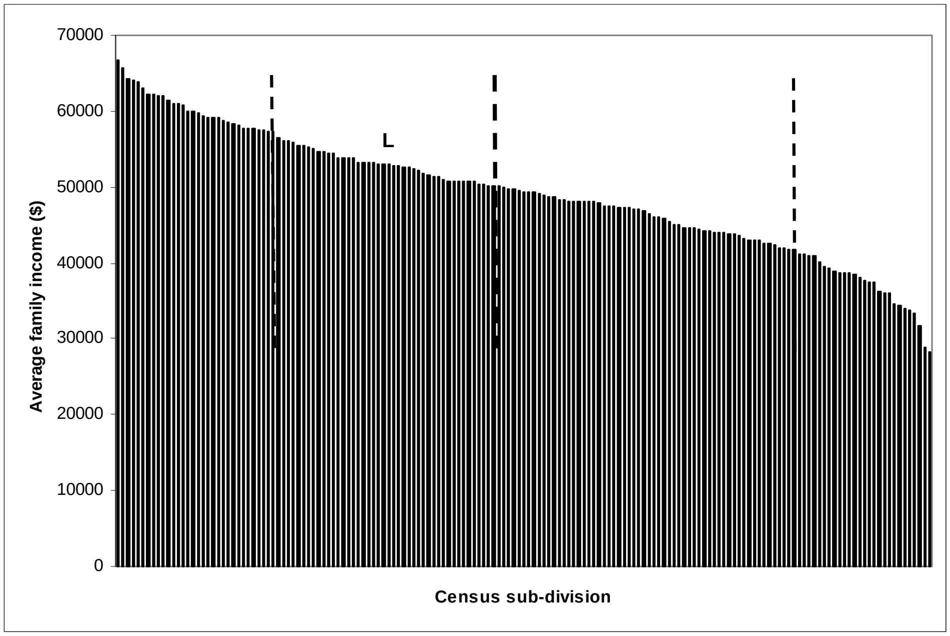

Figure 13. Family poverty rate (incidence of low income families)
(Family poverty rate in prairie cities = 10.44%)

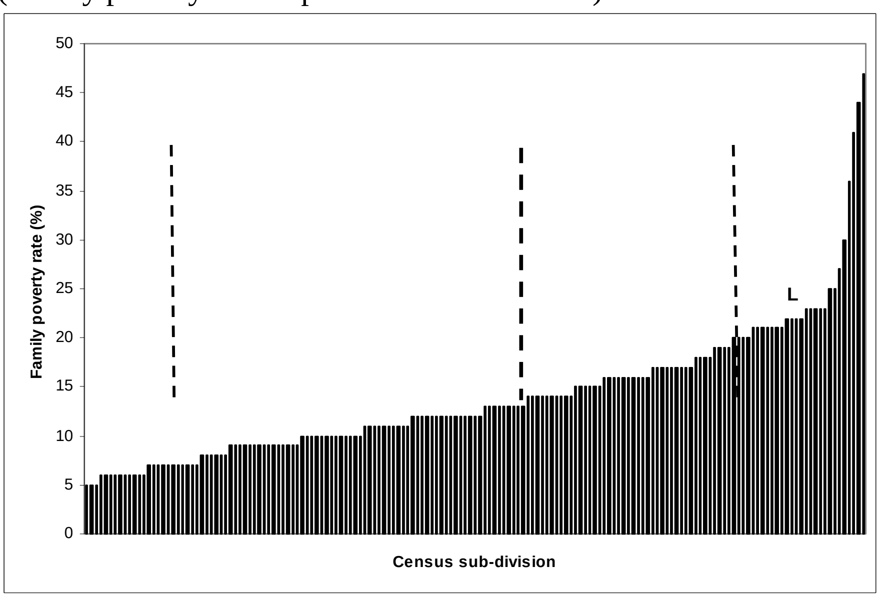

Figure 14. Unemployment rate in 2001 (%)
(Unemployment rate in prairie cities = 5.3%)

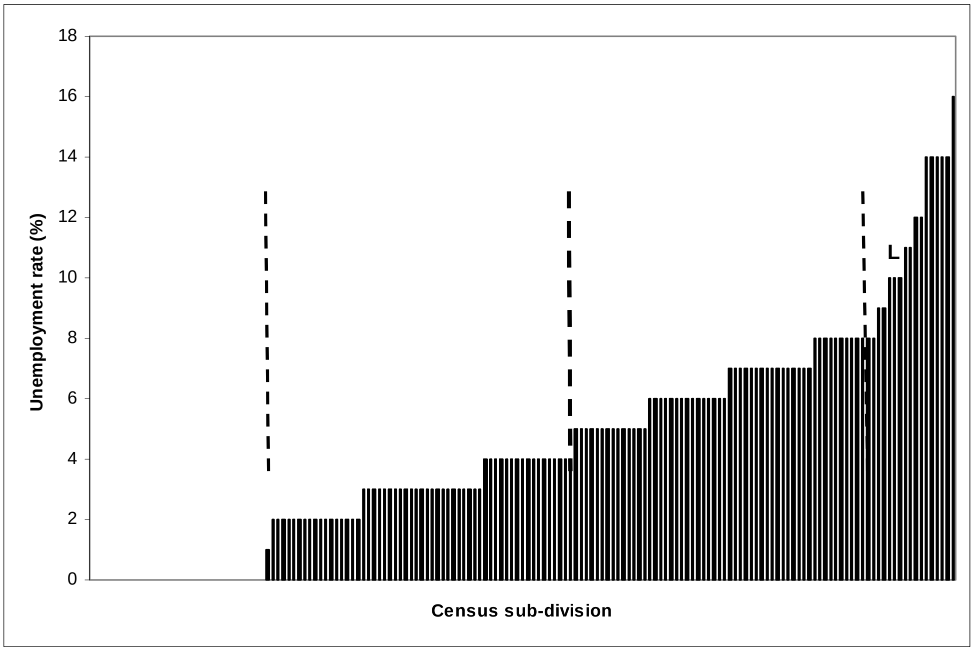

Figure 15. Population change between 1996 and 2001 (%)
(Population change in prairie cites = 9.0%)

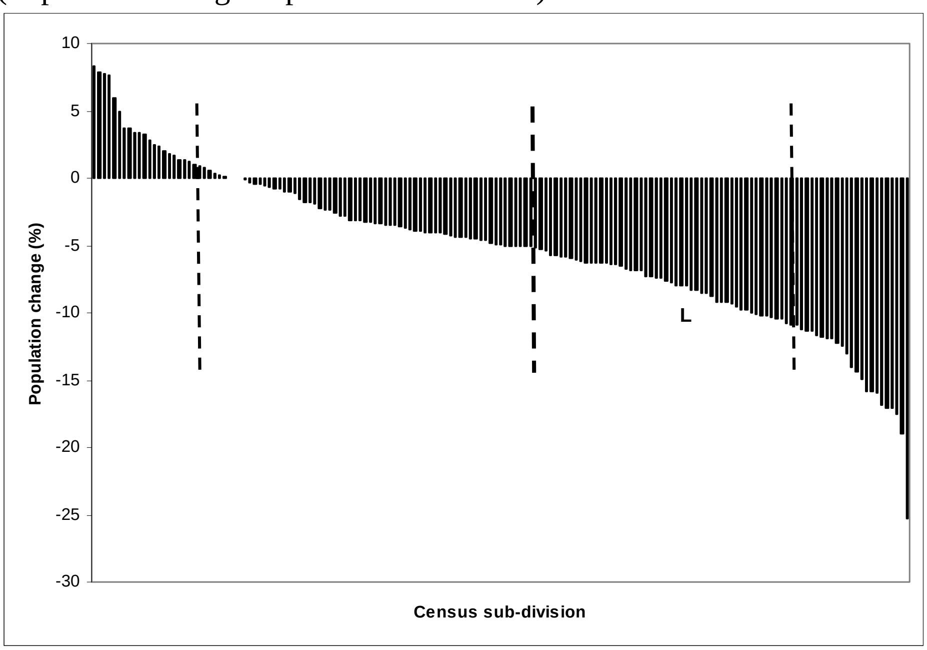

Figure 16. Corporate profitability indexes for Canada and Saskatchewan: 1962 to 2007

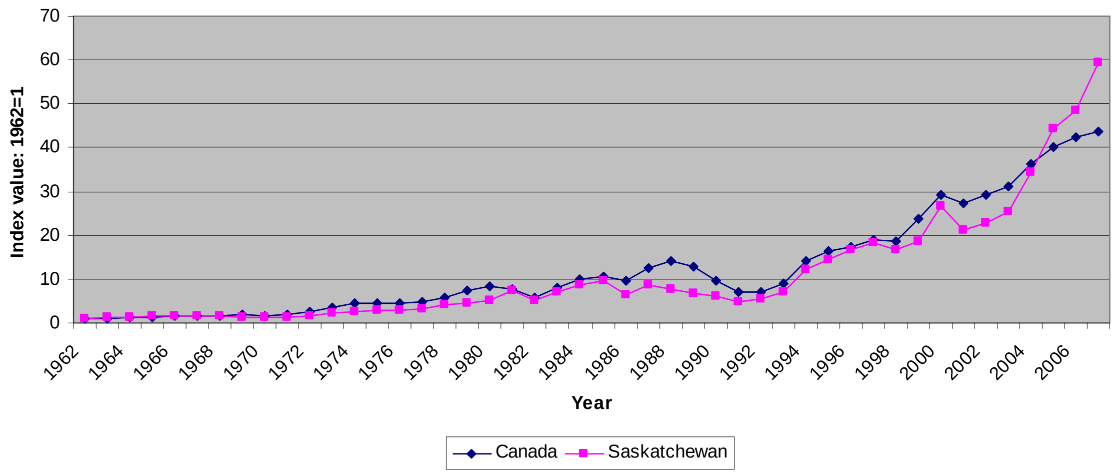

Figure 17. Economic diversity

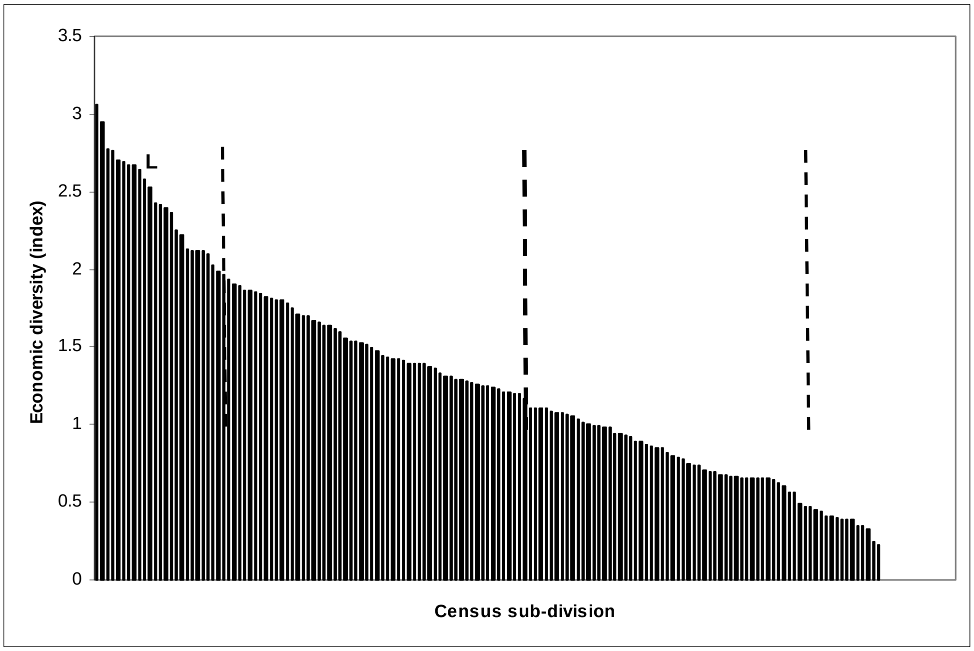

Figure 18. Resource dependence

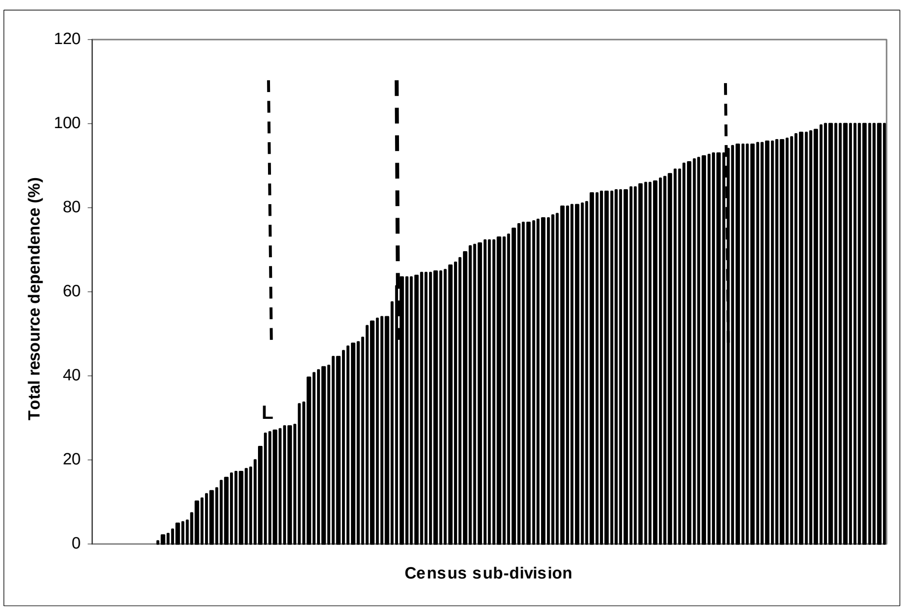

Figure 19. Proportion of the population with a trade certificate

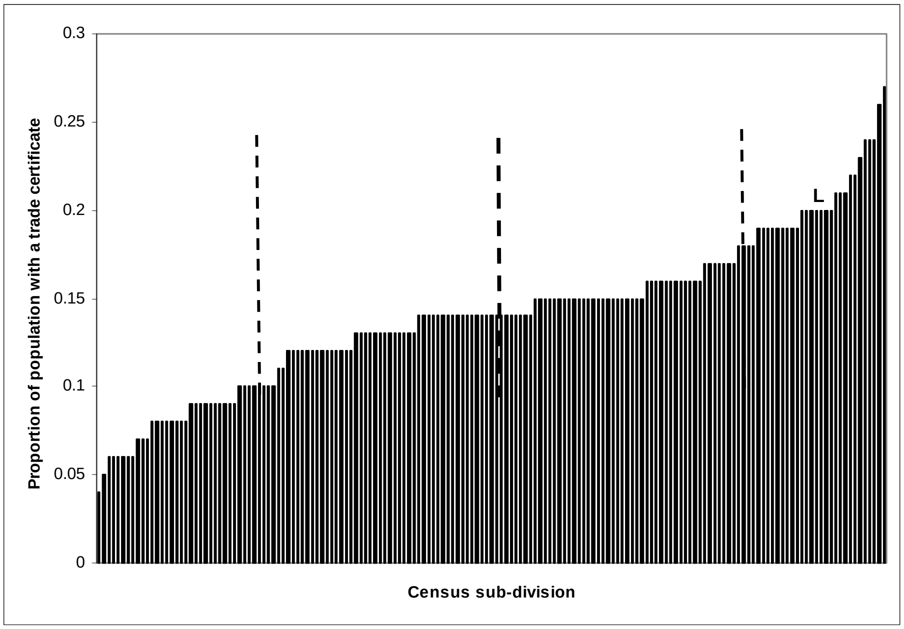

Figure 20. Proportion of the population with a university degree

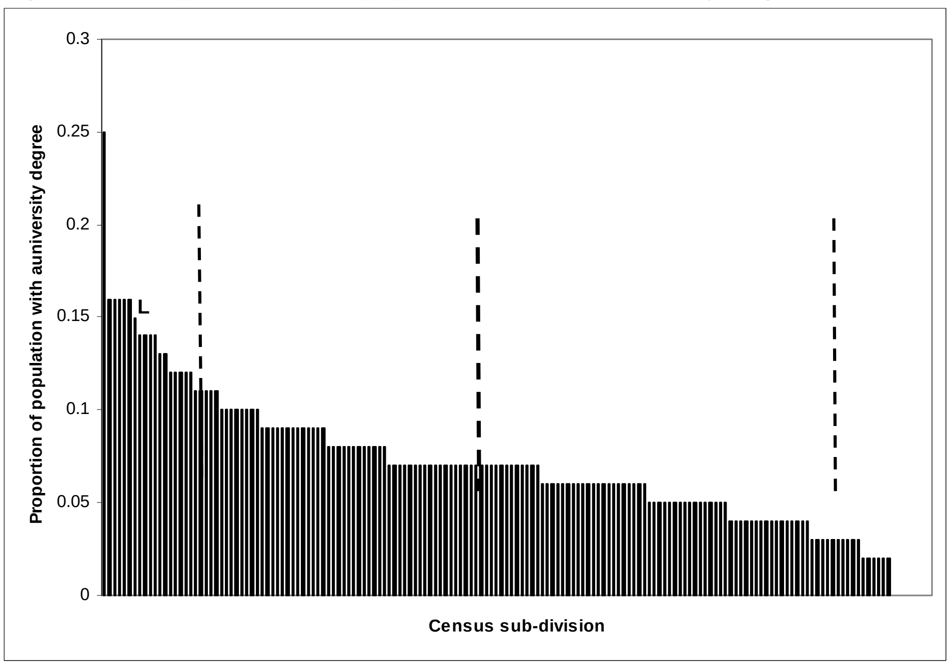

Figure 21. Location of Victoria Beach

Chapter 6
Assessment of Adaptive Capacity of Forest Managers

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In this section we present the synthesis of discussions with forest managers across the BPE designed to assess their perception of their adaptive capacity.

The underlying assumption in this project was that information on adaptive capacity in the forest sector is sparse in the scientific literature. This is due to the fact that the problem of climate change, especially the human dimension, is a relatively new area of research, particularly in the forest sector. In addition, adaptation is carried out locally with locally relevant solutions, so that documentation of experiences elsewhere are only partially useful. Finally, much good thinking is occurring among forest managers "on the ground" about what they can do about adapting to climate change, and none of this is being documented in publications.

Methods

For these reasons we carried out interviews and discussions with forest managers across the BPE. We attempted to explore with them their observations of climate change impacts, the degree to which climate change was part of their operational and planning activities, how they view their ability to successfully adapt to climate change, and what they see as the barriers to adaptation. We used a list of questions (provided in Appendix 2) to generally guide the discussions but did not prevent anyone from bringing up any other related points they wished to. We generally held the discussions with groups of five to eight individuals, as we found that a one-on-one interview would have been too formal, especially given the relative newness of the thinking around climate change. In addition, our experience was that meeting in small groups allowed ideas to develop through the course of the discussions, with one thought triggering others among the group members. Our goal was not to record the details of each person's contribution, but rather to distill the general points and identify common themes among managers. We were careful not to attribute any aspect of the discussion to any individual, company or government agency. We are primarily interested in general conclusions that seem to be relevant across the BPE, and also to compare and contrast a general "industry" perspective with that of "government" without being specific about identity. Discussions were recorded based on written permission of the participants, purely for the purposes of later transcription of the discussions. The text and details of the discussions will not be made public and are not included in this report. Following is a list of the companies, government departments and organizations with which discussions were held.

Government:

- Alberta Sustainable Resource Development
- Saskatchewan Forest Service
- British Columbia Ministry of Forests and Range (not located in the BPE)

Industry:

- Miller-Western (Alberta)

Albert-Pacific Forest Products (Alberta)
Domtar (Saskatchewan)
Council of Saskatchewan Forest Industries (Saskatchewan)
Independent Operators of Saskatchewan (Saskatchewan)
Mistik Management (Saskatchewan, interviewed as part of a previous project)
Tembec (Manitoba)
Louisiana-Pacific Forest Products (Manitoba)

NGO

Saskatchewan Environmental Society (Saskatchewan)

Adaptive capacity is defined by Adger et al. (2007) as "…the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies." It is important to note that this represents the *potential* for adaptation, while it is the *actual* adaptation responses that determine the ability of the system to cope effectively with climate change (Moser et al. 2008).

We characterize the results of the discussions with forest managers in terms of the determinants of adaptive capacity identified by Smit and Pilofosova (2001; see also Moser et al. 2008):

- Examine the range of available *technological options* for adaptation that would be considered in response to a perceived climate-related stress;

- Evaluate the *availability of resources* with particular attention paid to equitable distribution across the population;

- Explore the structure and functionality of *critical institutions* to understand the allocation of decision-making authority, institutional flexibility, and the decision criteria that would be employed;

- Assess the *human and social capital*, including the distribution of educational achievement, differential access to personal security and robust property rights;

- Document the system's (and individuals') access to *risk-spreading processes* (both formal and informal);

- Assess decision-makers' ability to *manage information*, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers themselves; and

- Calibrate the public's perceived *understanding* of the stresses and the population's readiness to engage in implementing necessary adaptation measures.

We used these determinants in structuring a set of questions that guided our discussions with stakeholders. Rather than address each of these factors directly, we used the questions to guide a broad set of discussion in order to allow participants maximum freedom to express their thoughts on adaptive capacity. However, we will present the results of our discussions in terms of these determinants of adaptive capacity.

Technological options

Forest managers in the BPE generally have access to technology that is sufficient and appropriate under current conditions. In discussing the role that additional or different technology might play in adaptation, the primary concern was cost relative to its utility. For example, high-flotation tires on skidders may allow operations during unfrozen conditions in some cases. However, the concern was that this option is expensive, can require additional maintenance, any may only be required sporadically. Therefore the expense would be difficult to justify.

Another use of technology to enhance adaptive capacity could be the use of genetic modification in producing tree varieties that are better adapted to future conditions. Again, cost is the primary concern, especially in the boreal region given slow growth rates and low return on investment for this technology. In addition, there is a lack of capacity at the firm level among most forest companies in Canada to undertake this kind of work. Research and development in this area is possible through partnerships with universities, but the generally low level of investment in R&D in the forest industry makes this option unlikely in the short term (see following section on resources). Finally, public acceptance of GMO organisms is still a problem in agriculture and forestry, and most companies will not pursue a policy that leads to social and political controversy. On the other hand, there is significant activity among both industry and government to modify seed transfer zones, which stipulate the location of seed used for regeneration. The concept is to restrict the use of seed to the area from which it was collected. Managers are now beginning to look at seed zones relative to where suitable locations may occur in the future, so that seed is “matched” to the future climate. This is currently being done on a test basis but is rapidly evolving into a management practice.

Technology may have an important role in allowing new species to be used for forest products. Tree species ranges are expected to shift as climate change unfolds (McKenney et al. 2007), resulting in the replacement of traditional commercial species with new ones. In some cases the changes could be significant, e.g. the replacement of conifers with deciduous species under a future of more forest fire activity (Williamson et al. 2008). Companies that are able to implement new technology to provide new products will have enhanced adaptive capacity. However, investment in the forest sector is currently low (FPAC 2007a), and it is unlikely that investment in new facilities and equipment will occur in anticipation of future species availability.

Availability of resources

Availability of resources for adaptation, especially financial resources, is extremely limited in the Canadian forest sector today. Over 45,000 jobs have been lost in the past 10 years and over 100 mills have been closed nationally (Van Damme 2008). It was made very clear in our discussions that most forest managers in industry are focused on day-to-day survival and do not have time to consider climate change and adaptation, even in cases where they know this will be important in the future. One of the by-products of the economic downturn is lack of investment in innovation, resulting in Canada having below average rates of private investment in R&D among the OECD countries (Industry Canada 2007). The forest industry in Canada has also been the victim of high exchange rates, competition with low-cost offshore producers and rapidly increasing costs of energy, further reducing adaptive capacity relative to future adaptation to climate change (FPAC 2007a). Finally, most forest products facilities are long-lived and require very large capital investments, so that making rapid adjustments to changes in the natural or economic-political environment difficult.

Critical institutions

Our interviews indicated overwhelmingly that institutional factors are the most important in limiting adaptive capacity among forest managers. While the financial position of the forest industry is also important, the general perspective is that this is a temporary problem and part of the business cycle. On the other hand, institutional barriers are seen as being long-term and an inherent part of the forest sector's structure and governance. In addition, the solutions are seen as requiring political change which may make them more difficult to implement. We present institutional factors in three categories: those related to the forest industry; those dealing with government, largely provincial regulators; and those that are a part of non-governmental institutions, e.g. forest certification bodies, professional associations.

Industry

Forest industry managers indicated that industry organizations are important to them as source of credible information. The Forest Products Association of Canada (FPAC) was mentioned specifically as their first stop for gathering information. FPAC works with companies to facilitate dialogue and work toward reforms in areas such as business (exchange rates, industry restructuring and competition policy, regulatory environment, etc.) and environment (air quality, environmental effects monitoring, climate change, species at risk). In addition, FPAC works with government in developing more efficient systems for international trade, streamlining regulatory requirements and enhancing investment. FPAC also works with environmental NGOs in developing large-scale conservation plans, e.g. the Canadian Boreal Initiative. Working with FPAC in developing industry-relevant information on climate change impacts and adaptation options would be a good way of bringing information to companies from a source they trust. An example of a previous successful initiative is the large amount of work FPAC has done on helping companies reduce greenhouse gas emissions. The forest industry in Canada has reduced GHGs by 44% since 1990 while increasing production by 20% (FPAC 2007b).

All jurisdictions in Canada require some type of long-term forest management plan, typically on a 20-year time horizon. Our experience in other projects and our discussions with industry managers indicate that the forest management planning function provides an excellent vehicle for considering climate change impacts and adaptations. The relatively long time horizon and the generally strategic focus of the plans means that climate change considerations can be brought in at a temporal and spatial scale consistent with the current state of understanding of climate change impacts. In addition, the plans are required under most provincial legislation, so this is an activity the companies will be undertaking regardless and is not a separate activity that would add additional cost to their operations. This provides an important example of “mainstreaming” climate change impacts and adaptation, as recommended by the recent Canadian National Climate Change Assessment (Lemmen et al. 2008).

To date we are aware of three examples of forest management plans that have included climate change I&A components; interestingly, all three occurred in the BPE. The first was an initiative of Louisiana-Pacific in SW Manitoba, in which scenarios dealing with future fire activity, forest productivity and forest carbon budgets were developed by a group of government and university scientists working closely with the company. The plan also included a range of other scientific investigations including a very advanced, spatially-explicit biodiversity analysis under several future harvest scenarios. The second example is a plan completed by Mistik Management in NW Saskatchewan which included analyses of forest productivity, fire activity and likelihood of winter frozen ground conditions under several future climate scenarios. Finally, Millar-Western in central Alberta recently completed a plan in which several future scenarios integrated the effects of climate change, oil and gas development and demographic change across their Forest Management Agreement area near Whitecourt (Van Damme et al. 2008).

While these efforts were a success in that I&A considerations were included in the final submitted plan, each was done in an *ad hoc* manner with no guidelines, no consistency among efforts, and no common understanding of how I&A should be addressed. We advocate the development of planning guidelines that could be used across all jurisdictions in order to provide guidance on how I&A considerations could be integrated into forest management plans. These would necessarily be general in order to accommodate variability among jurisdictions and biophysical conditions, but could be developed in a way that would be helpful to both industry and government planners. We also support the concept of “embedded science” (Van Damme et al. 2008). In this model scientists from government or academia work closely with company managers and planners in incorporating scientific analyses into the forest management plans. This collaboration is established at the beginning of the planning cycle so that the direction and approach used by the scientists support the objectives of the plan. Companies vary widely in their science capacity and their interest in such an arrangement, so we would not expect that this would work in all planning projects. But where the interest and capacity exist, we have found this to be a very rewarding experience for both scientists and industry staff.

We found a very interesting relationship between corporate culture and adaptive capacity (Van Damme 2008). Companies vary widely in such hard-to-measure characteristics as the strength of leadership, willingness to innovate and having a future orientation vs. maintenance of the status quo. In many cases these qualities came from specific individuals and reflected their personal values. While these progressive attitudes enhance adaptive capacity, there are examples in which this perspective disappears when an individual leaves the company. The issue becomes how to institutionalize these progressive attitudes and make it a part of corporate culture rather than just a function of specific individuals.

An additional issue in forest management is the fact that decisions taken today will persist for several decades. This is particularly true in the boreal forest of the BPE, where most species are harvested at 70-90 years. In contrast, decisions in agriculture about what crops to plant or what management practices to follow can be made annually or sometimes more frequently. The outcome of forest management decisions is difficult to predict under current assumptions about a stable climate, and much more so given the high likelihood of a different climate occurring several decades from now. This lack of ability to determine the correct long-term decision limits the adaptive capacity of forest managers and points out the need for climate sensitive tree growth models that can help managers envision future forest conditions.

Regulators

Ownership of forest resources lies with provincial governments as a result of the Natural Resources Transfer Agreements of 1930. Provincial governments manage crown forest lands under legislation that prescribes responsibilities of provincial regulators and the forest industry. Rights to harvest wood are granted to forest companies through Forest Management Agreements which stipulate harvest levels and other required activities the companies must undertake: reforestation of harvested areas; the submission of forest management plans; protection of fish and wildlife habitat and others. In general, forest companies are required to establish one or more wood-using facilities to make use of the timber harvested from the FMA area so that the companies manage both the forest landscape and the industrial facility, a factor known as appurtenancy. Provincial regulators exercise oversight of forest companies by requiring 20-year and operational plans, as well as enforcing regulations under forest management legislation.

Institutional barriers to adaptive capacity among provincial regulators are related to forest policy that usually assumes a forest that remains substantially the same over time. Policy is generally based on what has worked in the past rather than anticipating what is likely to happen in the future. This is particularly a problem with climate change given the uncertainty about future conditions. This may make acceptance of innovative ideas difficult, especially if the proposed alternative lies far outside of accepted practice. There is also much discussion in the forest sector currently regarding the need for change in the forest tenure (i.e. FMA) system. Long-term agreements that are stipulated by government may reduce the adaptive capacity of both industry and provincial regulators by "locking-in" levels of harvest or other aspects of forest management and may prevent adaptation options from being implemented (Haley and Nelson 2007). Innovative forest management practices that have both immediate and long-term benefits may become more difficult to apply give relatively inflexible tenure agreements. Similarly, agreements that stipulate both an industrial wood-using facility and management of large forest landscapes may reduce adaptive capacity in that the company must maintain a range of mill and forest management specialists, rather than focusing on one aspect or the other. A tenure agreement that is specific to the forest landscape, i.e. one that severs the appurtenancy requirement will likely result in agreements with companies that specialize in forest management. These companies are more likely to have the resources to carry out effective adaptation.

Non-Governmental Organizations

A number of Non-Governmental Organizations (NGOs) have developed in the past few decades that support the principles and application of Sustainable Forest Management (SFM). Forest certification bodies have developed standards for forest management that stipulate how SFM is to be achieved, and will certify a company's products as having come from a sustainably-managed forest estate. Certification is often required by wholesale buyers of forest products (e.g. IKEA, Home Depot), and is increasingly being sought by consumers at the retail level. Three certification standards have emerged in Canada: Forest Stewardship Council, Sustainable Forestry Initiative and the Canadian Standards Association. Over 134 million ha of forest land have been certified, representing over 90% of the managed forest land in Canada (FPAC 2007c).

While certification standards promote SFM, it is unclear to what extent they support or help develop adaptive capacity for climate change. In general the standards assume a relatively unchanging forest, and usually tend to support the protection and maintenance of existing species and habitats. Little is indicated about how forests may change or how practices need to adapt to new conditions. However, certification is seen by the forest industry as essential to continued market access and they will continue to seek this designation. Therefore we advocate the incorporation of climate change considerations into forest certification standards. This would necessarily be at a fairly general level but would provide guidance to companies on how to address the critical questions about likely impacts, vulnerability and adaptation options.

An international process in the 1990s resulted in agreement on a set of Criteria and Indicators for Sustainable Forest Management. The international agreement was further supported by national C&I programs among the signatory countries. In Canada, the Canadian Council of Forest Ministers (comprising the provincial and federal ministers of forestry) took responsibility for developing the Canadian C&I framework (CCFM 2003). The Canadian framework recognizes six Criteria of Sustainable Forest Management:

- 1. Biological Diversity,
- 2. Ecosystem Condition and Productivity,
- 3. Soil and Water,
- 4. Role in Global Ecological Cycles,
- 5. Economic and Social Benefits and
- 6. Society's Responsibility.

In its current configuration, the C&I framework is mostly a backward-looking instrument, i.e. its focus is on adjusting forest management practices so as to minimize impacts on diversity, ecosystem condition, etc. and maintain relatively "natural" forest ecosystems. In addition, Criteria 5 and 6 recognize the importance of forestry to aboriginal and non-aboriginal communities and the need for society to support SFM. None of these criteria as written deals with future change, in either the natural or socio-economic environment. As with certification systems, the existing C&I framework could provide an already accepted vehicle for identifying biophysical climate change impacts (Criteria 1-4) and impacts and adaptive capacity (Criteria 5 and 6). We advocate the modification of the C&I framework to incorporate these changes as a way of enhancing the adaptive capacity of the forest sector.

The Canadian forest sector has produced several national forest strategies since 1983. These have evolved over the past 20 years, increasingly emphasizing SFM and the need for sustainable communities as well as forest ecosystems. Planning is underway for the next strategy to begin in 2009. As background to the next strategy, the CCFM produced "A Vision for Canada's Forests: 2008 and Beyond" (CCFM 2008). This document was based on initial discussion papers by the National Forest Strategy Coalition followed up by extensive cross-country consultation. The vision document identifies two key themes that will guide the preparation of the next National

Forest Strategy – transformation in the forest sector, and climate change impacts and adaptation. We highlight this because we feel it is good evidence that the issue of climate change is firmly entrenched among stakeholders in the forest sector. As planning and discussion occurs for the 2009 strategy, climate change will be a high priority and should significantly enhance the adaptive capacity of the forest sector.

Canada is known internationally for the model forest program, which was an outcome of the Environmental Summit at Rio de Janiero in 1992. A model forest is a community-based partnership organized around the desire to develop and implement sustainable forest management practices. The partnership identifies local issues; develops innovative, locally-relevant SFM practices; and provides a forum for sharing results, resolving conflicts and ensuring equality of benefits among the partners. The MF program began in Canada and today comprises 14 model forests in nearly every province across the country. In addition, other countries began to be interested in the concept and the International MF Network was established in the mid-1990s. Today there are approximately 50 model forests on every continent except Antarctica. In the past several years, climate change has become a top priority for the MF system both domestically and internationally. Many of the Canadian MFs have local projects dealing with climate change, and the Canadian MF Network has funded several national initiatives that address climate change across several model forests. The International MF Network recently held a meeting of over 160 individuals from 33 countries representing all of the MFs around the world. Through a group prioritization exercise, the participants were asked to identify the main theme areas in which they would like to work in partnership, and climate change was in the top three. The model forest program is well placed to help support and develop adaptive capacity among forestry stakeholders, both in Canada and other countries.

Human and social capital

The forestry profession has a long history in Canada, with the first professional schools established in the early 1900s. The profession has developed a strong set of principles regarding SFM and strong governance in the form of professional societies in virtually every province, some with legal rights to approve management plans and other forest management activities. Professional societies enforce standards for education and ethical practices and provide incentives for continuing education. Forest science and management research is active in the professional schools across Canada and has resulted in one of the most advanced and technically sophisticated forest management communities in the world. At the basic level of forest management, the adaptive capacity of the forestry profession in Canada is high.

Forest companies and management agencies vary widely in their technical expertise, with some employing several Ph.D.-level scientists while others have very little advanced scientific capacity. Our discussions with both industry and government managers indicated that lack of capacity was an important issue relative to thinking about and planning for climate change I&A. Compounding the lack of scientific capacity is the fact that current information on climate change impacts is generally not available at spatial and temporal scales relevant to forest management planning and operations. In organizations with scientific capacity, information that is available can be modified (e.g. downscaling of global model results, use of ecosystem simulation models) so that it becomes more relevant, but most organizations would need to seek outside expertise for these kinds of analyses. In addition, government agencies that lack scientific capacity may be unable to review forest management plans that contain climate change analyses. We also heard that companies and especially government regulatory agencies are chronically understaffed, further reducing adaptive capacity. In some cases, forest managers work for small companies in isolated rural locations, further reducing their access to relevant information on I&A. Finally, most forest companies today are focused on surviving an economic downturn, increased competition from off-shore producers and large-scale restructuring in the industry. Even those companies who take climate change seriously and who have scientific capacity find it difficult to address this issue when day-to-day survival is their primary concern.

Social capital provides other sources of enhancing adaptive capacity (Williamson et al. 2007). Industry forest managers identified FPAC as an important organization that provides both technical and political support to companies. Their feeling was that information available from FPAC was credible and relevant, suggesting that FPAC would be a good organization to partner with in order to engage and educate the forest industry about I&A issues. Similarly, the provincial professional societies and the Canadian Institute of Forestry have continuing education programs, including an innovative web-based ("webinar") series instituted by the CIF in 2007. This monthly series has already highlighted climate change and will include further sessions on I&A in the future.

Risk-spreading processes

Forest companies, like any other, engage in risk management as a part of normal business practice. However, some aspects of forest management make risk management more difficult. For example, the commitment to long-term decisions mentioned above makes it difficult to change the species in a forest stand once they have been established. If an insect outbreak occurs, expensive treatments after the fact are usually the only option (spraying pesticides, salvage harvesting), rather than changing the tree species to something less susceptible. With respect to the impacts of climate change, the rate of change expected under future climate scenarios is likely to exceed the rotation period of most forest species in the BPE.

Another basic risk management approach in business is to diversify the portfolio of assets held. Forest managers are constrained both by the natural environment (only certain species will grow there) and by policy which usually stipulates that whatever species is harvested must be re-planted. The ability to diversify the species mix on the landscape may in some cases be limited. In addition, some managers focus on doing what has worked in the past and do not consider planting different species.

Manage information

The larger organizations generally have adequate knowledge-sharing mechanisms, such as in-house training sessions, newsletter and periodic meetings. However, corporations vary in their culture of sharing information. Some leaders see knowledge as power and will only share with those who will not use it against them. If innovation is required to adapt to future conditions, but the culture is one that does not value new information or ways of thinking, adaptive capacity will be reduced.

Understanding

The general level of understanding of climate change, and the willingness to take it seriously as an issue, is high in the Canadian forest sector. The question among managers is not whether climate change is real, but rather what the local impacts will be and what adaptation actions need to be taken. As mentioned above, current information on impacts is available at temporal and spatial scales quite different than those required for planning and operations. Downscaling and ecosystem modeling techniques exist that could partially answer some of these questions. However, they require fairly sophisticated expertise and have large uncertainties associated with them. Finally, climate change is only one source of change affecting the forest sector. Other sources of change include demographic shifts in rural populations, the effects of global market forces on the forest industry, local and national political change and changes in society's expectations of the values and benefits available from the forest. The integration of climate change with these other agents of change is a challenge for forest managers, given high levels of uncertainty and current economic instability and poor market conditions.

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Chapter 7
Assessing the Adaptive Capacity of Canadian Forest Sector Firms in the Boreal: How do they respond to climate change?

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The Canadian forest sector is both an important part of the Canadian economy (and even more so in many of the rural communities found across Canada) as well as the policy framework within which Canadian forests are managed. Given the potential of climate change to affect Canadian forest resources, there is still little understanding of how vulnerable the Canadian forest sector may be to such changes (Johnston and Williamson 2007). These changes may either have a physical effect upon the forest resource and/or socioeconomic effects through changes in costs, markets, or broader institutional changes such as the introduction of new management objectives or new regulations. A key part to assessing that vulnerability is understanding what exposure forest sector firms in Canada have to the effects of climate change and what factors affect their ability to adapt and minimize the potential negative impacts of these changes

The purpose of this paper is to investigate how Canadian forest sector firms perceive what exposure they have to climate change including the magnitude of those risks. I focus on those firms with operations in the Canadian boreal. It is anticipated that the boreal forest may face the greatest potential changes within Canada because of its existing location and a relatively greater increase in temperature relative to other regions of the world (Johnston and Williamson 2007; Ogden and Innes 2007b).

I first review the existing discussion around climate change and the Canadian forest sector. Much of the discussion has taken place around identifying the negative impacts upon the forest resource and implications for forest management, along with associated impacts upon other forest values. I then build upon the adaptive capacity framework proposed by Johnston and Williamson (2007), to consider what different factors are important in determining adaptive capacity and at what level those factors might operate (at the industry versus firm level). Based on a set of interviews with firm representatives, supplemented with additional information, I then provide an assessment of what factors currently appear to be most important in determining what actions Canadian forest sector firms might take towards responding to climate change, including to what extent the boreal poses particular challenges or opportunities.[15]

[15] I would like to thank William Nikolakis who carried out many of the interviews and who assisted in the preparation of the report.

Climate change impacts on Canadian forests

There is an extensive literature on the impacts climate change may have on Canadian forests, with most of the work focusing on biophysical effects and the resulting outcomes on the forest and consequently the forest sector through interruptions on fibre supply. Examples of this include increased natural disturbance (pest infestations and forest fires) Flannigan et al 2005; Logan et al 2003; Volney and Hirsch 2005) and extreme weather related events such as flooding and drought (Hogg and Bernier 2005). There may also be changes in timber quality (Kellomaki et al 2005, Spittlehouse 2005). Spittlehouse and Stewart (2003) also identify how shorter winter seasons may require companies to modify their winter operations.

There are also complex effects associated with climate change that have a more uncertain influence on forest productivity. For example, climate change may lead to variations in forest productivity that may have a positive impact on timber growth in some areas and on carbon storage (Johnston and Williamson 2005; Volney and Hirsch 2005). There could also be shifts in species composition (Johnston et al 2006). Ogden and Innes (2007b) note that the overall impact on forest growth and productivity can be expected to differ between regions, and will depend upon species composition, site conditions and local microclimate.

Ogden and Innes (2007a) identify strategic and operational adaptation options for forest management linked to these different impacts. Many of these would lead to changes in existing forest practices, whether in regards to harvesting, such as increased salvage logging associated with the increased disturbance (Spittlehouse and Stewart 2003); more intensive management on the landscape through zoning (Innes and Nitschke 2005); reductions in rotation ages (Lindner et al 2000); and changes in regeneration strategies (Kellomaki et al 2005; Lemmen and Warren 2004). There may also be impacts upon timber supply where forest managers start planning for increased disturbance (fire and pest infestation) and start changing protection and regeneration strategies, or move away from the standard forest management planning approach which assumes a static climate (Ogden and Innes 2007b). The effects of climate change can also affect other forest values (such as biodiversity) where existing habitat may be lost or degraded. Maintaining or providing replacement habitat may lead to competition between timber supply and these other values. This, in turn, can trigger changes in land use or the forest management framework in order to achieve environmental objectives with a subsequent impact on timber supply (Scott and Lemieux 2007).

Beyond these biophysical impacts on timber supply, a number of authors have identified new ways in which the forest resource could be used that can take these expected impacts into account. These include diversifying the forest economy by developing products for dead wood and non-timber forest products (Ogden and Innes 2007a) and looking towards new markets that may provide a value for enhancing carbon sinks and reducing emissions (St. Jean Conti 2008; BCMOF 2006).

Determinants of adaptive capacity

McCarthy et al. (2001) proposes that the adaptive capacity of human systems is determined by:

1. Science and technology (i.e., Do we have a sufficient understanding of the underlying science? Are there technological options available for adaptation?);
2. Social capital (trust, networks),;
3. Financial resource availability,
4. Human capital (knowledge, skills, experience, expertise),;
5. Institutional design (flexibility, autonomy, mobility),;
6. Risk management capacity; and
7. Perception of climate change risk.

Johnston and Williamson 2007 propose a framework that explains the vulnerability of the system (in this case the Canadian forest sector as part of the forest management system) based on the exposure of the system to climate change, the sensitivity of the system, and adaptive capacity.[16] In their framework they identify several different factors that can affect the ability and likelihood forest managers will pursue adaptation actions that mitigate impacts, including among others knowledge and awareness of potential outcomes, flexibility of existing institutions and policies, and the availability of financial resources, technological capacity, and human capacity. However, they note that there is a lack of understanding to what extent these are issues facing the Canadian forest sector or their relative importance in affecting forest management in Canada.

Adger et al. (2005) characterize actions associated with building adaptive capacity that include communicating the effect of climate change and building awareness, along with protecting resources, maintaining economic growth, or exploiting new opportunities. They also identify three directions for adaptation actions: those that reduce the sensitivity of the affected system; alter the exposure of the system; or increase the resiliency of the system. In the case of the biophysical impacts identified earlier, reducing the sensitivity could include planting tree stock that may be better suited to new climactic conditions or is hardier and better able to withstand temperature fluctuations and drought. Altering the exposure of the system might mean reducing the likelihood of large-scale disturbances (such as fires) through changes in forest management and planning. Increasing the resilience of the system could mean developing alternative products and markets that can offset potential losses in timber supply or a decline in timber quality.

Adger et al. (2005) also point out that adaptation takes place at different scales, where the national government may establish a general policy direction, where regulators (both economic and environmental) at the state level may provide more specific rules or objectives, while companies at the local scale make the decisions about how to best manage their business to meet both their business requirements and policy demands.[17]

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[16] In the rest of this paper I use the term risk to reflect how climate change is framed within the business community.

[17] They offer the example of UK water companies, where the UK government has required water companies to take climate change seriously and plan for a changing climate (without specifying how they should plan or what should be required in such plans). Both national regulators provide some additional rules, with the environmental regulator concerned about maintaining a reliable supply, while the economic regulator looks out for consumer interests while recognizing the need for firms to remain commercially viable. It is the companies themselves that decide whether they want to engage in mitigation activities or pursue demand management strategies or other ways of addressing the potential risks.

It is also important to distinguish between what factors are important at the industry level and what are significant at the firm level. Ultimately it is firms that undertake adaptation activities, and there are firm-specific characteristics that can affect their ability to adopt in addition to those sector-related factors. For example, technology may be widely available to the sector, so it is not firm specific, but the availability of financial resources to invest in or adopt those resources will be firm specific. In some cases, there may be information provision or information sharing that is generally available through industry consortia or networks that firms can access, but the ability of firms to utilize that information can depend on their capacity to acquire that information and process it (they may be small and not have the human resources or they may not have the expertise).

In the case of firms, climate change may also have economic and financial effects through their impact on markets, and firms may see different potential risks depending on what products they make and which markets they serve. For example, climate change can impact firms through (a) changes in prices of locally produced goods and services (i.e., as a result of price changes in export markets); (b) change in availability, quality and cost of inputs (e.g., wood inputs, energy); and (c) increased financial uncertainty (i.e., increased variance in supply of inputs and potentially in input and product prices). The magnitude of the net economic impacts on firms will ultimately depend on the ability of firms to adapt and adjust to these changes. Firms also have to take into account any regulatory changes (e.g., emissions regulations, carbon targets) that may also affect the business environment within which they operate as it can also affect their relative costs. All of these changes are also relative to how they may affect their competitors.[18]

One other important distinguishing factor at the firm level is differentiating between the actions the firm can take in the short-term versus the long-term. In the short term, business decisions are constrained by the fact that some inputs (such as a firm's capital stock) or reliance on particular markets and products are fixed and this can constrain options for adaptation in the short run. In the long term, all inputs (including capital) are variable and a different set of adaptation strategies might be possible.[19] Therefore, firms have greater flexibility to change their strategic focus. Part of this may involve making investment decisions (or changing the kind of investment decisions you make) to incorporate the risks associated with climate change that will help facilitate adaptation.

The starting point for many of these decisions is how the firm views climate change and in particular the risks and opportunities it may create for the firm. I earlier noted that there are a number of potential risks that have been identified; many of these are around the level of timber supply; greater variability in fibre availability and quality; and increasing cost structures. Because of this, information plays an important role both on the risk assessment side as well as

[18] The few studies that have looked at the effects of climate change on global timber markets suggest that there will be a general increase in global timber supply over time and that the main beneficiaries in terms of producer benefits will be countries with fast growing plantation forests (e.g., Chile, New Zealand). Producers of traditional forest products in Canada are more likely to be harmed by global market impacts due to a dampening of prices.

[19] In the context of investment decisions, short-term adaptation options might extend to technological options such as retrofitting existing mills or investing in harvesting equipment designed for different operating equipment; while longer-term firms could choose to invest in new facilities or new types of production processes.

informing the different adaptation options. From the impacts side there may be issues related to: information that is either lacking or scientific uncertainty (so there is uncertainty about the impacts and hence risks); the acquisition of the information (is the information out there but difficult or costly to find?) and the ability to utilize the information (is it in a fashion that is not useable from the firm perspective?). Similar questions may exist for adaptation options: firms may not have sufficient information on practices or technologies that may permit adaptation.

Therefore, in assessing the potential adaptive capacity of Canadian forest sector firms, we need to understand first how they view climate change and what urgency they attach to the issues it raises, and then investigate what factors influence their response-and to what extent those are specific to the firm or reflect more generalized systematic factors (such as policy).

Methodology

The primary research method was a survey instrument targeted towards senior decision-makers (at the vice-president level or higher) with Canadian forestry firms who had operations in the boreal. Through interviews with different stakeholders involved in climate change discussions (both in government and in industry associations) I identified representatives at those firms that were either responsible for addressing climate change or had represented the firm in climate change discussions in different venues. In total, we were successful in interviewing eleven senior forestry executives from seven Canadian forestry firms (of which six had operations in the boreal). Three firms declined or did not respond to requests for interviews. We also interviewed three industry representatives, two representing the national association and one a provincial association. We also utilized any publications where companies discussed climate change: these included sustainability reports as well as submissions prepared for different environmental initiatives (such as the Carbon Disclosure Project).

We organized our questions around four sets of topics: 1) those asking about what risks and opportunities firms saw and to what extent these may be specific to the boreal; 2) how firms could respond to those risk and opportunities and what internal and external factors affected their response; 3) how the company approached the issue of climate change and what motivated action; and 4) what was their future vision of the boreal.

In the results we first list the questions and then selected responses to those questions from the interviewees. We then summarize common themes or elements but also identify where there were important divergences in opinion and what factors might explain these differences.

Results

The first set of questions focused specifically on the forest resource itself to assess what knowledge firms had of potential impacts associated with climate change and to what extent they viewed the boreal (or their operations in the boreal) as being vulnerable to effects of climate change.

Does operating in the boreal make you more vulnerable?

"I don't think one forest region will be more adversely affected than others." *Chief Forester, major forest products company, Canada. (Company A)*

"You definitely see an effect; there is a movement of boreal tree line to the north and encroachment of aspen parkland. This reduces potential fibre supply and increase costs as we move further north." *Director of Environment, major pulp and paper producer, (Company B)*

"The boreal might shrink; we may see a fragmentation of forests. This will potentially have an effect on species migration. The boreal will be an issue of public policy for a long time to come." *Technology Director, major forest products producer (pulp division), Canada (Company A)*

"I don't know if the Boreal is at great risk, it's pretty resilient. It's not like the St Lawrence Great Lakes forest, where there are white oaks which are shallow rooted. Boreal is most at risk from fire and there are some shallow rooted species that may be impacted by drier conditions." *Senior Executive, North American forest products company. (Company B)*

"In the short term not a lot. Over the long term we will need to build flexibility in our models and monitor what's happening. If you're on the fringe areas you will be at greater risk. In the Prairies we will probably see changes... If you're on the cusp of transition areas you will probably be impacted first. If we're not getting cold temperatures then problems will happen like mountain pine beetle. We can overcome certain problems through spacing and focusing on mixed species. We can also overcome fire dangers. Species on dry sites will be impacted significantly." *Senior Executive, North American forest products company. (Company B)*

"The Northern strip Boreal is a bit more susceptible to changes in climate; there is lots of diversity and lots of likely changes. But it's not nearly as susceptible as agriculture in Central Canada because of a changing climate. In the Boreal its all speculations, we don't anticipate seeing major changes in the short term. There is a strong resiliency in forests- it's not believed by the media. The risks are more longer term than claimed in newspapers. We have time to adapt." *Senior Executive, North American forest products company. (Company D)*

"I don't think the Boreal will be affected more than other forests, the trees won't die- it will be greener if anything." *Senior Executive, Woodlands, North American forest products company. (Company B, US division)*

"We know now that the minus 40 degree isotherm has retreated into the boreal, it's now at its limit in the boreal…If -40 keeps on retreating eastward then there will be a complex interaction." *Technology Director, major forest products company, (pulp division) Canada (Company A)*

Overall the boreal forest was not seen by most interviewees to be particularly vulnerable. They did not see substantial risk in terms of changes in the physical availability of timber nor the quality of timber although several did see shifts in the distribution of forest that in some cases might affect specific operations.

The next question investigated in more detail what kind of risks might arise, including not only the biophysical effects but also at a more systemic level, including not only the business environment but potentially how it might change management emphasis or social expectations.

For forest product firms operating in the boreal what risks do you see from climate change?
Most of the interviewees were aware of the general impacts climate change could have on the forest resource in the boreal.

> "Climate change definitely increases the level of uncertainty. We will need to be adept to respond to insect infestations, changes in operating seasons." *Senior Executive, North American forest products company. (Company D)*

> "Harvesting methods may change as there may be soggier ground. This will also affect when and where we replant." *Technology Director, major forest products company, (pulp division) Canada (Company A)*

> "There will probably be an increased fire potential, this is less likely in hardwoods, but in the boreal there is lots of mixed wood so the potential there is higher. Mountain pine beetle and there may be problems with silviculture if it becomes too arid." *Senior Executive, North American forest products company. (Company B)*

> "If you look at the business in its entirety the risks will be that there may be a shift of species, forest fire, drought, varying weather conditions and these will impact fibre supply. There are also regulatory risks, risk with public and customers- the public relations risk." *Senior executive, major pulp and paper producer, Canada. (Company F)*

However, while interviewees were aware of the risks of increased fire, drought, or disturbance, no one had any specific information or projections as to how it might apply to either the boreal generally or more specifically to the region or province within which they were operating. One interviewee directly commented on the scientific uncertainty around what scenarios to consider:

> "There are so many different scenarios on climate change, I went to a conference in Denver and this guy from Champion says we've got two different climate models presented at this conference, one says Seattle will be warmer and drier and the other says colder and wetter, there is still a lot of uncertainty." *Senior Executive, major forest products company, (Company A).*

Instead many were focused more generally on how climate change might change overall risk within the system:

> "Thinking about risk it's a big topic. Climate change could potentially impact the entire businesses value chain; from the forest working through to processing and in the marketplace with the publics' perceptions on the role of forests in climate change. Climate change could impact our social license and the purchase of wood products by the public." *Chief Forester, major forest products company, Canada. (Company A)*

> “My first comment on risk is that our time frame is shorter than those in research and government. The projected effects of climate change on the Boreal like on species and operating seasons is longer than the business cycle. We have to be careful not to speculate, like whether some species will be suited to certain areas. We can’t let the long term impacts affect our short term decision making.” *Senior Executive, North American forest products company. (Company D)*

> “ENGO risk and other significant stakeholders focused on the Boreal for greater set asides and decreases in forest management. They are taking advantage of the climate change issue to slow down or eliminate extraction activities.” *Senior Executive, Woodlands, North American forest products company. (Company B, US division)*

> “Customers know that we don’t have supply in the Boreal and they are happy about this.” *Senior executive, major pulp and paper producer, Canada. (Company F)*

> “If we find a shift in climate, boreal may be an area where we may have to ratchet up our monitoring of bird and fish species. It’s a long term issue but always boils down to short term activities, will have to broaden scope of monitoring and landscape assessment.” *Senior Executive, Woodlands, North American forest products company. (Company B, US division)*

Instead, the greater risk for several of the interviewees associated with operating in the boreal was whether or not their activities within the boreal would be viewed as environmentally positive or could become the subject of market actions by ENGO’s.

Do you see any opportunities?

> “Overall we will better manage our forest asset because it will not simply be about cutting down trees; there will be more products outside conventional forestry available for companies.” *Senior executive, major forest products company, Canada. (Company E)*

> “Legislation on greenhouse gas is ok on the solid wood side, so I think we are overall in a good position. We are honestly sorting our way through the opportunities. Afforestation in the prairies is one, there are lots of potential for carbon trading- we haven’t looked too much into it. We use lots of biomass so we have may have lots of carbon credits.” *Senior Executive, North American forest products company. (Company B)*

> “We see climate change as an opportunity, wood is favorable in terms of carbon; this is a great opportunity for forest products from Canada to be a part of the solution. We are moving towards carbon neutrality. Forest management is excellent in Canada. We can pursue opportunities such as carbon capture through afforestation, as well as bio-energy and other uses of the forest to get higher value.” *Director, industry association. (Industry Association)*

> “The real opportunity is on the renewability of forests and that offset carbon.” *Senior Executive, North American forest products company. (Company D)*

> "I think you will see the industry adding new products." *Senior Executive, North American forest products company. (Company D) [Around biofuels and chemicals derived from cellulose]*
>
> "People talk about all these other products that may be produced using cellulose. Do you know how much it costs to build a pulp mill? It's about $1 billion dollars. We have a mill doing different kinds of things at Port Alice which is close to bankruptcy." *Technology Director, major forest products company, (pulp division) Canada (Company A)*
>
> "When we go to increase monitoring … you do it for the forest and you can sell it. There are people interested in it, those in the ethical investment communities. We can develop partnerships for assessments." *Senior Executive, Woodlands, North American forest products company. (Company B, US division)*
>
> "One of the more interesting opportunities is the alternative fuels or energies…The big chunk of biomass is from forests. We are in the wood business and there are a bunch of people in the energy business that want to come over to this." *Senior Executive, Woodlands, North American forest products company. (Company B, US division)*
>
> "We have to differentiate ourselves in the marketplace on carbon and being carbon neutral. We see margins; we can charge some customers more for green products." *Senior executive, major pulp and paper producer, Canada. (Company F)*
>
> "We think companies in BC are taking a backward approach to climate change by saying that we've done enough already. We think we can turn this around to our favor, like in generating green electricity and supporting value added manufacturing." *Senior executive, major pulp and paper producer, Canada. (Company F)*
>
> "Other opportunities include increases in non winter logging seasons. In order to minimize working capital outlays we have expanded summer logging seasons." *Senior Executive, major forest products company, Canada (Company A)*
>
> "Also, I haven't kept up with tree science, but studies on trees in the past showed that trees in enriched CO2 environments grow quicker. This may impact rotation and tree length. It's conceivable that we may have faster growth." *Vice President, major forest products company, (pulp division) Canada (Company A)*
>
> "It may enhance the growth of hybrid poplar plantations; we are conducting work to improve the species selection criteria, identifying the ambient air temperature to increase growth rates. Also, the carbon economy is another opportunity we are examining offsets through plantations. The commercial opportunity is to sell offsets as well as furnish to mill." *Director of Environment, major pulp and paper producer, (Company C).*

How can companies respond to the risks and/or opportunities?

"At an operations level, at mills there is an ongoing effort of energy efficiency and fuel switching done primarily as an economic driver, but it's also good for the climate." *Director, industry association*. (*Industry Association*)

"Climate change will force us to focus on eco efficiencies. We are now less likely to invest in derelict mills. In the past you had situations where the strongest companies bought out smaller weaker companies with older equipment. But now smaller companies are so derelict that they are not worth investing in unless they have lucrative tenures." *Technology Director, major forest products producer Canada (Company A).*

"The company is looking very carefully at which parts of our business are carbon positive and negative. We've been thinking about carbon balance for a long time. We have lots of data from studies we have conducted." *Chief Forester, major forest products company, Canada. (Company A)*

We have been followers on climate change, if you lead you may lose. For example there is still a lot of uncertainty about whether if you invest in an MDF plant in 1994 do you have any credit? *Senior Executive, North American forest products company." (WF)*

"We now have a greenhouse gas component in our budgets and projections, it is a debit or credit, but it's really difficult to identify the numbers." *Senior Executive, North American forest products company." (Company D)*

"There are two approaches. First you can be in denial of climate change, or secondly you can develop technologies to make the best of the changes by developing strategies and technologies to capitalise on climate change…We're fortunate that under Kyoto that biomass is seen as carbon neutral." *Senior executive, major pulp and paper producer, Canada. (Company F*)

"From a business perspective…green energy – that direction is the first step…We aren't leading the pack especially given the uncertainty." *Senior Executive, major forest products company, Canada. (Company G)*

"The company has done a lot of work on life cycle analysis and carbon footprint in manufacturing and extraction." *Senior Executive, major forest products company, Canada (Company A)*

"Identify the growth of trees and planting an optimal tree at the different latitudes. Also, this must feed into what climate change scenarios are probable and likely." *Director of Environment, major pulp and paper producer (Company C).*

For the most part firm's assessments of the opportunities and risks were shaped by the type of operations they carried out. Generally those firms that were either more oriented towards pulp and paper or executives responsible for pulp and paper within the firm were more predisposed to viewing climate change as an opportunity rather than a risk. Those on the solid wood side were unsure about the opportunities (around Carbon) although several discussed the idea of generally promoting wood as an environmentally preferred building material (both in its renewability and lower C footprint) and the expectation that it might help contribute to increased demand in the future.

What internal factors affect the ability of the company to respond?

> "In the short term it may be difficult to justify some of these decisions, particularly given the cost structures we already have. The issue is the sector viability in the short term versus mitigation of the long impacts of climate change." *Director of Environment, major pulp and paper producer (Company C).*

> "You either have the resources to think about climate change or greenhouse initiatives or not. The smaller you are the more focused you will be on efficiency." *Senior executive, major forest products company, (Company E).*

> "We cannot consider climate change in a strategic context. There are implications, but if I want to get it on an agenda I don't think I could keep it up high for very long. Can we focus on curtailment of production or on mitigation? It is a poor market place and we aren't very desirable for investors." *Senior Executive, major forest products company, Canada. (Company A).*

> "US companies have problems with understanding their civic duties in Canada. In Canada there is a higher level of management for forests." *Senior Executive, North American forest products company. (Company B)*

> "We have less capital and money to do things. It may need some incentives from the government side on carbon initiatives. Most money companies now spend is focused on increasing cost efficiencies. But at the same time we still focus on reducing our footprint." *Senior Executive, North American forest products company. (Company B)*

> "There is the cautious business approach which stops us flying into something that's just noise. We could be described as a conservative organization from the bottom to the top with regard to climate change. That has inhibited how fast we have embraced climate change. There is still scepticism when you hear reports last month when you hear that there was recovery of temperature in polar caps, temperatures lost have been fully regained. Let me talk more about scepticism, there is lots of noise we just don't want to throw money at something that isn't going to help us." *Senior Executive, Woodlands North American forest products company. (Company B, US division)*

> "The key to us is that there are so many things on our plate and are you going to spend too much time in the grey zone when there is so much black and white happening? So given the uncertainty we just don't have the resources." *Senior Executive, major forest products company, Canada. (Company G).*

One predominant theme was that current financial capacity was limited as was organizational resources that restricted the ability of firms to respond to issues raised by climate change. Not only was there a sense that climate change was not as urgent an question as other issues firms currently faced, such as the challenging economic environment, but that uncertainty around the potential physical impacts on the resource or to the firm meant it was difficult to raise as an issue that required immediate attention.

What external factors affect the ability of the firm to respond?

> "The financial impact of markets is having the biggest impact on the industry, you know if you ask someone in the emergency ward about their future they won't be able to tell you anything." *Director, industry association.* (*Industry Association*)

> "…In the Federal world there has been a lot of discussion for a long time on carbon, it's a slow process to implement anything but this is because of a change in government. At a provincial level we went from a government that wouldn't implement carbon regulations to a strong statement overnight on climate change. I don't know how this will play out for the sector. So you have regulation from two fronts and companies operating in more jurisdictions are facing regulation on a number of fronts during a time of great uncertainty…Businesses find it difficult to deal with uncertainty particularly with a long-term risk like climate change. Also people are beginning to discuss that in the US post election they will have a federal regulatory regime. This will have an impact given the importance of this market to Canada's forest products industry. So all this regulatory uncertainty makes planning difficult at this stage." *Director, industry association.* (*Industry Association*)

> "There is lots of uncertainty and confusion, Federal and Provincial policy is running parallel and this has slowed down forest product companies pursuing opportunities for greenhouse reduction. Do we get any credit for actions today, will it be from BC or the Federal government- there are currently no incentives to invest in these projects." *Senior Executive, major forest products company, Canada. (Company G)*

> "Carbon regulation will likely put constraints on pulp. We are price takers; we can't pass costs along to our customers. A lot of our competition is outside of the WCI. There are significant added costs. We are a small emitter of carbon, especially when you compare us to oil and gas and coal powered plants." *Senior Executive, North American forest products company. (Company D)*

> "There is the potential for double jeopardy for forest product companies paying for carbon." *Senior Executive, major forest products company, Canada. (Company A)*

> "We may potentially be at a competitive disadvantage in BC if we buy in at a carbon tax of 30% when the Federal system is at 18%." *Technology Director, major forest products company, (pulp division) Canada (Company A).*

> “The different base years creates problems across the provinces. Why would you do something if you aren’t sure if it’s the base year, you won’t get any credit for it.” *Senior Executive, North American forest products company. (Company B)*

> “The forest management regime of the province doesn’t support strategic planning. Decisions made in the last 10 years by government have continued to make it clear to companies that what they have may not last into the future, this will need to be addressed- companies won’t take long term strategies.” *Director, industry association. (Industry Association*)

> “We are just a tenant...Are we going to be there long enough? There is no incentive as a license holder to invest in potential projects if we don’t have certainty in reaping the full benefit of it. These predictions on higher tree growth, operating seasons and fibre are too risky to base investment on. But at the same time we have to keep nimble to take advantage of any potential changes.” *Senior Executive, North American forest products company. (Company D)*

> “…On crown land on volume based tenures it makes it difficult to play in that game as the landlord will probably accrue the benefits.” *Senior Executive, major forest products company, Canada (Company G).*

> “Social perception of the role of the forest product sector on climate change. If we are seen as part of the problem then capital will shift away from our business.” *Senior Executive, major forest products company, Canada (Company A).*

Again access to capital and market conditions were also cited as external factors that were impediments to responses. Despite the interest in renewable energy and availability of “green capital” in the private sector, none of that was flowing into forestry. Several interviewees noted that the longer-term nature of the issue was at odds with the current forest management framework, and that firms did not see how they might benefit from undertaking any kind of different forest management activities.

How does your company deal with something like climate change?

> “Climate change comes up regularly on the Boards agenda; they are briefed quarterly on the Environmental, Health and Safety sub Committee…Awareness is high; we have reduced our carbon emissions and manufacturing costs.” *Senior executive, major pulp and paper producer, Canada. (Company F*)

> “…We now have Independent Carbon Verification through [Det] Norske Veritas, we also have ISO 14000 64 on carbon reductions. When you’ve got a leader who is green it helps with this kind of thing.” *Senior executive, major pulp and paper producer, Canada. (Company F*)

> “Policy Council has a sub group on both climate change and green building. This is across both borders, has a couple of people from legal, forestry and business.” *Senior Executive, North American forest products company. (Company B)*

"Development and stewardship plans will incorporate climate models and make more sophisticated decisions on the land base and its use." *Senior Executive, major forest products company, Canada (Company A).*

"We will need to rethink training with employees and contractors to include fire fighting and fire suppression. If we are working in drier conditions then the likelihood of fire is increased." *Senior Executive, major forest products company, Canada (Company A).*

"We have internal climate change teams. We are trying to do a better job of tracking emissions and reducing our carbon footprint. We are actively trading on the Chicago Climate Exchange." *Senior executive, major forest products company, (Company E).*

"We have also mapped the life cycle of our products from the forest to the mill, tracking the carbon with Home Depot, the Hines Centre, Stora and Time Magazine to understand our footprint. We are closely plugged in, particularly with pulp mills to our carbon balance. BC Hydro just recently told us that our pulp mills are the biggest source of green energy in North America. We are expanding our biomass capacity, removing bottlenecks and putting in a gasifier to handle mountain pine beetle volumes. Gasification technologies are common place in Europe, but not in North America, they just haven't take hold here, but I think they will." *Technology Director, major forest products company producer, (pulp division) Canada (Company A).*

"We have a fibre strategy group who develop a long term fibre supply outlook. We also have a carbon team in our business group who look at emissions and try to understand the changing regulations…Our action to date is less than moderate, other than viewing carbon as a commodity and reducing carbon emissions on site…We are aiming to have an adequate supply of biomass to export electricity." *Director of Environment, major pulp and paper producer, (Company C)*

"We are looking at ways to utilise all fibre, leaving nothing left at the cut block. We can use everything that we cut for bio-energy, chips and saw logs." *Chief Forester, major forest products company, Canada. (Company A)*

"The Provincial government developed programs on strategies in forest management planning to deal with climate change. Also we receive information bulletins and memos on climate change from CFS, Forestry Canada, SFMN, FERIC- we get this on a regular basis." *Chief Forester, major forest products company, Canada. (Company A)*

"We value the work of others to help bring understanding like CFS, but there are too many silos between industry, government and academia that prevent cooperation." *Director, industry association*. (*Industry Association*)

In your view what would motivate your firm to take action?

"There is so much uncertainty, we haven't taken any of it on board. We haven't pursued opportunities because if we are regulated then do we pursue these new markets. We operate to react to legislative changes. But on the ground we haven't done anything that isn't supported economically- it needs to make economic sense." *Senior Executive, North American forest products company. (Company D)*

"There is a need to conduct some gap analysis to take some of the low hanging fruit. It doesn't cost a lot of money to do things." *Senior Executive, North American forest products company. (Company B)*

"On carbon trading there are lots of different places that we get information from and this in itself causes a lot of confusion." *Senior Executive, North American forest products company. (Company B)*

The internal responses to climate change varied between companies. Some had undertaken to incorporate it into standardized decision-making procedures (there were committees organized around it or it was a regular item at board meeting), while others were still treating it on an ad hoc basis. Several were involved in different C-trading schemes including the Chicago Carbon Exchange (CCX) or were participating in voluntary Carbon reporting initiative such as the Carbon Disclosure Project (CDP).

Strategic responses varied. All of the firms interviewed had developed either an emissions reductions and or energy management strategy for their facilities. Some firms had also pursued new product opportunities, looking into developing low Carbon products or the feasibility of supplying green energy. Only one company had actually introduced such a product however.

In terms of the physical risk, no firms had developed explicit strategies to address any of the potential impacts or any effect on overall timber supply (indeed one interviewee in a subsequent follow-up said that they did not have to incorporate climate change as the provincial government did that in its determination of the AAC). As noted earlier, one company did have a pre-existing fibre strategy, and that firm was starting to incorporate some of the physical changes associated with climate change into identifying whether it might lead to a modification in its strategy.

What mainly motivated firms to act at this stage was risk management. All firms said economic drivers were the most important determinant of the actions that they could take (where there were existing marketplace opportunities) and indeed all the concrete moves they had made (investments) were all low risk in that they had pursued project or products with a profitable payoff that also had Carbon benefits. The main types of projects pursued included energy-switching projects utilizing wood residue and biomass (all of the firms surveyed had shifted their fuel use), and promoting products that reduced the use of virgin wood fibre use (either through the recycling or lowering the fibre content).

What is your vision for the future for the forest sector in the boreal?

"The long term future looks good. We still have a good fibre quality; we can make unique products that you can't get in South America, Asia or Southern US." *Senior Executive, major forest products company, (Company E).*

"My sense is that there will be political and demographic changes across the Boreal, including Russia. It will be a managed forest to serve global need for forest products because other forests around the world will be under a lot of pressure from population encroachment and other values such as recreation. The Boreal in Canada is well regulated and managed compared to competitors around the world." *Senior Executive, North American forest products company. (Company D)*

"I think the forest in the Boreal will be utilized, the government will be analytical. They will cut back on extraction, there are also other reasons, but it has to create jobs…It will be business as usual, it's an appropriate approach…You can't just set forests aside and think that they will look gorgeous forever, if you don't manage it properly then it's not the right thing to do, I think the world has learned that you just can't put forests aside for conservation." *Senior Executive, Woodlands, North American forest products company. (Company B US)*

"With respect to the Boreal and the various proposals on the importance of the Boreal, there will be increasing demands for protected areas and in reductions of extractive industry. Conceivably over time this will have implications on harvest level and location." *Senior Executive, major forest products company, Canada (Company A).*

"The boreal will be significantly smaller. There will be reduced harvesting, less industrial activity…this will occur in the Boreal for climatic and economic reasons." *Technology Director, major forest products producer, (pulp division) Canada (Company A).*

"We will need to move out of commodities like pulp and 2 x 4's and focus on value added products in the boreal. The bio-refinery model seems to be a good concept, where you have processing of cellulose for ethanol and generating surplus power- there may be the potential for generating green power which gets a premium when exported. Developing biodiesels for transportation will be an important supplement." *Director of Environment, major pulp and paper producer, (Company C)*

"The Boreal is an important player in the carbon climate change debate. My personal view is that the business will grow in the region and continue to be carbon positive. The industry will continue to look at opportunities to provide for regional communities." *Chief Forester, major forest products company, Canada. (Company A)*

Discussion

Canadian forest sector firms operating in the boreal have started to undertake actions to increase their adaptive capacity in response to climate change. Most of that activity has been directed towards incorporating the effect of C emissions in their business activities. There are also variations between companies; several have pursued some of the opportunities further than others, which in certain cases appear to be either related to the nature of the markets within which firms are operating or opportunities they see, while others express more skepticism or uncertainty and have focused more on managing risk around their C emissions. The potential biophysical impacts or forest management implications did not appear to be a major consideration for firms in assessing climate change, and there did not appear to be any kind of significant response to date (either at an operational or strategic level).

The emphasis on C emissions and progress made in this area occurred despite the lack of formal regulatory structures throughout most of Canada until recently, driven in large part by an overall change in the business environment in which Corporate Social Responsibility (CSR) has become part of the landscape.[20] In CSR, firms are evaluated on their performance on social and environmental issues (see Cohen, Nelson and Nikolakis 2007), and greenhouse gas emissions and efforts to reduce Carbon emissions are the main ways in which company efforts are assessed in regards to climate change (Bonini and Mendonca 2008; Esty 2007). This has contributed to dialogues and quantification protocols raising awareness within companies. It has also led companies to devise strategies around emissions reductions, including internal targets and in some cases firms are also developing procedures or assigning responsibility to climate change, institutionalizing within the firm. Some of the firms interviewed are also starting to incorporate C impacts into their overall business strategies and decision-making procedures.

Some firms have been exploring product development and one firm was investigating differentiating itself or at least a portion of its product line) on the basis of being low Carbon (or carbon neutral). There is also an industry-wide initiative in this regard (FPAC's pledge for Carbon neutrality by 2015).

The main risk companies saw was the existing regulatory uncertainty around Carbon. Competing schemes stall investment and make it difficult for firms to develop longer-term plans. Table 1 illustrates the different schemes currently announced that can potentially affect firms operating in the Canadian boreal. In addition to differences in the type of system, and different rates, there are also potentially different baselines and different rules for what may qualify as offsets, adding to the regulatory confusion.[21]

Table 1. Different GHG Regulatory Systems Potentially Affecting Canadian Forest Sector Firms Operating in the Boreal

Jurisdiction	Requirement	Effective Date	Mechanism	Offsets to be allowed
Canada	20% "Intensity" reduction by 2020	2010	Intensity cap & Trade for Large Emitters	Yes
BC	33% absolute reduction	2008	Carbon tax, cap & trade for large emitters	Yes
AB	20% intensity reduction	2007	Intensity cap & Trade for Large Emitters	Yes (Alberta

[20] The theological question-should there be CSR?-is so irrelevant today.. The question is not whether but how…" John Ruggie, Harvard University, as quoted in the Economist January 17, 2008

[21] "The different approaches could create a fragmented regulatory framework that would make Canada's securities law minefield seem like child's play by comparison." Melnitzer 2008

				only)
MB	15% minimum absolute reduction	2009/2010	Cap & trade for large emitters	Yes
PQ	Reduction to 1990 levels	2008/2010	Carbon tax on energy producers and importers (2008), cap & trade for large emitters (2010)	Not yet specified
ON	Reduction to 1990 levels	2010	Cap & trade for large emitters (2010)	Not yet specified
Western Climate Initiative (WCI)(BC, MB, SK, PQ, Wa, Ca, Mt	15% minimum absolute reduction from 2005 levels	2011	Cap & trade for large emitters	Yes

BDO Dunwoody 2008

There is not much discussion or awareness at higher levels within the firm of what physical risks firm may actually face to their timber supply or infrastructure. Corresponding to this is that in terms of strategies firms do not feel the need currently to address physical risks associated with climate change nor to prepare themselves. It is not clear whether this is due to the fact that most firms feel the effects are far enough away or the uncertainty is so great so as to not warrant further attention, or whether they do not have the capacity or resources to devote to those kind of efforts. Indeed there are only a few firms in Canada that have addressed climate change in the context of preparing their long-term forest management plan (Van Damme et al. 2008). Elsewhere, forest management plans continue to rely on incorporating static analyses of climate and associated disturbance rates with no changes in assumptions about the success of different reforestation strategies For the most part firms appear to either have an expectation that government will do it or that it will not have a material effect upon their operations (or at least within a time frame that they appear concerned about).

None of the firms appear to have considered whether C emphasis and combining with timber supply may lead to new vulnerabilities-increasing competition on the landscape and other values for the forest resource. Some firms did see additional uncertainty in how the market might perceive their firms, especially for those operating in the boreal where there competing versions of how forest management should be viewed (these are differences between ENGO's and governments).[22]

[22] Ethical Funds (2008) recently released a report in which they assessed the efforts of Canadian banks in regards to climate change by assessing their lending practices, with a focus on forest management and land use in the boreal and to what extent banks took current ENGO proposals into account.

There has been substantial discussion of the implications climate change may have for businesses, including its effect on supply chains (see, for example, GBN 2007; GCI 2006a; GCI 2006b; and Llewellyn and Chaix 2006) but no one interviewed suggested that they had undertaken any kind of larger strategic analysis such as the kind proposed by Porter and Reinhardt (2007) to see how the firm might either reshape itself to take advantage of opportunities or examine how the competitive landscape might change for their existing businesses.[23]

Conclusions

In terms of the policy implications, these results raise several issues. First, the acquisition and utilization of scientific information has been identified as an issue for the Canadian forest sector previously (Nelson et al. 2003), and there are issues around the knowledge and information Canadian forest sector firms have about the magnitude of the biophysical risks firms may face in the boreal. There is a need to resolve where there are information gaps versus clarifying what uncertainty exists about the range of impacts (for example, under current management approaches fires are expected to increase significantly with a corresponding increase in the amount of area burned).

Second, the existing confusion due to the profusion of competing regulatory schemes reduces the ability of firms to undertake longer-term actions-investments-that could enhance their adaptive capacity. This is not just a Canadian issue - it is a broader one affecting firms more generally.[24] But within Canada the need for a coherent and consistent regime is essential, especially if firms are to develop an effective risk-management approach around C, and to pursue C related market opportunities (whether it is in forest offsets, green energy, or more C friendly products).

While Canadian forest sector firms have shown the ability to mobilize their resources and reduce their C footprint, (embracing alternative and renewable fuels, adopting fuel saving technologies, and implementing emissions abatement practices), much of this has been done to reduce the impact of increasing energy prices. Firms have seen such strategies as low risk as these investments and changes can pay for themselves. But any major changes in business models or any kind of significant investment in adaptation will wait until firms start to develop a strategic approach to climate change. For that to happen, firms will need to see more clarity in the regulatory environment, not only on the C emissions side but also on whatever offsets regimes are proposed. Firms need to see that markets will be viable and to have greater certainty on what carbon prices might be.

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[23] At the same time, it was apparent in the interviews that this was rapidly changing landscape-one association representative indicated that it was only within the past few months that some companies had become more energized around climate change issues, especially those that had expressed more scepticism about the issue.

[24] "In the current unpredictable national climate policy environment [referring to the US], it is exceedingly difficult and risky for businesses to evaluate and justify the large-scale, long-term capital investments needed to seize existing and emerging opportunities…"
Financial investors writing the US Congress in the Spring of 2007 (Esty 2007:30)

Finally, as part of developing adaptation strategies, Canadian forest sector firms will also have to gain a better understanding of how the impacts of climate change might affect the forest resource, even if firms do not currently see a direct impact upon the forest resource. Although they may view it as being sufficiently far in the future that it is not within their decision-making horizon, there is the potential through the existing policy framework in which current management plans or emphasis might change even to address expected future impacts. Therefore, there may be changes in forest management policies that take place sooner, prior to directly observing some of these impacts, and firms do not appear to have prepared or started examining that possibility. It is important to identify how the science around climate change will translate into policy and what implications that might have for firms (for example, how might provinces adopt different management practices to reduce the risk of fire or pest outbreaks and what impact would that have on timber supply?). Only a few firms have even taken the basic step of assessing their potential vulnerability through consideration in their longer-term forest management plans, but even in these considerations the objectives of forest management remained unchanged and it is not clear how the policy framework itself might change to facilitate adaptation. The challenge here is how to determine how both forest managements and firm managers can identify which range of measures that they can take that will support each others' actions, increasing not only the resiliency of the forest resource but the forest sector itself. One approach to start developing an awareness and discussion of the issues and adaptation options could have the regulator requiring companies to start taking climate change into account in the preparation of their forest management plans (without necessarily specifying yet how they might do it) and thereby starting to institutionalize the process of adaptation.

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Chapter 8
Assessment of Adaptive Capacity in Aboriginal Communities: Two Case Studies from Saskatchewan

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Two case studies are included, both based on M.Sc. student projects. The first is by Jeremy Pittman, M.Sc. student in the Department of Geography at the University of Regina and supervised by Dr. David Sauchyn. Jeremy did his work in the First Nations communities of Shoal Lake and the James Smith Cree Nation. Shoal Lake is approximately 200 km east of Prince Albert, while James Smith is approximately 40 km southeast of Prince Albert. See Pittman (2008) for further details.

The second is by Mathieu Lebel, M.Sc. student in the Department of Geography at the University of Saskatchewan and supervised by Dr. Maureen Reed. Mathieu's work took place in the Montreal Lake First Nation, approximately 80 km north of Prince Albert. In both projects, the students spent many hours in the communities talking with community members and elders about their experiences with climate and climate change, how they might be able to adapt to these changes and what factors limit their adaptive capacity. See Lebel (2008) for further details.

Case Study #1: James Smith and Shoal Lake First Nations

"This climate change is becoming an issue and there is more and more concern...the impacts it is having on [our] society as First Nations people because of our cultural links with Mother Earth. It has made impacts and...we have to live in the environment." - Respondent

Climate related stresses have the potential to threaten livelihoods, ecosystems, and the stability of communities throughout the globe. First Nations communities in Saskatchewan are no exception. Climate change will expose these communities to new climates and new stresses, either providing them with new opportunities or new challenges. Their ability to respond and cope with these changes is largely dependent upon their adaptive capacity. Adaptive capacity refers to the ability of the community and its members to cope and respond to change (Smit and Wandel, 2006). In order to gain insights into the sorts of adaptive capacities that exist in First Nations Communities in Saskatchewan, two case studies were completed in the communities of James Smith (I.R. 100) and Shoal Lake (I.R. 28A). A brief description of the communities and the results of the case studies follow.

Description of the communities

The communities of James Smith and Shoal Lake are situated in the Boreal Transition Ecoregion of Saskatchewan. The Boreal Transition Ecoregion is an area of transition between the grasslands and the boreal forest (Acton 1998), containing deciduous and coniferous trees and grasses at their range limits. Areas such as these are expected to undergo some of the most significant ecological changes under climate change (IPCC 1996, Wheaton 1997, Saporta et al. 1998), and communities in these areas will have to cope with, or respond to, these changes. With this in mind, the communities of James Smith and Shoal Lake were selected for the study.

James Smith

James Smith is located in an area that has undergone significant ecological changes in the past. Deciduous trees and bush were once predominant in the area and a trapping economy developed based on the wildlife that thrived in these conditions. Then the area was cleared for agriculture and farming became the main industry for the community. Today, there are no on-reserve farmers. The agricultural land is leased out to surrounding farmers. One of the most extensive kimberlite fields in the world is located just east of the community under traditional lands. Diamond exploration has recently been developed in the area, but has yet to provide the community with many economic benefits.

Shoal Lake

Shoal Lake is located in an area a great distance away from any large developments. The community was once a seasonal camp for people coming from The Pas, Manitoba. Trapping was the main economic activity in the area, but it is no longer viable. A forestry industry developed and provides some employment for community members. The forestry industry in traditional lands is currently not managed by the community, but rather by the provincial government. Much of the reserve is located on swampy, marginal lands, and agriculture is not an option there. The community has been suffering since 2000 from higher than usual water levels in the lake that borders their town site.

Both of these communities have a unique set of circumstances that cover a broad range of conditions that face First Nation communities.

Adaptive capacities

Adaptive capacities of the two communities were assessed from data collected via primary and secondary sources. A vulnerability approach was adopted following the recommendations of Ford and Smit (2004). In-depth interviews with community members were conducted in order to document firsthand the stresses that the community has been exposed to in the past and the adaptive strategies undertaken in light of these exposures. The determinants used to assess adaptive capacity were consistent with the literature (Smit et al 2001, Yohe and Tol 2002, Adger 2003) and included economic wealth, technology, information and skills, infrastructure, institutions, social capital and equity. The cognitive aspect of adaptive capacity was not assessed to a great extent, but insights into this were gained from the research. This study is primarily an assessment of objective adaptive capacity.

Adaptive capacity of the James Smith First Nation

"That is one of the conflicts we have: too many chiefs and not enough Indians." – Respondent

“If you are drinking and doing drugs you don’t see these things. You just worry about the next party.” - Respondent

Alcohol and drug abuse problems on the reserve significantly decrease the adaptive capacity of the community. Individuals become dependent on these substances and neglect other aspects of their life. Their individual capacities are reduced and this in turn reduces the adaptive capacity of the entire community. Steps have been taken in the community, however, to alleviate the negative effects of these addictions. There are Alcoholics Anonymous meetings and there is access to the Sakwatamo Lodge for counseling. Many respondents who were recovering alcoholics referred to their reliance on faith and traditional teachings to assist them in beating their addictions. Traditional beliefs and mentoring by Elders and other spiritual leaders were cited as the most supportive means of overcoming their addictions and building their own personal capacities. In turn, this builds the capacities of the community as a whole. Access to and awareness of traditional knowledge is increasing in the community through cultural camps and workshops that were held over the past few years.

Economic wealth is limited in the community. The median household income in 2000 was $24,576, while the median household income for Saskatchewan was $40,251 (Statistics Canada, 2001). These data would suggest that households in the community have less access to economic capital than other communities in Saskatchewan. The chief and council obtain funding for community projects from government agencies and non-profit organizations such as Indian and Northern Affairs Canada (INAC) and Saskatchewan Indian Gaming Authority Inc. They are dependent on these outside sources to fund all development projects in the community. Low levels of economic capital in the community and the dependence on outside sources for economic capital limit the adaptive capacity of the community since the community members and local government do not always have adequate funds to support and implement adaptive strategies. In the summer of 2007, the community received high amounts of rainfall and certain areas of the town site were flooded due to inadequate drainage. The local government did not have the funds available to dig ditches and install the necessary culverts. Large sections of the community remained under water, reducing the mobility of community members.

Further reducing adaptive capacity is the fact that the current chief and council are plagued by the mistakes made by their predecessors. Previous local governments incurred huge debts and misused money, leaving the band in a disastrous state of affairs. The band was stripped of their right to manage their funds and is currently under third party management, which means that the allocation of their funding is controlled by a manager from outside of the community. The main goal of the third party manager is to reduce the debt. Respondents reported that often this means that money is allocated away from projects or programs that serve to build social capital and thus adaptive capacity – e.g. projects involving sports and recreation often suffer. Previous band governments also mismanaged loans from the Canadian Mortgage and Housing Corporation (CMHC) for houses. The houses were built, but the records required by CMHC were not kept and rent was not collected, resulting in CMHC revoking the ability of the community to borrow more money for new houses. The community will not be able to obtain funding for new houses until they comply with CMHC’s standards. The current housing manager has been complying and the community should be in a position to borrow money as of April of 2008.

To exacerbate the aforementioned issues, approximately 20 years ago the local government divided itself into three separate band governments based on old associations – James Smith, Peter Chapman, and Chakastaypasin. This move tripled the bureaucracy on the reserve, solidified divisions within the community, and caused discord between the bands when dealing with issues. INAC only recognizes one band, James Smith, and funds the reserve accordingly. Funding for one band is received and divided three ways based on population percentages of each band. This leaves the bands with tighter budgets.

Respondents reported that the political situation under the three band system is hindering the community. The community is pulled in three different directions and this inhibits strong cohesive actions to deal with important issues and reduces social capital. Dealing with the potential diamond mine is a perfect example. There is dissent among the leaders about how negotiations with the diamond mine should proceed and how benefits should be divided amongst the three bands. These disagreements hinder the bands' ability to adapt to the new conditions that the diamond mine will impose.

Many respondents noted the lack of equity on the reserve. Inequitable distribution of jobs was a particular problem that came up frequently in the interviews. The discrimination is based on divisions between the different clans that come from different bands. There are clan names unique to James Smith, Peter Chapman, Chakastaypasin, and others, and these often serve as the basis for employment distribution. One clan is favored over another depending on who is offering the job.

Adaptive capacity of the Shoal Lake First Nation

"We still get the teachings of the elders in traditional ways." – Respondent
"Everybody talks about how development is good but we need to come up with a better way of planning carefully." – Respondent

Alcohol and drug abuse are problems in the community of Shoal Lake as well. But similar to the case of James Smith, people cited their belief and reliance on traditional teachings as the most successful means of beating their addictions. Access to traditional knowledge plays a huge role in increasing the capacity of the community.

The promotion and preservation of culture has been well established in the community. The percentage of the population whose mother tongue is an Aboriginal language, Cree n-dialect in this case, is 98.2% and the percentage of people with knowledge of the Cree language is 99.1% (Statistics Canada Aboriginal Profiles 2006). These figures are significant compared to the percentage of the Aboriginal population of Saskatchewan that speak an Aboriginal language; only 28.6% of the Aboriginal population of Saskatchewan has any knowledge of an Aboriginal language (Statistics Canada Aboriginal Profiles 2006). Shoal Lake has done an excellent job of preserving its language. Respondents noted how the community is envied by other Aboriginal communities in Saskatchewan for this reason.

The community also promotes culture by hosting a Family Camp each summer. The camp is open to anyone, aboriginal or non-aboriginal, and is a means to teach children about the old way of life and how to live in nature. Almost the entire community of Shoal Lake in addition to individuals from other communities in the area (last year there were attendees from James Smith) set up camp in the forest surrounding the community in the traditional lands. This past year the camp was held at an area close to a traditional campsite referred to as Camp 6. It was impossible to host the camp at the original site due to high water levels and the fear of disturbing a burial ground that is known to be in the area. The camp has been held since 1998 and is a huge success – passing on traditional knowledge to the youth and building social capital in the community.

Shoal Lake is similar to James Smith with respect to economic conditions. The median household income in the community in 2000 was $20,160, slightly less than that of James Smith, but significantly less than that of Saskatchewan (Statistics Canada 2001). Similar issues of dependence on outside sources of funding are present in Shoal Lake as well. The community is searching for opportunities that would allow it to become more self-reliant. The viability of ecotourism and forestry development in the area is currently being explored. The community has made significant efforts to train people in these industries by introducing certificate programs and projects in ecotourism, business management, heavy equipment operation and tree planting. Such efforts are essential to contributing to the ability of the community to adapt to changing economies.

Currently, the lack of economic capital and infrastructure in the community has severely hindered the community's ability to deal with the increase in lake levels. Basements of houses have been continuously flooding, consequently reducing the amount of living space and causing the growth of mold, which is detrimental to inhabitants' health. Houses in the community are already overcrowded and the floods only add further strain to the housing situation by making large portions of affected houses uninhabitable. Insufficient economic capital was available to build new houses or repair the flood damage. As a result, community members were forced to live in these conditions for the last five years. In an attempt to solve this problem, Shoal Lake is participating in a community planning project. The project has identified areas in the community that are least susceptible to floods and has designated them for new housing development. Funding for the new houses is expected to be borrowed from CMHC. The participation in this planning project has greatly increased the ability of the community to manage floods.

Conclusions

Adaptive capacity in First Nations communities in Saskatchewan is greatly affected by the promotion of culture and traditional knowledge, dependence on external sources of economic capital, participation in planning projects, level of discord amongst community members, and the effects of previous mismanagement by community governments. The promotion of culture and traditional knowledge serves to build capacities by increasing social and human capital. Dependence on external sources of economic capital can serve to hinder or hold back adaptive efforts. Planning projects can allow the communities to develop in ways that can potentially reduce their exposure to various stresses. Dissent amongst community members pulls communities apart and limits their ability to act together when faced with change. Also, previous mismanagement has put some communities in a position, economically and institutionally, that limits their adaptive capacity. The adaptive capacities of First Nations communities in Saskatchewan will play a major role in determining how well these communities are able to cope with climate and other changes in the future.

Case Study #2: The Capacity of Montreal Lake, SK to Adapt to an Uncertain Future

Montreal Lake is a First Nations community located in north-central Saskatchewan within the southern boreal forest. The community's main town site is situated on the southwest end of Montreal Lake on Indian Reserve #106, the main reserve set aside for members of the Montreal Lake Cree Nation. Montreal Lake is situated within the Prince Albert Model Forest area, just outside the eastern boundary of Prince Albert National Park. The community can be accessed year-round by a gravel road that branches off a major provincial highway and is approximately half way between Prince Albert and LaRonge SK. It should be noted that there are two reserves set aside for members of the Montreal Lake Cree Nation, who reside in various communities throughout the region. The second reserve, officially Montreal Lake Indian Reserve #106B but known as the Little Red Reserve, is located approximately 40 km south near Prince Albert. This study pertains only to the community of Montreal Lake situated on Indian Reserve #106.

The people of the Montreal Lake Cree Nation are members of the Woodland Cree and the Prince Albert Grand Council, and are governed by their elected chief, two vice-chiefs, and twelve councilors. Montreal Lake's leaders have a long history of being active and vocal in an effort to improve their community's socio-economic situation (Goode et al. 1996). The community of Montreal Lake had a population of 880 residents in 2006, an increase of 2.2% from 2001 (Statistics Canada 2007). However, from 1996 to 2001 the community experienced a growth rate of 30.7% (Statistics Canada 2002). Like many First Nations communities across Canada, Montreal Lake's population is growing rapidly and can be described as young, with a high percentage less than working age. The community is considered to be cohesive barring a few isolated events with high priorities centered on the availability of basic services (Parkins et al. 2001).

Montreal Lake has been described as a non-traditional forest dependent community, in the sense that the majority of jobs are found in other sectors (Parkins et al. 2001). Forestry related employment has continued to decline in recent years with layoffs at the nearby Wapawekka sawmill in 2005 and the closure of the Prince Albert pulp mill in 2006. However, the community remains strongly tied to the forest for lifestyle and non-industrial uses. Employment opportunities are limited and have been especially impacted in recent years by the aforementioned declining forestry operations and the closure of the commercial fishery on Montreal Lake in 2006. As a result, many residents are forced to search for work elsewhere in the province and beyond. The most recent data reveal that the community's unemployment rate rose to 36% in 2006 from 31% in 2001 (Statistics Canada 2007). On the other hand, some Band-based initiatives, notably in the manufacturing of ready-to-move homes, have been very successful and are continuing to grow and expand their labor force.

Montreal Lake's climate is influenced strongly by its mid-continental position, resulting in temperatures that range from -40ºC to 32ºC and total annual precipitation of 400 - 500 mm (CFS 1996). Forest fires are very common in the region, with a major fire coming within a few kilometres of the main town site in 2003. Although there is little direct stress from human activity, Montreal Lake is subject to acid deposition like the rest of the Churchill River Basin

(SWA 2007). The amount of acid deposition in the Churchill River Basin and its potential impacts on aquatic ecosystems led Saskatchewan Watershed Authority to the conclusion in 2007 that the watershed is currently in an impaired state of health.

Methodology

In 2006, Montreal Lake was selected as a case study community for a project titled “A Comparative Assessment of the Capacity of Canadian Rural Communities to Adapt to Uncertain Futures”. This joint initiative between Carleton University, Simon Fraser University, and the University of Saskatchewan examined the current and potential future exposure and response of four rural resource-based communities across Canada to multiple stressors including environmental, social, economic, and political factors. Although climate change was the underlying focus, this study did not assume that it had the most significant influence in the capacity of rural communities to cope with and adapt to uncertain futures. The communities of Change Islands NL, Edwardsburgh/Cardinal ON, and Alert Bay BC were also involved in this study but only the Montreal Lake component is discussed here.

This study employed a phased research approach which included initial engagement of the community and preparation of background material in the spring and summer of 2006, a community workshop in October 2006, and analysis and synthesis of data in November 2006. Existing relationships between the University of Saskatchewan and Montreal Lake provided a platform to proceed with the research, and the community’s strong ties to the forest made Montreal Lake an ideal community for this study.

Initial engagement of Montreal Lake involved first obtaining commitment from a community official who also acted as the project’s key informant, contributing thorough knowledge of the community’s history, local development issues, current opportunities, future plans for development, and identifying participants for the workshop. Information was then gathered about recent trends and issues in Montreal Lake through consultation with other community representatives, analysis of existing data (i.e., demographic trends, economic activities, community wellbeing, etc.), and a literature review. This information was then used to develop a Montreal Lake background paper which was distributed to participants prior to the community workshop to initiate discussion.

The workshop followed a four step framework and was loosely guided by a standardized set of questions. Discussion in Montreal Lake focused on four main themes: (1) past changes in the community, including the evolution of both the socio-economic and environmental situations, (2) current community well-being (3) observations of climate change in the past and today and its impacts on the community, and (4) the community’s future, including prospects, opportunities and issues that need to be addressed. The main objective of the workshop was to determine the ability of Montreal Lake to adapt to both socio-economic and environmental pressures in the future

The workshop lasted approximately four hours and was attended by sixteen participants including representatives from the Elders Council, Band Council, Resource and Environment Office, Montreal Lake School, William Charles Health Centre, Montreal Lake Child and Family Agency, Youth Council, and members of the general public. As mentioned earlier, participants were selected with the assistance of the study's key informants in order to ensure the most fair and equitable representation of the community's groups as possible. This approach was similar to that of Parkins et al. (2001) who examined sustainability within the community of Montreal Lake.

Midway through the workshop, an overview of climate change was presented. This was then followed by an interpretation of two Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) Scenarios (Market first and Sustainability first). These IPCC SRES Scenarios were downscaled to the northern Saskatchewan regional level by the Adaptation and Impacts Research Group (AIRG) of Environment Canada based at the University of Toronto. The interpretation of these scenarios included potential climatic changes that might occur in the Montreal Lake region as a result of the predicted temperature and precipitation. These presentations integrated climate change into the discussion on the community's future.

During the workshop, the participants were asked to answer and discuss each question; having the opportunity to do so uninterrupted. Before the next question was introduced, participants were invited to comment on the previous responses. The workshop dialogue was independently chronicled by two researchers from the joint project and a rapporteur to ensure that the forum's key points were captured. All participants were advised of the conditions of their voluntary participation and informed consent was obtained prior to the workshop's commencement. At the workshop's conclusion, an honorarium was offered to all participants for their contributions to the project.

Once the workshops for all communities were completed the joint project's research team met in Ottawa in for two days to assess the key elements of community well-being in all four communities. Environmental and socio-economic factors were discussed in all communities in the context of changes and adaptations in the past that may impact each community's ability to adapt to the future. Results from the analysis were presented in a synthesized format. Prior to the Brklacich et al. (2007) final report being made public, a preliminary draft was sent to each participant for verification.

Discussion

Of the four main themes considered in the Montreal Lake workshop, past changes and current community well-being dominated the discussion. Participants identified a mix of positive and negative changes that have occurred in the community in recent years, but were in general agreement that overall well-being is increasing. However, participants were quick to indicate that the community has a long way to go and that there is an urgent need for residents to come together and find strategies to address the socio-economic pressures facing residents of Montreal Lake.

The most prominent issue faced by the community is to assist and provide for the needs of its rapidly growing population. Until recently, Montreal Lake had very few problems with its youth population. However, participants indicated that several issues with the youth population that are present in many communities, such as addictions, vandalism, and gangs, are now a concern in Montreal Lake. Participants agreed that guiding youth in the right direction was one of the community's utmost priorities. Furthermore, participants also suggested that a significant challenge rests in preparing the youth for the opportunities that exist outside the community. Participants expressed that it is not only possible to prepare the youth to take advantage of the opportunities that surround them, but necessary.

Two of the most positive changes in the community in recent years identified by participants have been the development of community-funded infrastructure and an increase in control of services to band members. Specifically, through a self-government taxing system, the local arena, church, and recreational facilities have been built without federal funding. These structures have built a sense of community within Montreal Lake and are a starting point to healthier options and lifestyles for the youth. The community has also taken control over education, health, social assistance, and policing which has allowed Montreal Lake's leaders to directly address concerns of residents. However, participants also indicated that despite taking control of certain programs, as First Nations people, they have always been marginalized by other levels of government. Participants suggested that this discrimination has limited their growth and well-being, and has been a major barrier to community development.

Although the recent reduction of forestry operations and the closure of the commercial fishery have decreased employment opportunities within the community, participants indicated that Montreal Lake has never had a thriving community. Limited employment opportunities for many successive years have resulted in the departure of many community members, especially the youth, in search of jobs. The community's poor economic condition is a reflection of the reality that the reserve land base is no longer capable of supporting Montreal Lake's population. Participants indicated that the inadequacy of the reserve land base was true not only for providing jobs, but also for supporting wildlife populations that are valuable for subsistence and traditional activities.

In terms of observations of climate change, participants indicated that they had noticed a general warming trend over the past 50 years in their surrounding environment. Participants used a variety of indicators to express their observations including the timing and duration of seasons as well as average temperatures, but each supported the notion that the region's climate has become warmer. Some participants also noted that it was becoming increasingly more difficult to predict the weather and that weather events were now of a greater magnitude than they had been in the past. Despite these noticeable changes in climate, participants did not indicate that there had been any significant impact on the community up to this point.

Once the climate projections for the region were presented, participants carefully reflected upon the significance of and the impact the changes in precipitation and temperature would have on the region. In particular, participants considered the effect that hotter and drier summers would have on forest fires in the region. However, it was evident that addressing the impacts of climate change on future development is a low priority for the community. Montreal Lake is facing many more pressing socio-economic issues at the moment which must be resolved before climate change will figure into long-term community planning

This research emphasized the reality that some rural resource-based communities in Canada are currently facing strong socio-economic pressures. Montreal Lake's top priorities are to address these immediate issues, with climate change estimated to be a relatively minor factor in comparison. Consequentially, it was determined that the capacity of Montreal Lake to adapt to an uncertain future is low. Until the community is able to address the more pressing socio-economic stressors, it will be difficult to develop the capacity to anticipate and offset future stresses including climate change.

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Chapter 9
Synthesis and Conclusions

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This report considers the adaptive capacity of a particular cross-section of human system communities within the boreal plains ecozone. For the purposes of this chapter we use the term "community" in the broadest sense. Community is defined as a group of interacting individuals, organizations, and agencies that share something in common and/or that are geographically tied together and/or that have common purpose and/or that are governed by a common set of rules, standards, conventions, traditions, regulations, and institutions. Given this broad definition there are multiple interacting communities within the boreal plains ecozone. The subset of communities we consider in this report includes traditional resource based communities, the community of rural residents that reside outside of formal organized towns and cities, the forest management community (comprising provincial forest management agencies, industrial forest managers, firms, and NGOs), and First Nations communities. This group of communities provides a reasonable cross section of community types in the boreal plains ecozones (with the exception that urban centres in the boreal plains are not looked at in great depth).

Adaptive capacity vs. adaptive capacity deficits

Chapter Four of this report introduces a new metric for assessment of adaptive capacity. Adaptive capacity deficits exist in cases where there are systematic barriers or system failures relative to the ability of a particular community to optimally invest in adaptive capacity. Chapters Four and Five show that the conclusions reached through assessment and comparison of adaptive capacity levels and the conclusions reached by analyzing adaptive capacity deficits may be quite different. With some exceptions (e.g., communities like Fort McMurray and other communities where the energy sector is a major part of the local economy), the adaptive capacities of the various types of communities in the boreal plains ecozones reviewed in this study (i.e., resource based communities, rural areas, the forest management community, First Nations communities) are lower than adaptive capacities in communities in other contexts (e.g., urban centres) and/or in other parts of Canada. However, we speculate that this is mainly a consequence of social and economic circumstances and choices by communities about how much to optimally invest in adaptive capacity and not necessarily the result of systematic impairments in the ability of boreal plains communities to optimally invest in adaptive capacity[25]. Thus, differences in adaptive capacity by itself do not necessarily mean that communities are differentially vulnerable. There are a number of legitimate reasons why adaptive capacity is lower in communities in the boreal plains compared to other contexts. For example it may be that the cost of providing adaptive capacity services is higher (see Chapter Four for a more detailed overview). In terms of understanding vulnerability to climate change, a

[25] Sub-optimal investment in adaptive capacity may result from market failure, government failure, excessive bureaucracy, outdated and inflexible institutions, non-cooperative behaviour (e.g. Nash equilibriums develop where there is a lower cumulative payoff than what might be possible with greater cooperation), decisions are not made because of lack of information and knowledge, incorrect decisions are made because they are based on the wrong information, and/or decision makers are irrational.

more useful approach is to assess the extent to which there are currently adaptive capacity deficits in place and/or whether there is the potential for adaptive capacity deficits to emerge. Adaptive capacity deficits occur where there is a gap between actual levels of adaptive capacity and a socially optimal level of adaptive capacity. Such gaps are caused by failures or impairments that prevent the particular community from optimally investing in adaptive capacity.

It is often suggested that the availability of resources for adaptation, especially financial resources, is a determining factor of adaptive capacity. However, resource availability may in fact, be a poor measure of adaptive capacity. Adaptive capacity is certainly constrained by budgets (i.e. resource availability). But budgets (and availability of resources) are given and they are not discretionary. The question of importance is – given a particular level of resources – is the amount invested in adaptive capacity socially optimal.

Assessment of current adaptive capacity deficits of communities in the boreal plains
Chapters Five to Eight suggest that the adaptive capacity of those selected communities included in this study are generally lower than adaptive capacity in urban centres and in some cases lower than adaptive capacity of similar types of communities in other regions. Contributing factors include low economic diversity, small scale, remoteness, isolation, lower investment in science and technology, less access to science, marginal natural resources, and lower investment in human capital. However, as noted below, adaptive capacity does not necessarily equivocate to higher vulnerability.

The adaptive capacity of the forest management community varies across the boreal plains ecozone but a general lack of response (or in some cases delayed response) to climate change and other changes by the forest management community within the boreal plains suggests a lower level of adaptive capacity compared to the forest management community in other parts of the country (e.g., BC and Quebec) where positive adaptation responses by the forest management community are being put in place. The marginal (in the economic sense) nature of forest resource assets within the boreal plains ecozones may be a contributing factor to low adaptive capacity of the forest management sector in the boreal plains. Nonetheless, low current adaptive capacity of the forest management sector is not an indication of higher vulnerability. The level of current adaptive capacity may be close to what is currently socially and economically justified. There is no reason to suspect that low adaptive capacity is caused by systematic failures that are impeding or preventing a socially optimal level of investment in current adaptive capacity in the forest management sector in the boreal plains ecozone.

Current adaptive capacity deficits may, however, exist in a number of First Nations communities in the boreal plains. As is the case with other types of communities, adaptive capacity varies across First Nations communities. Some First Nations communities in the boreal plains ecozones (e.g., the Lac La Ronge Indian Band) have relatively high adaptive capacity. These are often communities with strong social networks, high levels of human capital, strong and dedicated leaders, and communities that have retained Aboriginal culture and traditions. Other First Nations communities are facing dramatically higher levels of poverty and unemployment (e.g. Shoal Lake in Saskatchewan). Social pathologies such as substance abuse, gangs, and crime are emerging or becoming worse. These types of social pathologies are likely indicative of existing adaptive capacity deficits caused by barriers that are impairing optimal investment in adaptive capacity. Factors that may be contributing to sub-optimal investment in adaptive capacity in some First Nations communities include (1) failure of local governance (corruption, mismanagement, inefficiency, weak leadership), (2) excessive bureaucracy, (3) laws and institutions that reduce incentives for investing in adaptive capacity (even though the returns outweigh the costs), (4) discrimination and injustice, (5) psychological factors such as hopelessness, despair, lack of purpose, and lack of identity that ultimately impair judgements about the value and utility of investing in adaptive capacity, (6) lack of information about sources of vulnerability in First Nations communities, and (7) immobility. Within the boreal plains ecozone, suboptimal investment in adaptive capacity by individuals in some First Nations communities makes these communities relatively more vulnerable to climate change impacts.

Emergent adaptive capacity deficits

The boreal plains ecozone will likely be subjected to relatively high rates of climatic change and climate change impacts (e.g., increased frequency of extremes, ongoing change in mean values leading to chronic impacts, increased rates of large-scale disturbances and surprise and the presence of unknown risks). Thus, climate change in the boreal plains ecozones combined with other social and economic trends will likely increase the need for resiliency and the demand for adaptive capacity potentially more than in other Canadian contexts. Existing levels of adaptive capacity and resiliency may be sufficient for past and current requirements but socially suboptimal relative to future requirements. If groups are rational, expectations of higher demand for adaptive capacity should (at some point) lead to greater investment in adaptive capacity and increases in factors that contribute to adaptive capacity by communities in the boreal plains ecozone. However, it is possible (if not somewhat likely) that the rate of increase in adaptive capacity requirements will exceed the ability of human systems and institutions to respond in a timely manner. If this turns out to be the case, adaptive capacity deficits are likely to emerge and the size of the deficits will likely continuously increase until such time as the affected communities take action to address their higher requirements.

The remainder of this chapter summarizes some the general findings of the study relative to factors that may contribute to emergent adaptive capacity deficits of communities in Canada's boreal plains ecozones.

Need for greater local authority and autonomy in decision making

Climate change effects will vary from place to place. There may, therefore, be a need for local adaptation and for transfers of authorities and autonomy in a way that allows individuals, firms, towns, and resource managers to more effectively adapt to local changes[26]. The actual trend, however, may actually be in the opposite direction. A trend toward more centralized institutions may limit the amount of autonomy, control, flexibility, and power that decision makers have relative to implementing adaptation responses that are tailored to local requirements.

[26] For example, changed circumstances may require land-use change and/or conversion of natural capital into other forms of capital (e.g., manmade capital). Currently, communities have relatively limited power and authority relative to these types of decisions at local scales.

Climate change feedbacks on adaptive capacity
Climate change can also have feedbacks in terms of potentially reducing a community's ability to supply an appropriate level of adaptive capacity services. For example if an area's natural capital is depleted as a result of climate change, the resources it has available for adaptation may decrease. A potential strategy of local decision makers relative to ensuring the optimal level and mix of adaptive capacity resources may be to allow local decision makers greater latitude in substituting determinants that contribute to adaptive capacity at local levels. For example, communities may find it beneficial to convert adaptive capacity factors at risk of impacts (e.g., natural capital at risk) to other forms of capital that are less sensitive to climate change and that contribute to local well being and local adaptive capacity. Currently, however, there are significant institutional constraints on the ability to achieve this at local scales.

Knowledge gaps about future impacts
There are significant knowledge gaps about climate change impacts on communities at locally relevant scales. Knowledge gaps prevent local decision makers from taking action and/or result in the wrong choices. The interviews conducted in the course of the study suggest that decision makers generally have insufficient information about future climate change effects upon which to plan for climate change effects or base adaptation decisions. The various communities indicated that they are concerned about climate change but at the same time, they have not developed plans or strategies to deal with or prepare for climate change. One of the stated reasons was that there is a lack of information about climate change and climate change impacts at locally relevant scales. Thus, more and better organized science to deal with knowledge gaps that are impairing adaptation policy and decision making is needed. However, the multifaceted nature of climate change mean requires a trans-disciplinary approach to climate change impacts and adaptation science, in which stakeholders and scientists jointly determine the direction of the scientific investigations that are required.

Mobility and liquidity constraints
An adaptive response to climate change effects may be to relocate. High mobility contributes to high adaptive capacity and vice versa. There are, however, mobility and liquidity constraints for some communities in the boreal plains. Mobility constraints include specialized job skills that are not transferable to other economic activities, and cultural constraints in aboriginal communities. Liquidity constraints arise from an inability to sell property and/or inability to transfer or convert capital assets. For example, individuals in single industry resource based towns may find it difficult to sell their homes in low markets and/or move to other locations where home prices are significantly higher. Historically the forest industry has relied on large mills and associated scale economies to produce a narrow range of products, but in large volume. Large scale fixed capital investments reduce the ability to adjust to new market realities in the short term.

Rigid institutions
Our interviews indicated overwhelmingly that institutional factors are the most important factor relative to limiting adaptive capacity – particularly with forest management. On the other hand, institutional barriers impairing climate change adaptation in the forest management community are significant. An important factor is a lack of high level executive support for preparing for climate change. This is seen as essential before any kind of institutional change can take place. High level executive support to modify institutions so that climate change considerations are

taken into account in rules, regulations, norms, standards, planning systems, and property rights configurations is not evident as of yet in the boreal plains ecozones.

In the case of forest management, policies and practices have not been modified to account for climate change. New concepts such as adaptive management and risk management are not being implemented. Forest management continues to be prescriptive and is generally based on the assumption that the future will be like the past. Forest management plans generally do not take climate change into account. Similarly, traditional communities, First Nations communities, are not considering climate change in planning.

Institutions are not providing an incentive structure that is conducive to investment in adaptive capacity and/or for ensuring that adaptive capacity resources are utilized to address adaptation requirements. More flexible, adaptive and forward looking institutions are required. Given the heightened uncertainties associated with climate change, greater risk taking in policy and institutions may be necessary. Some institutions seem to be moving toward greater centralization at a time when more decentralization in decision making may be required. A broader suite of management options are needed but there is limited progress in developing and applying new approaches. At the same time it needs to be acknowledged that organizations and agencies cannot change institutions autonomously. Imposing institutional change can create dis-harmony, dis-trust and conflict. Institutional change needs to be done in a harmonious way and in a collective way. It requires social learning and the participation of the full range of affected stakeholders. This may require new models and approaches for decision making and policy development.

Institutional barriers to adaptive capacity among provincial regulators are related to forest policy that usually assumes a forest that remains substantially the same over time. A similar perspective probably applies to institutions and policies affecting resource-based towns and First Nations communities. Policy is generally based on what has worked in the past rather than anticipating what is likely to happen in the future. This is particularly a problem with climate change given the uncertainty about future conditions. A high level of uncertainty makes acceptance of innovative ideas difficult, especially if the proposed alternative lies far outside of accepted practice. At the same time, a do nothing approach has the potential for increasing future impacts on communities in the boreal plains ecozones. In the case of forest management, long-term agreements that are stipulated by government may reduce the adaptive capacity of both industry and provincial regulators by “locking-in” levels of harvest or other aspects of forest management and may prevent adaptation options from being implemented. Innovative forest management practices that have both immediate and long-term benefits may become more difficult to apply give relatively inflexible tenure agreements. Similarly, agreements that continue to link industrial wood-processing facilities and management of large forest landscapes may reduce adaptive capacity in that the company must maintain a range of mill and forest management specialists, rather than focusing on one aspect or the other. A tenure agreement that is specific to the forest landscape, (i.e., one that severs the appurtenance requirement inherent in some large scale forest management agreements) will likely result in agreements with companies that specialize in forest management. The province of BC, for example, has eliminated the linkage between mill processing requirements and timber supply as part of an exercise to modernize its forest policy regime.

Need for higher levels of social capital in support of collective action

Successful adaptation to climate change will require a collective approach that involves all stakeholders. Traditional resource based communities will need to work with each other, with higher levels of governments, and with business to enhance adaptive capacity and develop adaptation strategies to minimize climate effects. Private sector forest managers operating on large area-based leases will need to work with provincial regulatory agencies to ensure that forest impacts are minimized or mitigated. The ability to work collectively will be enhanced if there are strong social networks and trust. However, current levels of social capital may be lower than that necessary in the future. Our surveys suggest that there may not be sufficient collaboration between various parties in cases where this collaboration will be important if not essential for adaptation. Groups are either working independently to incorporate climate change into planning - or they are not working at all on adaptation because of the risk that their efforts will not be approved by regulators. A more collective and collaborative approach will be needed in responding to the impacts of climate change.

Given their strong linkages to affected natural resources, resource based communities will also need to work collectively with public agencies and the private sector to ensure effective land use planning and economic development. Social networks and trust (i.e. social capital) is required for collective action. Resource managers and the science community will need to work together to ensure that science is communicated to decision makers and to ensure that decision makers needs are communicated to the science community.

Need for awareness raising and risk communications

Perceptions and awareness of climate risk are important because mis-perception and/or lack of awareness will result in either inaction or inappropriate action. For communities in the boreal plains, it is possible that inaction in preparing for future climate changes and/or in investing in adaptive capacity to prepare for future climate change effects reflects a lack of awareness of climate change and/or misperception of climate change risks. Our interviews of senior executives in firms indicate that there is not much discussion or awareness within the firm of what physical risks firm may actually face to their timber supply or infrastructure. Corresponding to this is that in terms of strategies firms do not feel the need currently to address physical risks associated with climate change nor to prepare themselves. It is not clear whether this is due to the fact that most firms feel the effects are far enough away or the uncertainty is so great so as to not warrant further attention, or whether they do not have the capacity or resources to devote to climate change adaptation or to increase adaptive capacity.

Need for enhanced science capacity at all scales and across contexts

Climate change is a complex science-based issue. Assessment of impacts and the development of ways to adapt will need to be based on the best available science. At the same time the science will need to be operationalized and used to support policy and decision making. Science organizations will need to continue to work on the science of impacts and adaptation, expand the knowledge base, and reduce uncertainties. However, forest managers will need to have the capacity to interpret and apply impacts and adaptation science on the ground and in the context of policy development. Recent experience has shown that close interaction among scientists and practitioners (i.e. “embedded science”) within firms and with management agencies increases adaptive capacity.

Forest companies and management agencies vary widely in their technical expertise, with a limited few employing several Ph.D.-level scientists while others have very little advanced scientific capacity. Generally science capacity at the firm level among most forest companies in the boreal plains is low. Similarly the ability to assess impacts and develop science based adaptation responses in resource based communities is relatively low. Our discussions with industry, government managers, and leaders in resource based towns indicated that there is a relatively low level of science capacity pertaining to climate change and few mechanisms through which managers and community leaders could access climate science in ways that are useful to them.

Climate change should be included in long term planning
All forest management jurisdictions in Canada require some type of long-term forest management plan, typically on a 20-year time horizon (although the planning horizon for timber supply analysis can be up to 200 years). Our experience in other projects and our discussions with industry managers indicate that the forest management planning function provides an excellent vehicle for considering climate change effects and adaptations. The relatively long time horizon and the generally strategic focus of the plans means that climate change considerations can be brought in at a temporal and spatial scale consistent with the current state of understanding of climate change impacts, and consistent with the scale of forest management decision-making. In addition, the plans are required under most provincial legislation, so this is an activity the companies will be undertaking regardless and is not a separate activity that would add additional cost to their operations. We advocate the development of planning guidelines that could be used across all jurisdictions in order to provide guidance on how I&A considerations could be integrated into forest management plans. These would necessarily be general in order to accommodate variability among jurisdictions and biophysical conditions, but could be developed in a way that would be helpful to both industry and government planners. Similarly, incorporating climate change into community strategic and economic development plans would enhance the capacity of these communities to adapt.

Use of certification standards to support impacts and adaptation and to encourage investment in adaptive capacity
While certification standards promote SFM, it is unclear to what extent they support or help develop adaptive capacity for climate change. In general the standards assume a relatively unchanging forest, and usually tend to support the protection and maintenance of existing species and habitats. Little is indicated about how forests may change or how practices need to adapt to new conditions. However, certification is seen by the forest industry as essential to continued market access and they will continue to seek this designation. Therefore we advocate the incorporation of climate change considerations into forest certification standards. This would necessarily be at a fairly general level but would provide guidance to companies on how to address the critical questions about likely impacts, vulnerability and adaptation options.

Chronic understaffing of regulatory agencies and agency overburden
Another finding from the interviews was that companies and especially government regulatory agencies are chronically understaffed, further reducing adaptive capacity. In some cases, forest managers work for small companies in isolated rural locations, further reducing their access to relevant information on I&A. Finally, most forest companies today are focused on surviving an economic downturn, increased competition from off-shore producers and large-scale restructuring in the industry. Even those companies who take climate change seriously and who have scientific capacity find it difficult to address this issue when day-to-day survival is their primary concern.

Complexity of regulatory environment
A complex regulatory environment reduces the ability of firms to undertake longer-term actions-investments-that could enhance their adaptive capacity. This is not just a Canadian issue - it is a broader one affecting firms more generally.[27] But within Canada the need for a coherent and consistent regulatory regime is essential, especially if firms are to develop an effective risk-management approach around carbon management, emissions controls, and adaptation. In terms of the regulatory environment in some cases results based approaches may be preferred to prescriptive approaches – particularly in the context of expectations of a greater need for adaptation that is tailored to localized effects.

Culture, traditions, sense of place, pride in community, community cohesion, trust encourage community action and adaptive capacity
Adaptive capacity in First Nations communities in Saskatchewan is greatly affected by the promotion of culture and traditional knowledge. The promotion of culture and traditional knowledge serves to build capacities by increasing social and human capital. Dissent amongst community members pulls communities apart and limits their ability to act together when faced with change. Culture, traditions, a sense of place, pride in ones community, community cohesion, and trust contribute to higher adaptive capacity in all types of communities.

Special needs of First Nations communities
The most prominent issue faced by First Nations communities is to assist and provide for the needs of its rapidly growing population within an environment of climate change. The interviews indicated that several issues with the youth population are beginning to appear in many First Nations communities, such as addictions, vandalism, and gangs. Participants agreed that guiding youth in the right direction was one of the community's utmost priorities. Furthermore, participants also suggested that a significant challenge rests in preparing the youth for the opportunities that exist outside the community. Participants expressed that it is not only possible to prepare the youth to take advantage of the opportunities that surround them, but necessary.

One option that shows promise in First Nations communities is to provide more local control. Two of the most positive changes in the community of Montreal Lake Saskatchewan in recent

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[27] "In the current unpredictable national climate policy environment [referring to the US], it is exceedingly difficult and risky for businesses to evaluate and justify the large-scale, long-term capital investments needed to seize existing and emerging opportunities…"
Financial investors writing the US Congress in the Spring of 2007 (Esty 2007:30)

years identified by participants have been the development of community-funded infrastructure and an increase in control of services to band members. Specifically, through a self-government taxing system, the local arena, church, and recreational facilities have been built without federal funding. These structures have built a sense of community within Montreal Lake and are a starting point to healthier options and lifestyles for the youth. The community has also taken control over education, health, social assistance, and policing which has allowed Montreal Lake's leaders to directly address concerns of residents. However, participants also indicated that despite taking control of certain programs, as First Nations people, they have always been marginalized by other levels of government. Participants suggested that this discrimination has limited their growth and well-being, and has been a major barrier to community development.

Although the recent reduction of forestry operations and the closure of the commercial fishery have decreased employment opportunities within the community, participants indicated that Montreal Lake has never had a thriving community. Limited employment opportunities for many successive years have resulted in the departure of many community members, especially the youth, in search of jobs. The community's poor economic condition is a reflection of the reality that the reserve land base is no longer capable of supporting Montreal Lake's population. Participants indicated that the inadequacy of the reserve land base was true not only for providing jobs, but also for supporting wildlife populations that are valuable for subsistence and traditional activities.

The need for institutionalization of climate change

The boreal plains ecozone is situated in the continental interior of a northern latitude country. The rate of climate change in the boreal plains ecozones will exceed anticipated global average climate change and it may exceed the rate of climate change that are will ultimately occur in other parts of Canada. Current adaptive capacity of communities (forest management, traditional resource based towns, First Nations communities, rural residents) is already lower that in other socioeconomic contexts. This is the result of existing conditions and circumstances and in itself should not be considered to be a source of vulnerability. A larger concern is the degree to which there may be inherent barriers that are preventing or impairing communities in the boreal plains from investing in their own adaptive capacity in anticipation of increased future requirements related to climate change. While Canadian forest sector firms have shown the ability to mobilize their resources and reduce their C footprint, (embracing alternative and renewable fuels, adopting fuel saving technologies, and implementing emissions abatement practices), much of this has been done to reduce the impact of increasing energy prices. Firms have seen such strategies as low risk as these investments and changes can pay for themselves. This illustrates the importance of having the right incentive structures in place and the importance of institutions in promoting adaptive capacity and ultimately providing an environment that is conducive to adaptation.

However, any major changes in business models or any kind of significant investment in adaptation will wait until firms, communities, and forest managers start to develop a strategic approach to climate change. For that to happen, communities will need to see what direction governments are taking, they will need more clarity in the regulatory environment, and they will need to see that adaptation and adaptive capacity enhancement is consistent with the policy environment.

Finally, as part of developing adaptation strategies, communities in the boreal plains will also have to gain a better understanding of the impacts of climate change. It is important to gain a better understanding of the science of climate change impacts and adaptation and to identify how the science around climate change will translate into policy and what implications that might have for communities. A few firms in the boreal plains ecozone with large areas-based forest management agreements have taken steps to assess their potential vulnerability through consideration in their longer-term forest management plans, but even in these cases the objectives of forest management remained unchanged and it is not clear how the policy framework itself might change to facilitate adaptation. The challenge here is how to determine how both forest managements and firm managers can identify which range of measures that they can take that will support each others' actions, increasing not only the resiliency of the forest resource but the forest sector itself. One approach is to start developing an awareness and discussion of the issues and adaptation options and to start taking climate change into account in the preparation of their forest management plans (without necessarily specifying yet how they might do it) and thereby starting to institutionalize the process of adaptation. A similar approach could be developed for traditional resource-based communities and First Nations communities.

Acknowledgements

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APPENDIX ONE

1A. Using the Community Information Database To Determine Community Adaptive Capacity

V. Wittrock, Saskatchewan Research Council

Introduction and objectives

Forests are likely to experience large impacts from climate change. These will have associated effects on small communities that depend on forest product mills and the attendant economic effects (Williamson et al. 2005; Sauchyn and Kulshreshtha 2008). The primary objective of the overall project is to carry out adaptive capacity assessment of the forest sector in the Boreal Plains Ecozone in central Canada (Johnston et al. 2007). Adaptive capacity has been defined as "the potential or capacity of a system to adapt to (to alter or better suit) climatic stimuli or their effects or impacts" (Smit and Pilifosova 2001). Key determinants of adaptive capacity include: a) the range of available technological options for adaptation, b) economic resources (e.g., income), c) institutional design and structure, d) human, social and natural capital of adapters, e) capacity to manage risk, f) knowledge and information access, and g) perceptions and attitudes of adaptors (Smit and Pilifosova 2001). However, some of these determinants can be difficult to measure (Warren and Egginton 2008).

The goal of this section is to undertake an analysis of community adaptive capacity using the Community Information Database (CID). The study area is Boreal Plains ecozone with emphasis on La Ronge SK, Victoria Beach MB, Deschambault Lake SK and Montreal Lake SK. The selected study region closely follows both the Boreal plains ecozone and the Forest management industrial leaseholds (Figure 1).

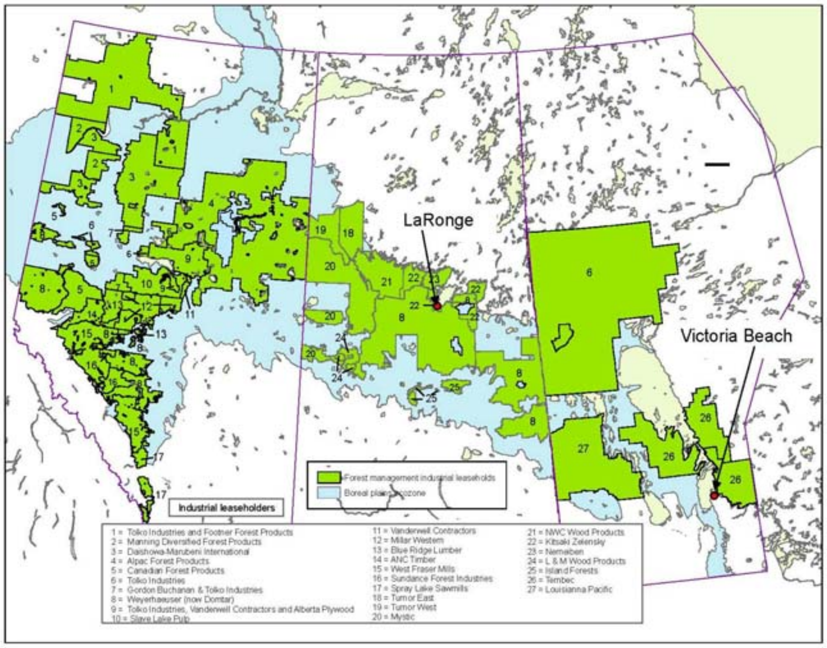

Figure 2. Boreal Plains Ecozone with Forest Management Leaseholds (Johnston et al. 2007)

The objectives of this section are to use the CID database to:

- Assess and interpret the relevance of the specific indicators to determine usefulness regarding the potential adaptive capacity for various communities
- Assess other regional and local features (e.g., water resources) to further explore adaptive capacity
- Develop maps to indicate regions and levels of adaptive capacity following the approach used by Schröter et al. 2005, for example.
- Make recommendations on the relevance of existing indicators and recommend additional indicators.

Socio-economic indicators of adaptive capacity

This section examines the Community Information Database (CID) plus selected socio-economic models that examine the potential adaptive capacity of a region. This section compares the models and CID to assess whether the CID is a useful tool in determining the adaptive capacity of a community.

The Community Information Database (CID) was developed to capture demographic/socio-economic data (Rural Secretariat ND). The CID is intended to:

- Measure, assess and compare community performance
- Identify key socio-economic aspects and trends at the community level
- Compare information and analysis over time and among communities
- Analyze data across several layers to identify potential linkages
- Provide information and analysis essential to community development planning.

The CID has 14 indicators with 347 sub-indicators. The 14 indicators are community type, population, education, language, aboriginal peoples, income, employment, agriculture, environmental stewardship, engaged population and institutions, infrastructure, selected community indexes and 1996-2001 change. This data is mainly sourced from Statistics Canada's Censuses of Population in 1996 and 2001 (CID website accessed October 2007 www.cid-bdc.ca). The selected community indexes (see Appendix 1C for more detail) were calculated using various types of information collected by Statistics Canada including Gross National Product, Consumer Price Index, plus others.

This large number of indicators was formidable and many are not relevant to region; therefore, based on professional knowledge (T. Williamson p. comm. 2008) and adaptive capacity literature (e.g., Smit and Pilifosova 2001), the 14 prime indicators were reduced to 11, with 74 sub-indicators. The indicators and sub-indicated are listed in Table 1.

Table 1 Selected Indicators and sub-indicators from the CID (Rural Secretariat ND).

Indicators	Sub-Indicators
Community Type	Metropolitan Influence Zone (MIZ)
	Resource Reliance - Category
Population	Total Population
	Male Population
	Female Population
	Population density
	Population mobility
	Immigrant population
Aboriginal Peoples	Total Aboriginal Population
Education	Not attending school
	Attending school full-time
	Attending school part-time
	Less than grade 9
	Grades 9 - 13
	Trades certificate or diploma
	University
Income	Average family income $ - Male lone-parent families
	Average family income $ - Female lone-parent families
	Economic families - Low income
	Economic families - Other
	Economic families - Incidence of low income - %
	Unattached individuals - Low income
	Unattached individuals - Other
	Unattached individuals - Incidence of low income - %
	Total population in private households - Low income
	Total population in private households - Other
	Total population in private households - Incidence of low income - %
	Average personal income - males
	Average personal income - females
	Average family income
	Composition of income (employment)
	Composition of income (government transfer)

Indicators	Sub-Indicators
	Composition of income (other)
Employment	Employment rate
	Full-time employment
	Self-employment
	Not in the labour force - 15 years and over
	Unemployed - 15 - 24 years
	Employment to population ratio - 15 - 24 years
	Employment rate - 15-24 years
	Unemployment rate - 15 - 24 years
	Employment to population ratio - 25 years and over
	Employment rate - 25 years and over
	Unemployment rate - 25 years and over
	Employment to population ratio - Males 15 - 24 years
	Employment rate - Males 15-24 years
	Unemployment rate - Males 15 - 24 years
	Not in the labour force - Males 25 years and over
	Employment to population ratio - Males 25 years and over
	Employment rate - Males 25 years and over
	Unemployment rate - Males 25 years and over
	Not in the labour force - Females 15 - 24 years
	Employment to population ratio - Females 15 - 24 years
	Employment rate - Females 15 - 24 years
	Unemployment rate - Females 15 - 24 years
	Not in the labour force - Females 25 years and over
	Employment to population ratio - Females 25 years and over
	Employment rate - Females 25 years and over
	Unemployment rate - Females 25 years and over
Environmental Stewardship	Land area in square kilometres, 2001
	Resource Reliance - Employment
	Resource Reliance - Income
Engaged Population and Institutions	Local Institutional Capacity
Infrastructure	Education Services
	Health and Social Services
	Number of funded Community Access Program sites
	Number of occupied private dwellings
	Tenant-occupied non-farm, non-reserve dwelling
	Owner-occupied non-farm, non-reserve dwelling
Selected Community Indexes	Regional Disparity
	Economic Stability
	Social Progress
	Economic Competitiveness
	Global Exposure and Integration
	Industry Integration
	Industry exposure - export proportion of total trade
	Industry exposure - export proportion of GDP
	Vulnerability - population decline
	Vulnerability - employment decline
1996-2001 Change	Population Change, 1996-2001
	Population Mobility Change, 1996-2001

Indicators	Sub-Indicators
	Immigrant Population Change, 1996-2001
	Average Personal Income Change - Males, 1996-2001
	Average Personal Income Change - Females, 1996-2001
	Average Family Income Change, 1996-2001
	Full-time Employment Change, 1996-2001
	Self-employment Change, 1996-2001
	Education Services Change, 1996-2001
	Health and Social Services Change, 1996-2001

In order to assess and interpret the relevance of these selected indicators, a literature review was undertaken to determine their usefulness regarding potential adaptive capacity. Several methods have been developed to determine adaptive capacity (for example, Smit and Pilifosova 2001, Schröter et al. 2005, Swanson et al. 2007, Diffenbaugh et al. 2007, Metzger et al. 2006 and Williamson et al. 2007, Yohe and Tol 2002).

Some researchers appear to use adaptive capacity and vulnerability assessments synonymously. Brooks et al. (2005) noted that vulnerability and adaptive capacity were difficult to disentangle. They determined that vulnerability related more to short-term hazards and adaptive capacity related to a longer-term process of adjustment. The result is we will be assessing the methodologies regardless of whether the researchers termed their models as vulnerability assessments (e.g., Schröter et al. 2005) or adaptive capacity determinants (e.g., Smit and Pilifosova 2001).

Smit and Pilifosova (2001) identified the main determinants of communities that appear to determine a community's adaptive capacity. These determinants include economic wealth, technology, information and skills, infrastructure, institutions and equity (Table 2). They also hypothesize that the determinants are not independent of each other, nor are they mutually exclusive. Adaptive capacity of a community or region is a combination of the determinants and varies widely from region to region and between communities. It also varies over time.

Yohe and Tol (2002) developed a method for assessing a community's vulnerability by incorporating exposure, sensitivity and adaptive capacity. They utilized and further refined the adaptive capacity determinants defined by Smit and Pilifosova (2001) (Table 2). The result is a method of evaluating a community's abilities to handle external stress by assessing the potential contributions of various adaptation options by focusing on the determinants of adaptive capacity.

The ATEAM project (Advanced Terrestrial Ecosystem Analysis and Modelling) uses an ecosystem assessment approach by integrating the potential impacts in a vulnerability assessment (Metzger et al. 2006). They state that adaptive capacity reflects the potential to implement planned adaptation measures and is concerned with deliberate attempts to adapt to or cope with change.

They use four steps to derive adaptive capacity indices:

1. Develop of a socio-economic framework using indicator-based approach;
2. Estimate future values of the indicators using regression models

3. Aggregate of the estimated values of the indicators using fuzzy models[28]
4. Use validity tests of the fuzzy models using uncertainty and sensitivity analyses

Metzger et al. (2006) utilized 12 socio-economic indicators that feed into six determinants. These six determinants feed into three components (awareness, ability and action) which lead into determining the regions adaptive capacity (Figure 2).

The determinants used by Metzger et al. (2006) are similar to the key determinants of adaptive capacity defined by Smit and Pilifosova (2001). However, their groupings are different because of the 12 base indicators selected (Table 2). For example, Smit and Pilifosova (2001)'s "human and social capital" is in the equity and infrastructure determinants.

Williamson et al. (2007) found many factors affect adaptive capacity, including wealth, mobility, education, social networks, trust, institutions, risk perceptions and natural resource endowments (Table 2). The capacity to adapt exists both as a property of individual households and firms and as a general property of the community and the local economy. The accurate portrayal of adaptive capacity requires measurement at different levels of aggregation. Adaptive capacity may also vary depending on whether it is assessed over the short term (where assets are fixed) or over the long term (where assets are variable).

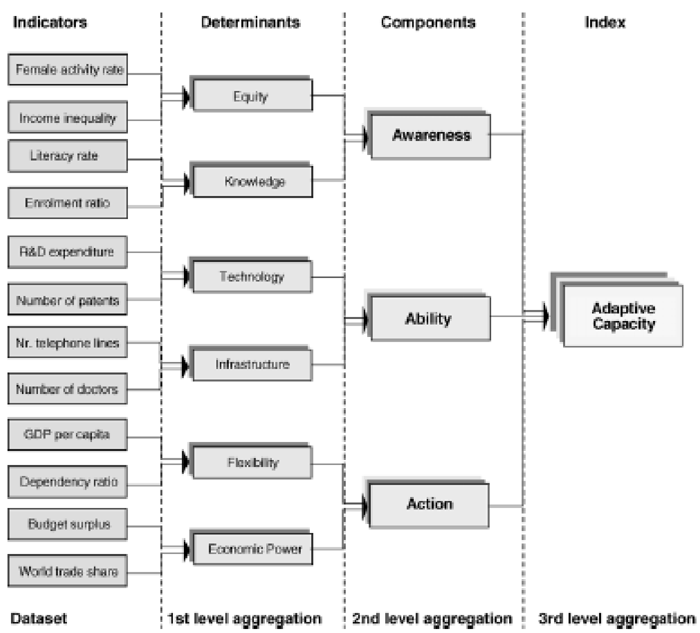

Figure 2. Indicator Framework used to develop the adaptive capacity model (Metzger et al. 2006)

They developed a 14 step method for identifying and describing the components of a vulnerability assessment framework and outlining a structured approach for conducting as assessment (Williamson et al. 2007). One of the steps is to assess the adaptive capacity of a

[28] Fuzzy models are based on a continuum of values and are approximate in value (Encyclopaedia Britannica 2008)

community. A list of questions was generated to help determine a community's capacity to adapt (Williamson et al. 2007: 34):

- "Are there significant facts that may limit the capacity of households, firms and social and economic systems within the community to adapt to climate change?
- Does the community have strong and active social networks?
- Are there significant institutional barriers to adaptation?
- In cases where climate change has the potential to increase risk, are households, firms and organizations aware of these increased risks?"

Swanson et al. (2007) used the 2001 Canadian Census of Agriculture database to derive 17 adaptive capacity indicators (Figure 3 and Table 3). They organized the indicators into six determinants based on Smit and Pilifosova (2001). The determinants were: 1) Economic Resources, 2) Technology, 3) Infrastructure, 4) Information, skills and management, 5) Institutions and networks, and 6) Equity.

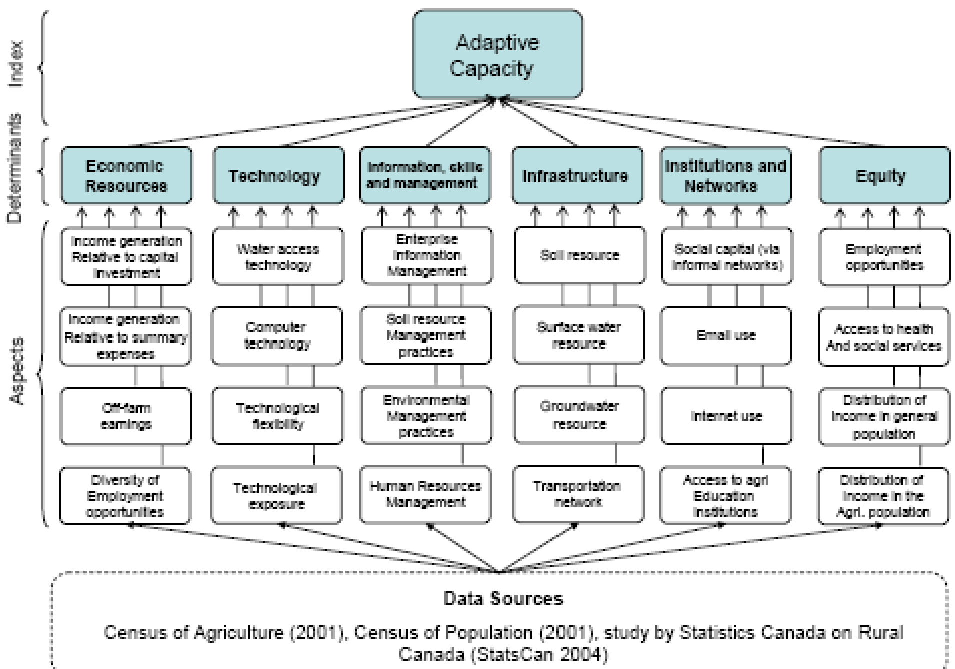

Figure 3. Framework for adaptive capacity (Swanson et al. 2007)

Diffenbaugh et al. (2007) assessed vulnerabilities to climate change around the world by developing an indicator of socio-climatic exposures by integrating climate, poverty, wealth, and population. For climatic exposures, seasonal temperature and precipitation were used to create climate index with a point system of 0 to 4 for temperature and 0 to 4 for above normal precipitation and 0 to 8 for below normal precipitation. Sea level change was also utilized in their analysis. They then used this index named National Climate Change Index (NCCI) to create socio-climate indicators:

Climate Change population index = NCCI * scaled total population

Climate Poverty Density Index = NCCI * scaled percent of each nation's population living on less than two dollars per day

Climate Wealth Index = NCCI * scaled per capita gross national income (purchasing power parity)

Climate Wealth Intensity Index = NCCI * scaled wealth by scaled population.

Climate Poverty Intensity Index = NCCI * scaled poverty by scaled population.

This index was used to estimate where potential problems may be with relation to climate change (Giorgi 2006). The disadvantage with this method is its narrowness in scope as it only deals with population, and income. This model can also be viewed positively because of its simplicity and relative ease of obtaining information. A second disadvantage is a need to put in a new point system for the climatic indices to better suit the needs of the study region as it would not be as diverse as when Dieffenbaugh et al. (2007) examined the world. The change in sea level would have no influence on the results so would not be used in the analysis. Lake water levels data may be of use but may not be available.

Table 3 **Indicators identified for the aspects of adaptive capacity (Swanson et al. 2007)**

Determinant	Aspect	Indicator
Economic Resources	Income generation relative to capital investment	Ratio of gross farm receipts to total capital investment. Higher is better.
	Income generation relative to summary expenses	Ratio of income to expenses. Higher is better.
	Off-farm earnings	Off-farm earnings as a percent of total family income where families have at least one farm operator. Higher is better.
	Diversity of employment opportunities	Ratio of off-farm contribution of time to on-farm contribution of time. Not available with current dataset. Alternative was the ratio of employment in agriculture to employment in other industries within CD. Lower is better.
Technology	Water access technology	Ratio of value of irrigation equipment to value of all other farm equipment. Higher is better.
	Computer technology	Ratio of farms reporting use of computer to all other farms. Higher is better.
	Technological flexibility	Ratio of value in tractors under 100 hp to total value of all other tractors. Lower is better.
	Technological exposure	Ratio of technologically-demanding to less demanding farm types. Higher is better.
Information, skills and management	Enterprise information management	Ratio of Farms reporting computer livestock and crop record keeping to all other farms. Higher is better.
	Sustainable soil resource management practices	Ratio of area of no-till or zero till seeding to tilled area. Higher is better.
	Sustainable environmental management practices	Ratio of Farms reporting windbreaks and shelter belts to all other farms. Higher is better.
	Human resources management	Ratio of Total farms reporting paid ag labour to all other farms. Higher is better.
Infrastructure	Soil Resources	Proportion of area in dependable agricultural land. Higher is better.
	Surface Water Resources	Ratio of surface water area to total land area. Higher is better.
	Groundwater Resources	No. and/or yield of wells. Higher is better.
	Transportation Network	Ratio of high capacity to low capacity roads. Higher is better.
Institutions and Networks	Informal operating arrangements	Ratio of Total farms reporting formal agreements to total no. of farms reporting sole proprietorships and partnerships without written agreement minus miscellaneous category. Lower is better.
	Email use	Ratio of Total farms reporting Email use to all other farms. Higher is better.
	Internet access	Ratio of Farms reporting internet use to all other farms. Higher is better.
	Opportunity to access agricultural education institutions	Distance between centroids of each Census Division and the nearest regionally significant Ag institution. Lower is better.
Equity	Employment opportunities	Unemployment rate from Statistic Canada's 2001 Census of Population 20% Sample Data for Population of 15 years and over. Lower is better.
	Opportunity to access health and social services	Ratio of labour force in health and social service occupations to all other occupations. Statistics Canada 2001 Census of Population 20% Sample data for Population. Higher is better.
	Distribution of income - general population	Rating by Alessandro's work as published in Catalogue no. 21-006-X1E (Rural/urban divide is not changing: income disparities persist)
	Distribution of income - agricultural producers	Ratio of farms reporting sales in excess of 250k to all other farms. Lower is better.

Schröter et al. (2005) used five criteria for vulnerability assessments.

1. The knowledge base engaged for analysis should be varied and flexible.
2. Vulnerability assessments should be "place-based" with an awareness of the nesting of scales.
3. Global change drivers examined should be recognized as multiple and interacting.
4. Vulnerability assessments should allow for differential adaptive capacity.
5. The information should be both prospective and historical

Schröter et al. (2005) have an eight step method for conducting global change vulnerability assessments (Figure 4). This assessment sets out three steps that should be carried out prior to modelling and five steps that involve modelling and post modelling. They have designed the process to be circuitous in nature because models generally need to be modified as research is carried out which results in some of the steps needing to be repeated.

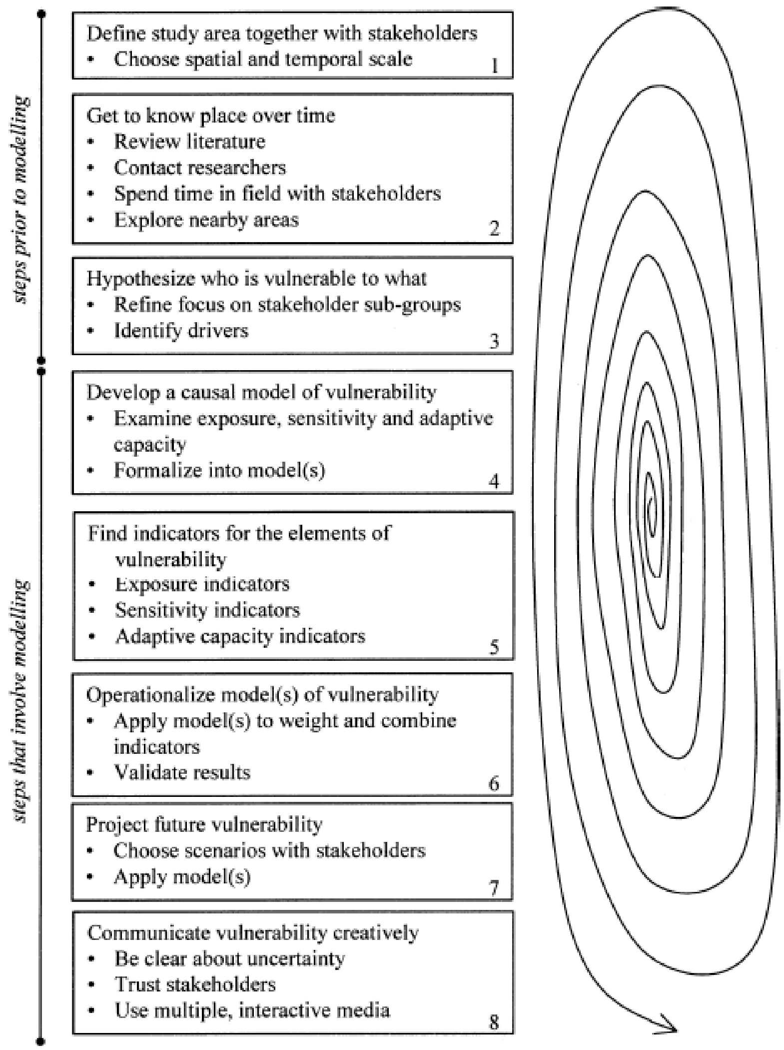

Figure 4. Global Change Vulnerability Assessment (Schröter et al. 2005)

The 5th step of Schröter et al. (2005) method involves finding and deciding what adaptive capacity indicators are important. They do not stipulate quantitative indicators for determining adaptive capacity. They do state that indicators should be spatially explicit so mapping can occur. They recommend that researchers state why they are including or not including a particular indicator in their causal model and how this inclusion/non-inclusion may bias the model results.

In order to assess and interpret the relevance of the CID indicators, it needs to be determined how the indicators fit with historic adaptive capacity models. Table 2 shows the comparison.

The CID indicators have values for most of the categories that the other models have except technological information and people's attitudes (e.g., risk perceptions and level of trust). In addition, some of the indicators can and should be placed into more than one category (e.g., selected community indexes) because some of these indexes help determine risk management while others demonstrate economic resources. This shows that the CID will be a useful tool in determining a community's adaptive capacity based on models available in the literature. However, there is information lacking including the CID does not document technological options available in the community nor does it supply information on peoples' perceptions or attitudes to various topics including adapting to extreme climatic events.

Table 2 Adaptive Capacity Determinants - Model Comparisons

	Determinants (Smit & Pilifosova 2001)		**Determinants (Yohe & Tol 2002)**		**Determinants (Metzger et al. 2006)**	**Indicators (Diffenbaugh et al. 2007)**	**Determinants (Swanson et al. 2007)**	**Factors (Williamson et al. 2007)**		**Indicators (CID 2007) (Data available for 1996 and 2001)**
Socio-Economic	Technology	Varies between communities and regions. Varies with time.	Technology	Varies between communities and regions. Varies with time.	Technology		Technology		Varies with time	
	Economic Resources		Economic Resources		Economic Power, Equity	Population, Income	Economic Resources, Equity	Wealth, Mobility, Natural Resource Endowments		Population, Aboriginal Peoples, Employment, Community Type, Income, Environmental Stewardship, Selected Community Indexes
	Institutional design and structure		Decision making structure and credibility		Infrastructure		Infrastructure, Institutions and Networks	Institutions		Infrastructure, Engaged Population and Institutions
	Human, social and natural capital of adaptors		Human and social capital					Social Networks		Engaged Population and Institutions, Selected Community Indexes
	Capacity to manage risk		Ability to share (between several parties and thus reducing the impact) or reduce the risk		Flexibility					Environmental Stewardship, Selected Community Indexes
	Knowledge and information access		Knowledge and informational needs		Knowledge		Information, skills, and management	Education		Education
	Perceptions and attitudes of adaptors		Perceptions of risk					Risk Perceptions		
								Trust		
Bio-Physical						Climate (temperature and precipitation)				
						Sea Level				

Bio-physical indicators of adaptive capacity

An important determinant missing from most of the models is the bio-physical component (Table 2). Bio-physical resources of a region have an influence over the adaptive capacity of a community. The level of adaptive capacity of a community is impacted by the regional and local bio-physical features and should be assessed. This section examines the bio-physical features of the case study communities of La Ronge, Victoria Beach, Montreal Lake and Deschambault.

The Boreal Plains eco-zone is made up of the Boreal Transition, Mid-Boreal Lowland and Mid-Boreal Upland eco-regions. These regions range from in the southern end being a mix of forest and farmland to completely forested areas further north. The forested regions have a mixture of aspen, jack pine, black spruce and tamarack to name a few (Padbury and Acton 1994).

The bio-physical components of the Boreal plains eco-zone that influence communities' adaptive capacity are:

- Vegetation
- Wildlife
- Extreme events
    - Fire
    - Insects
    - Droughts
    - Floods
    - Extreme temperatures
    - Extreme Wind
- Air quality
- Water quantity and quality

These components change over time and vary between regions. It is often the case one bio-physical event leads to a second and third event which may further test the adaptive capacity of a community and the region. For example, high temperatures and low precipitation may lead to drought conditions causing low water quantity which decreases water quality. The same drought may result in wildfires which in turn affects air quality. Thus low water supply and poor quality in addition to poor air quality may put communities at risk and taxing the communities' adaptive capacity having to deal with more than one negative situation.

Many communities in the Boreal Plains Ecozone including the La Ronge, Deschambault and Montreal Lake communities, are involved in many climate sensitive activities including forestry, trapping, fishing, wild rice harvesting and mushroom and berry picking (Olmos and Williamson 2007; Langford et al. 2007; Lebel 2006). Other communities such as Victoria Beach are resort community dependent on tourism and tourism activities (Government of Manitoba ND).

Each of the communities' bio-physical elements is different. For example, La Ronge utilizes Lac la Ronge for a variety of reasons including potable water, recreation, and fishing to name a few. Water levels in Lac la Ronge have remained relatively stable since the lake became regulated in 1968 (Wittrock and Wheaton 2007).

At Deschambault Lake, the stream courses have major influence on hunting, trapping and gathering of country foods. The stream courses are used as a means of transportation (Langford et al. 2007). When these stream courses become flooded or dry, people who utilize them have to alter their utilization strategies.

Montreal Lake is used by Montreal Lake Cree Nation for a variety of reasons including fishing, and is the community's potable water supply. The community of Montreal Lake used to operate a commercial fishery. It was temporarily closed in 2006 due to decreasing numbers of commercial fish such as white fish (Lebel 2006). The reason for this decrease in believed to be overexploitation (Brklacich and Woodrow 2007). In addition, there are decreasing population of pickerel in Bittern River. It is hypothesize this is due to sediment from the community of Montreal Lake's access road washing into the river after intense precipitation events (Lebel 2006). It is speculated that if water levels of the lake increase in the future will reduce water quality and increase the community's vulnerability. An added potential threat to this community's water system is that it is wholly funded by Indian and Northern Affairs Canada so in order to make changes or upgrades to the system, Montreal Lake needs approval and funding from the federal government (Brklacich and Woodrow 2007).

Land base is a concern for First Nation communities. This is because it limits resource development and subsequent revenue generation and employment for the band (Brklacich and Woodrow 2007).

Saskatchewan has a Community Wildfire Risk Assessment (Johnson et al. 2006). This assessment results in the communities being rated as extreme, high, medium and low risk from wildfires. These ratings are based on infrastructure, household structures, community preparedness, suppression and detection in the area as well as the number of residents and monetary value of the community. Other ratings include the potential fire behaviour, and the history of wildfire ignitions. The results of these rankings indicate that Montreal Lake and La Ronge are high risk communities for wildfires while Deschambault Lake is moderate risk.

Victoria Beach underwent a risk assessment in 2005, carried out by the Manitoba Model Forest, Manitoba conservation and the Rural Municipality of Victoria Beach. The results of this assessment were not known by the authors at the time of publication.

Use of community information database in determining adaptive capacity

The Community Information Database will be a very useful tool for community adaptive capacity assessment. As mentioned earlier, the CID documents many different socio-economic data, including some indices including Local Institutional Capacity, Regional Disparity, Economic Stability, and Vulnerability (Population Decline and Employment Decline). These indices would be useful because they give an indication of the adaptive capacity of the communities. For further information on definitions of the indices refer to Appendix 1C or the CID web site: http://www.cid-bdc.ca/. This section examines a select few of the datasets. The complete set of maps are in Appendix 3.

The CID categorized the Boreal Plains ecozone into four categories: agriculture, energy, forestry and mining. Alberta has agriculture, energy and forestry, Saskatchewan has agriculture, energy, forestry and mining and Manitoba has agriculture, forestry and mining (Figure 5). The type of resource reliance influences the population, employment, income and infrastructure. For example, the Fort McMurray region is categorized as energy, it has the highest total population, the highest total aboriginal population, the highest immigrant population, the largest number of people moving into the area, the largest number of people with post secondary education to name a few. This is due to the extreme influence the tar sands have on the Fort McMurray region.

The CID calculated the level of employment and the level of income based on the relationship between social and natural resource systems. There are difficulties with using these data because the two census years split categories differently for example in 1996, agriculture was its own category, but in 2001, it was combined with forestry, fishing and hunting (Burns 2004). Based on the 2001 Census year, employment levels in the southern area of the Boreal Fringe Zone have the greatest resource reliance. This location has a strong agricultural component. Northern Saskatchewan has low employment reliance on resources. In Alberta, the highest reliance is similar to Saskatchewan in that the agricultural region in northwest Alberta has the highest employment resource reliance compared to other regions. This trend is similar in Manitoba where the southwestern portion of the FMA has a larger agricultural component than the other regions (Figure 6 and 7). The trend in income – resource reliance (Figure 8) has a similar trend where the agricultural areas have higher resource reliance than other locations. One area that is different is Fort McMurray which has a strong income resource reliance.

Population in the Forest Management Area (FMA) ranges from less than 500 to greater than 25,000. Saskatchewan and Manitoba have the lowest population by Census Sub-Division (CSD) and Alberta the greatest (Figure 9 and 10) with CSDs growing between 1996 and 2001 (Figure 11).

The largest number of people who have Grade 9-13 are located in Alberta with the lowest number in Saskatchewan (Figures 12 and 13). The largest percentage of people in all of the four study sites have between Grade 9 and 13 education in 2001: Montreal Lake 18%; Deschambault Lake 17%; La Ronge 14% and Victoria Beach 36% (Table 4).

Local Institutional Capacity is characterized by the competence (demonstrated practical ability) and autonomy (legal and structural ability). Across the prairies, in 1996 (Figure 14) Northern Saskatchewan has the highest institutional capacity and northwest Alberta has the lowest. In 2001, the institutional capacity rose in northern Manitoba (Figure 15). When the four study sites are examined, in 1996, La Ronge had the highest institutional capacity at 8.37 and Deschambault Lake the lowest at 0. In 2001, the lowest was Victoria Beach at 1.12 with La Ronge the greatest at 11.35 (Table 4).

Regional disparity describes the variations in wealth and socio-economic conditions. A high degree of disparity is when only a few places in a geographic region hold most of the resources whereas a low index indicates low disparity or that resources are spread out among many places. Figures 16 and 17 show the extent of regional disparity across the Boreal Ecozone. Northern portions of the Boreal Plain Ecozone have a high level of disparity while the lower half of the boreal plains ecozone has low regional disparity. An examination of the four study sites show that within the town sites themselves, there is very low disparity (Table 4).

Economic Stability is an indicator that incorporates Gross Domestic Product, unemployment and inflation. A value of zero is a region of high economic stability or no economic fluctuation to a value of one, indicating a region of low economic stability or high fluctuations. Figures 18 and 19 indicate that the southern regions of the boreal plains ecozone have low to mid-range economic stability where as the more northerly portions have higher economic stability. The three Saskatchewan study sites have economic stabilities in the mid to high 0.2 range where as Victoria Beach, a resort community is in the mid 0.3 range (Table 4).

The CID has two datasets that examine vulnerability: population decline and employment decline. These maps (Figures 20 and 21) illustrate that Saskatchewan appears to be the most vulnerable in terms of long-term population decline as well as employment decline, especially on the eastern side of Saskatchewan's forested area. The three Saskatchewan study sites are projected to be somewhat vulnerable to population decline, with levels of 0.39. Victoria Beach has low vulnerability to population decline rated at 0.05 (Table 4). The CID also determined that the four communities have a low vulnerability to declining level of employment with levels of less than 0.10 (Table 4). This indicates that the four communities' employment levels should not drop lower than they currently are with Montreal Lake at 32, Deschambault Lake at 23, La Ronge at 68 and Victoria Beach at 58 in 2001 (Table 4).

The four study sites indicate that there is little to no metropolitan influence to their census sub-divisions. The largest centre is La Ronge at nearly 3000 people but the population decreased by 258 people between 1996 and 2001. The majority of the people in Montreal Lake and Deschambault Lake are First Nations people while La Ronge is about half First Nations people, half non-First Nations. The smallest community is Victoria Beach. Victoria Beach is a resort community so the population likely increases during the summer months. There is a small contingent of First Nations people at Victoria Beach (Table 4).

The average family income at Montreal Lake and Deschambault Lake is below $25,000 per year in 2001. La Ronge's average family income is higher at more the $50,000 per year and Victoria Beach is higher at over 65,000 per year in 2001. Over 40% of the income at Montreal Lake and Deschambault Lake is from government income while it is just over 10% at La Ronge and a little higher than 15% at Victoria Beach. These income levels are reflected in the employment rates. Montreal has an employment rate of between 27 and 32% while Deschambault has an employment rate of between 20 and 23%. La Ronge's employment rate has stayed between 68 and 69% during the two census periods. Victoria Beach's employment rate is 58% (Table 4).

Based on the information supplied by the CID, it is not possible to determine which of the four communities has the greatest adaptive capacity. The reasons include:

- Lack of information regarding the range of technological options
- Most of the adaptive capacity models (Table 2) do not utilize bio-physical information. This addition would be beneficial in determining adaptive capacity.
- Lack of information regarding the communities' perceptions and attitudes to various topics including extreme events.

The four communities analyzed are different. Victoria Beach is a resort community, with small population, relatively high income and high education but according to the CID it has low institutional capacity. La Ronge is the largest community with moderate levels of income compared to the other three communities. It has high economic stability and with low regional disparity and the highest level of institutional capacity. La Ronge is susceptible to various bio-physical events including wildfires, high water and low water, water quality issues, and changing country food supplies, changing fish stocks, changing winter road conditions, to name a few. The two First Nation's community (Montreal Lake and Deschambault) have, according to the CID, economic stability but are projected to be vulnerable to population decline. The CID also indicates that their employment levels should not decline below their 2001 levels. These communities are similar to La Ronge's bio-physical susceptibility. In all four case studies, it is not known what their capacity to cope with extreme events is.

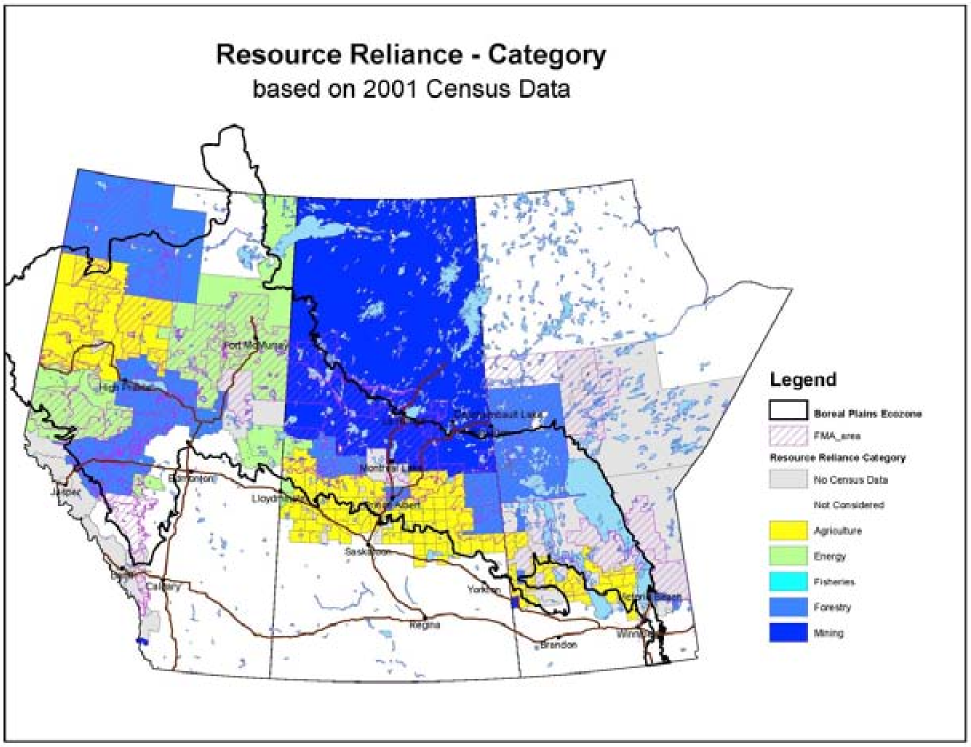

Figure 5. Resource Reliance – Category based on 2001 Census Data (Data Source: Rural Secretariat ND)

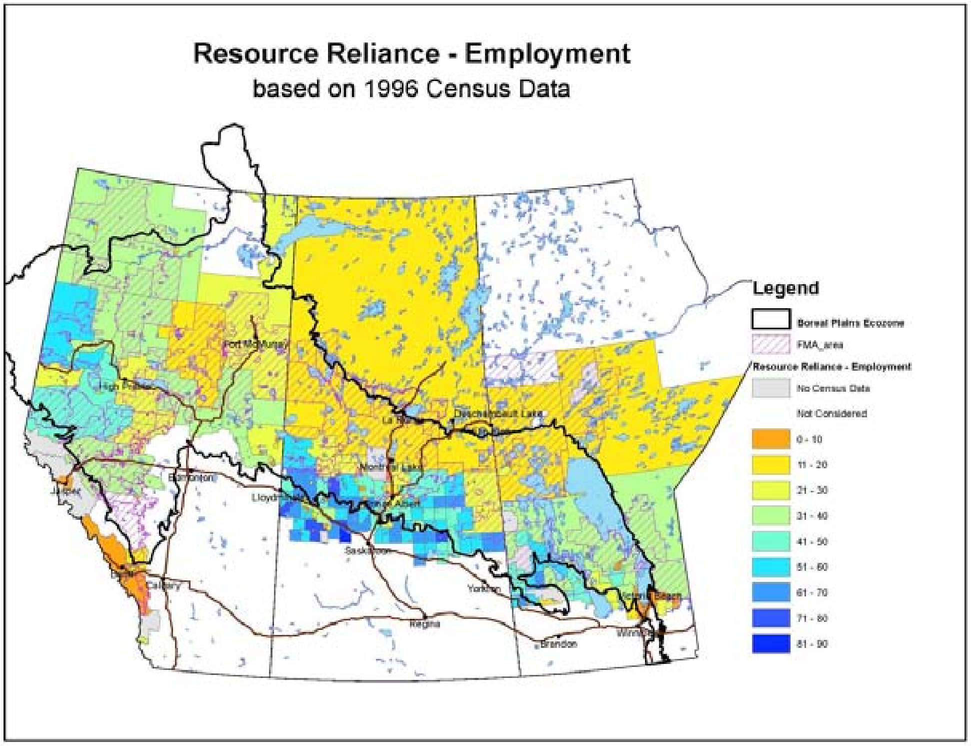

Figure 6. Resource Reliance – Employment based on 1996 Census Data (Data Source: Rural Secretariat ND)

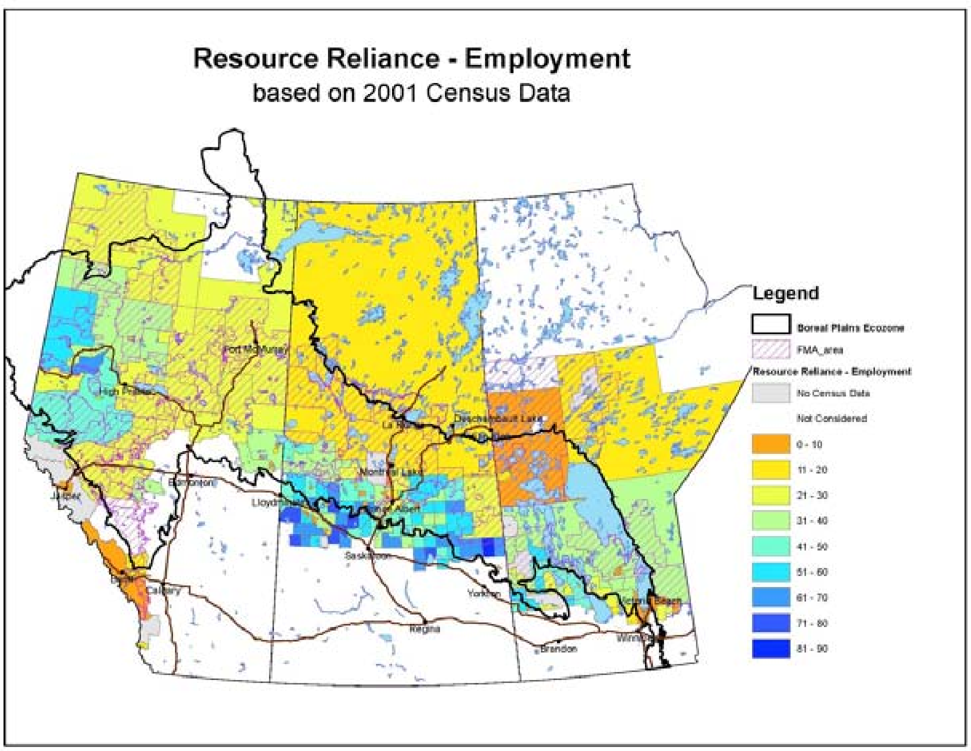

Figure 7. Resource Reliance – Employment based on 2001 Census data (Data Source: Rural Secretariat ND)

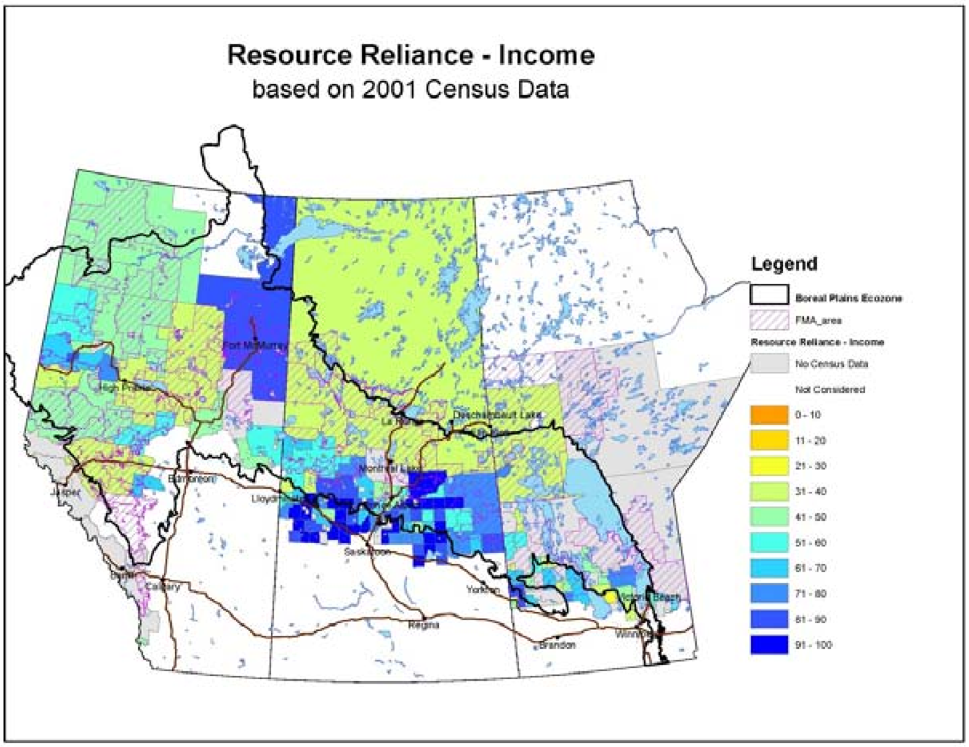

Figure 8. Resource Reliance – Income based on 2001 Census data (Data Source: Rural Secretariat ND)

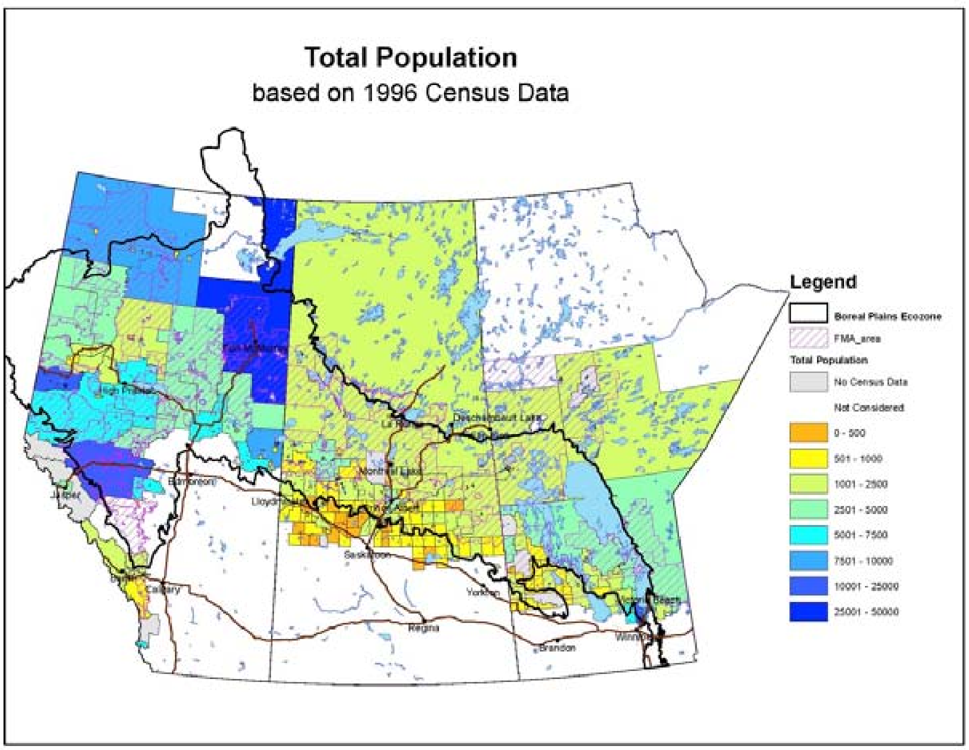

Figure 9. Total Population based on 1996 Census data (Data Source: Rural Secretariat ND)

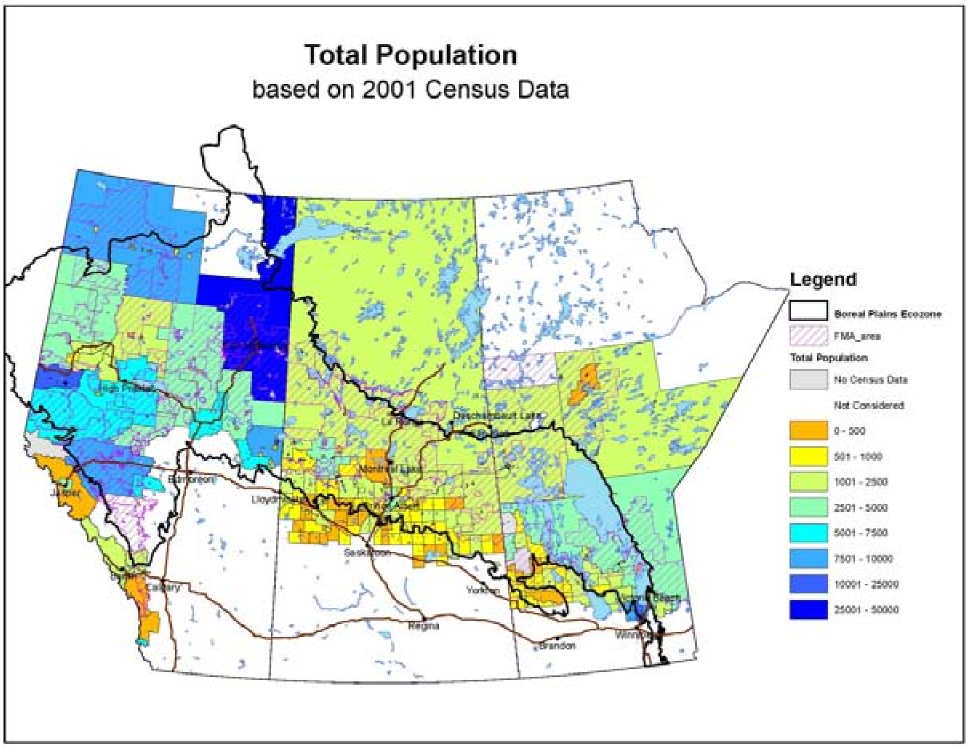

Figure 10. Total Population based on 2001 Census data (Data Source: Rural Secretariat ND)

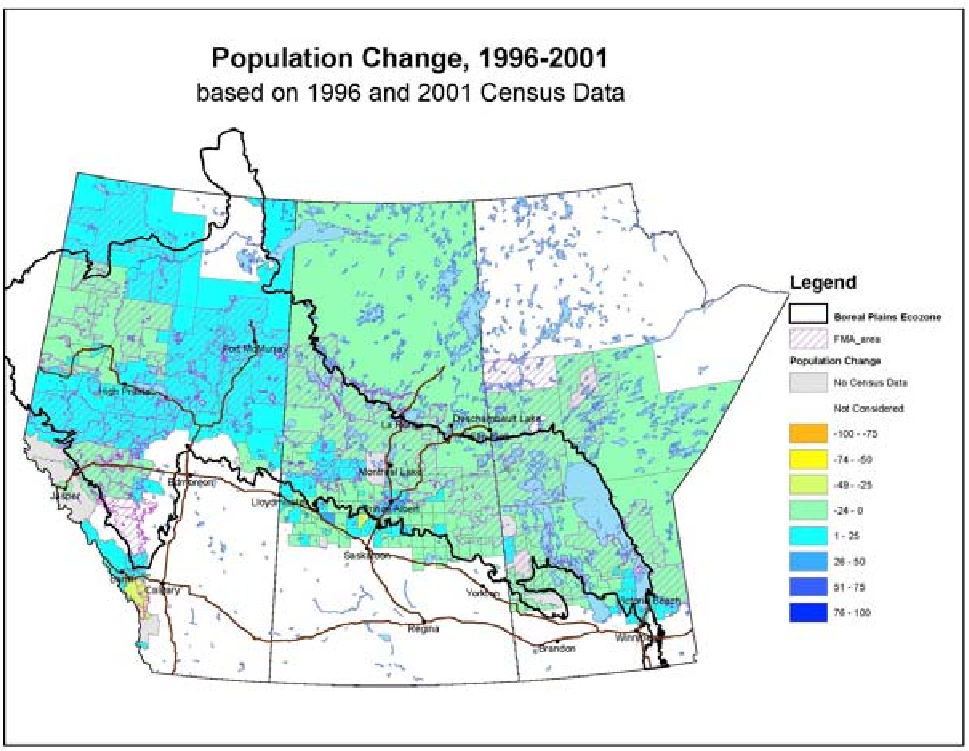

Figure 11. Population Change, 1996-2001, based on 1996 and 2001 Census data (Data Source: Rural Secretariat ND)

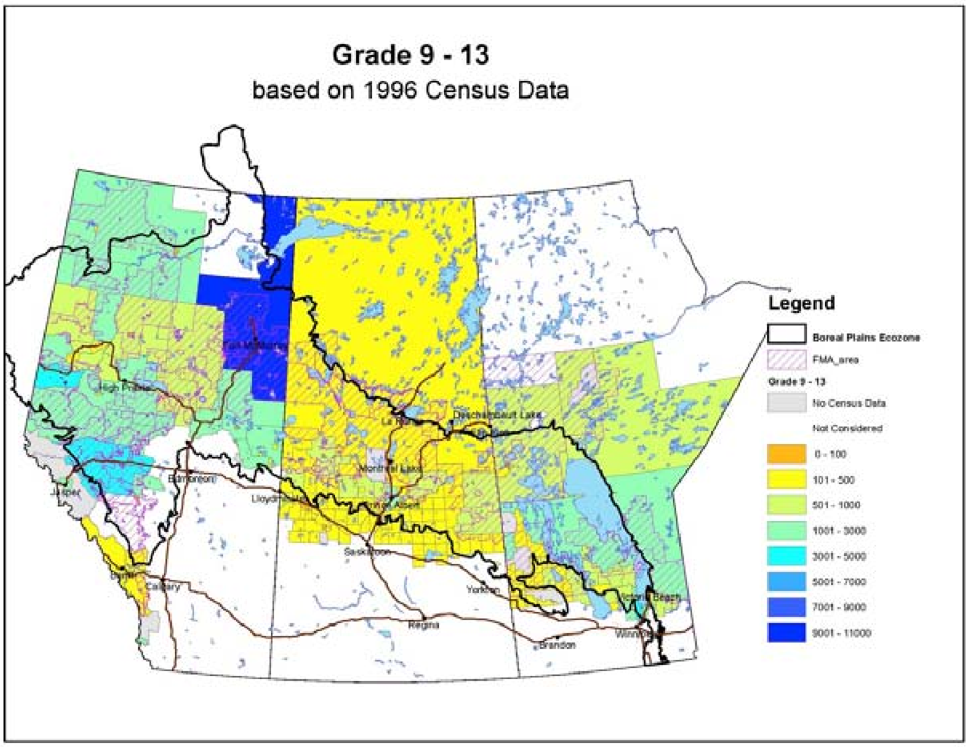

Figure 12. Grade 9 – 13 based on 1996 Census data (Data Source: Rural Secretariat ND)

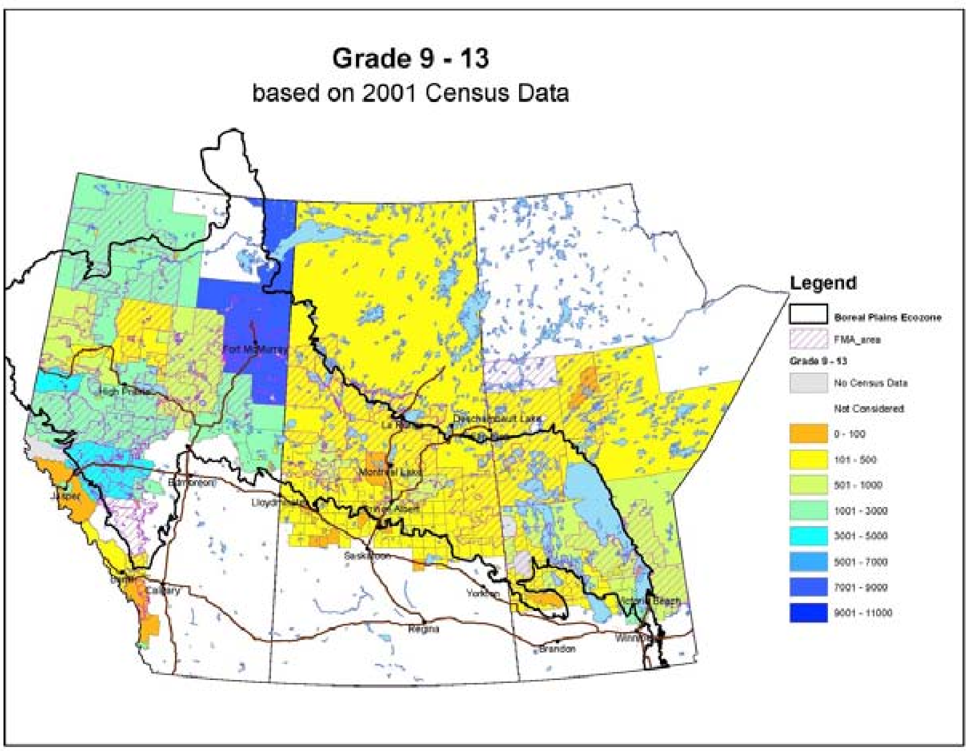

Figure 13. Grade 9 – 13 based on 2001 Census data (Data Source: Rural Secretariat ND)

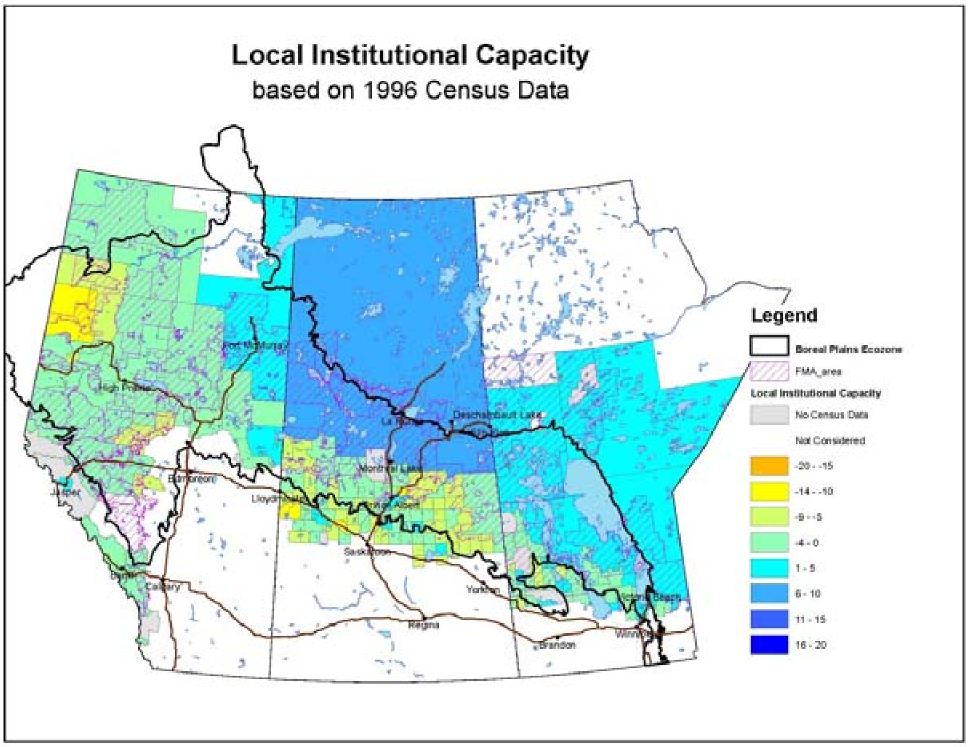

Figure 14. Local Institutional Capacity based on 1996 Census data (Data Source: Rural Secretariat ND)

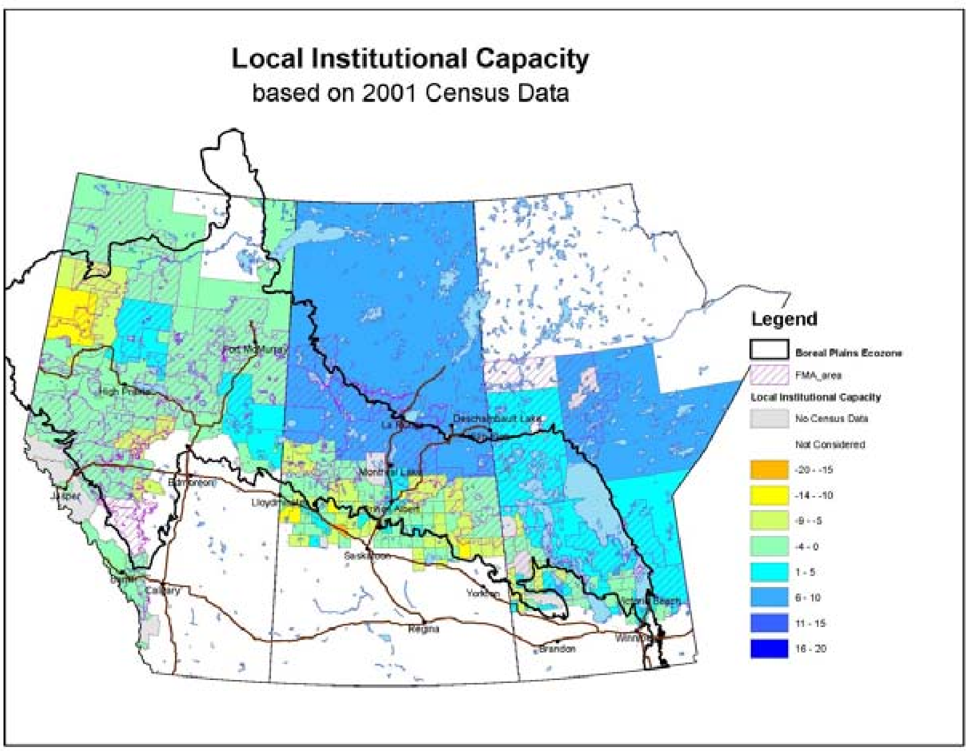

Figure 15. Local Institutional Capacity based on 2001 Census data (Data Source: Rural Secretariat ND)

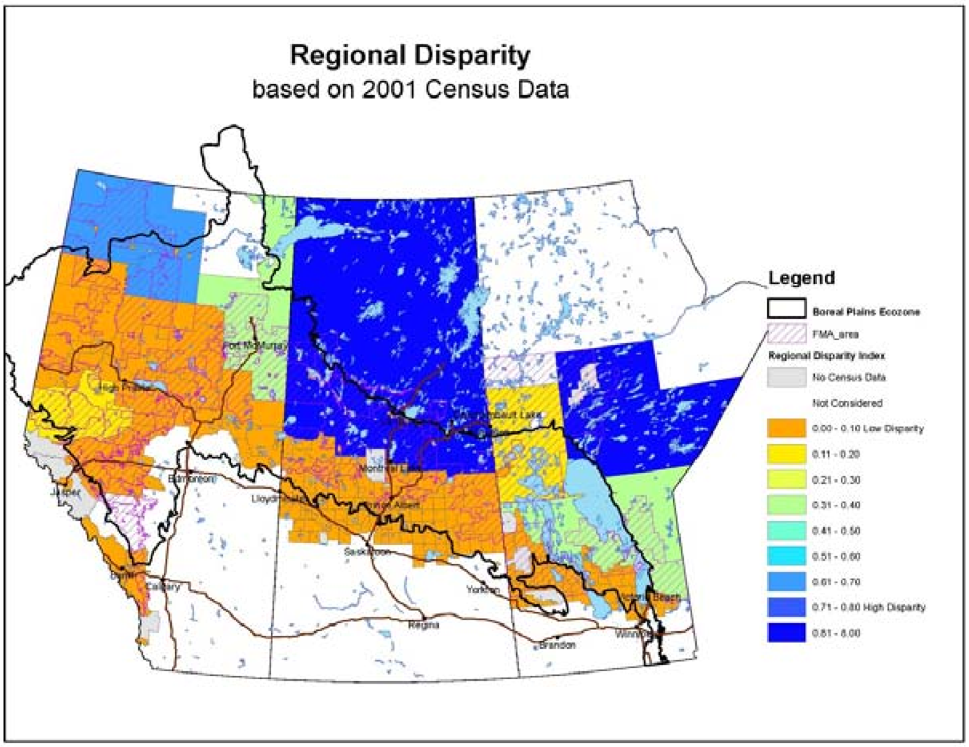

Figure 16. Regional Disparity based on 2001 Census data (Data Source: Rural Secretariat ND)

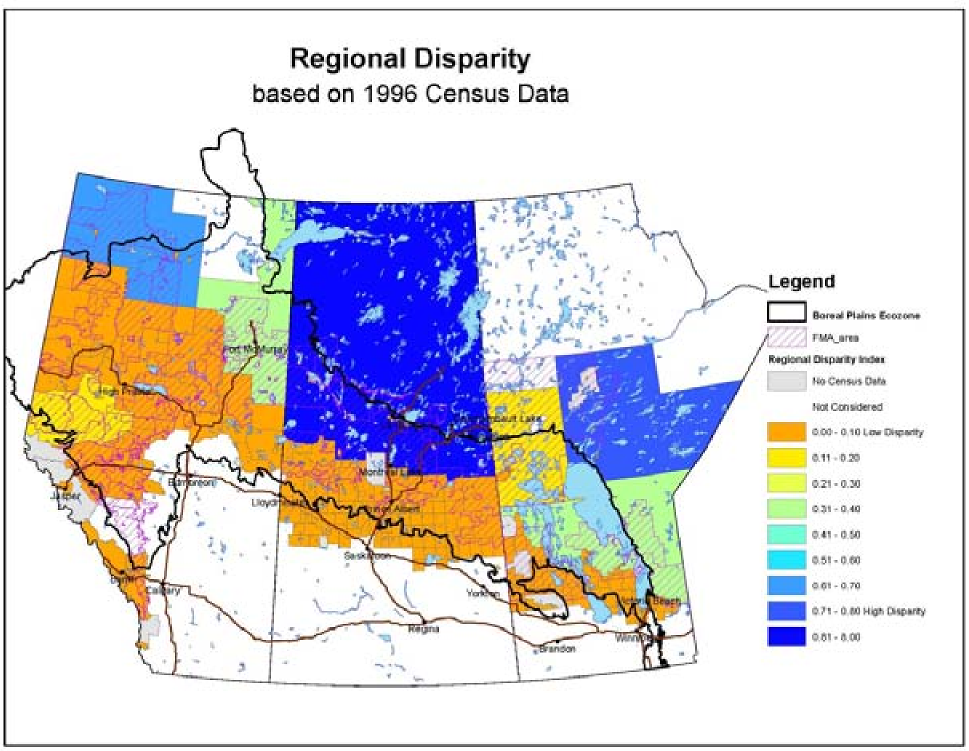

Figure 17. Regional Disparity based on 1996 Census data (Data Source: Rural Secretariat ND)

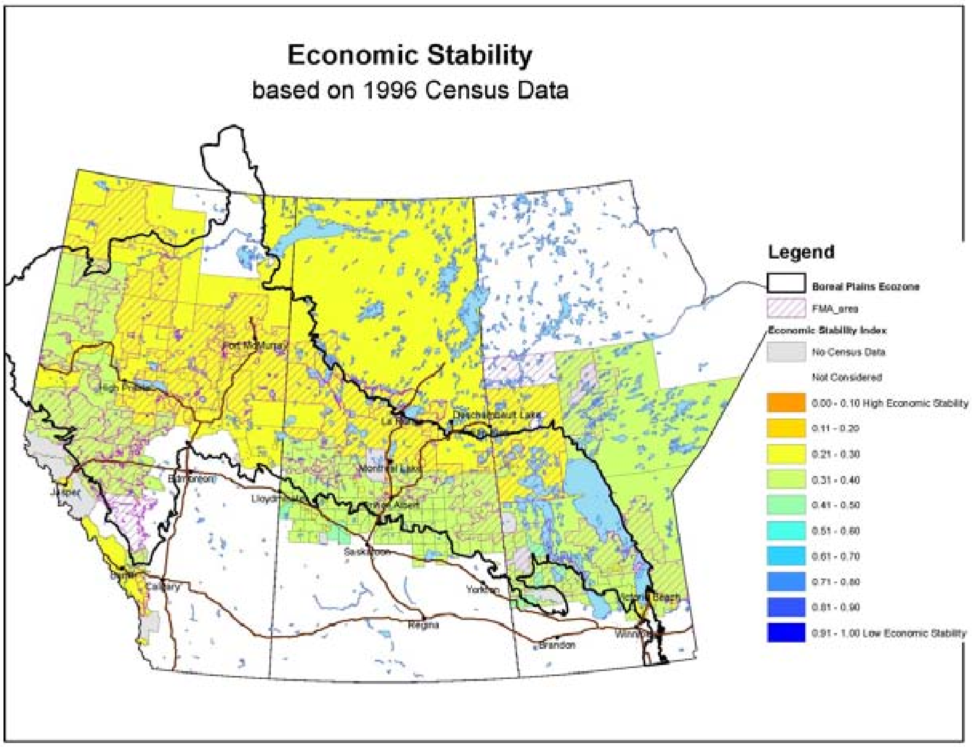

Figure 18. Economic Stability based on 1996 Census data (Data Source: Rural Secretariat ND)

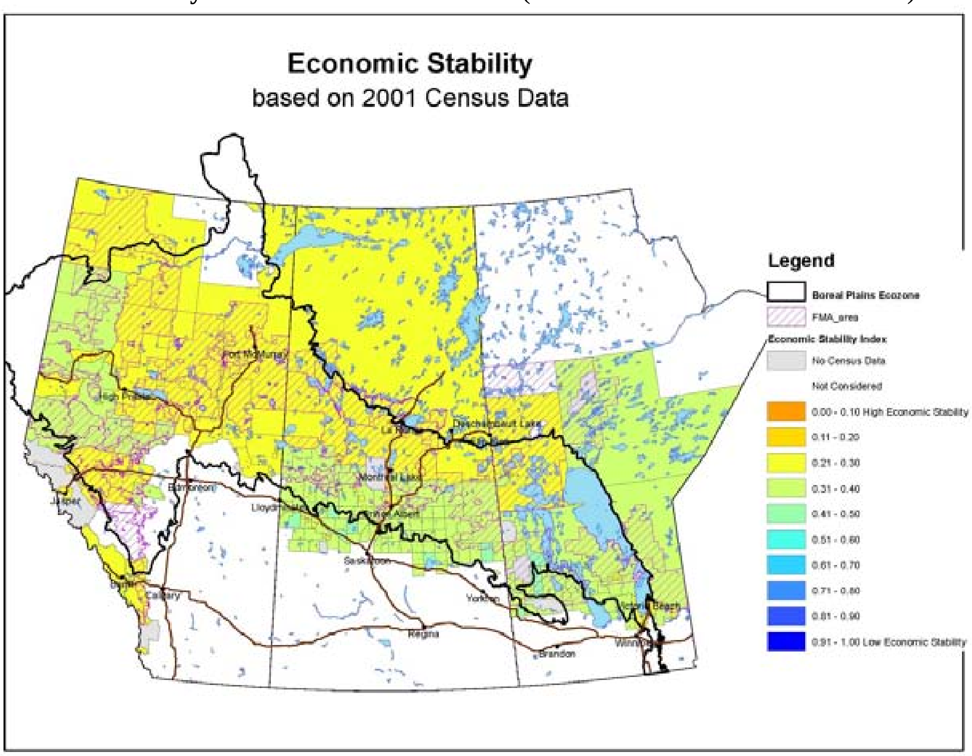

Figure 19. Economic Stability based on 2001 Census data (Data Source: Rural Secretariat ND)

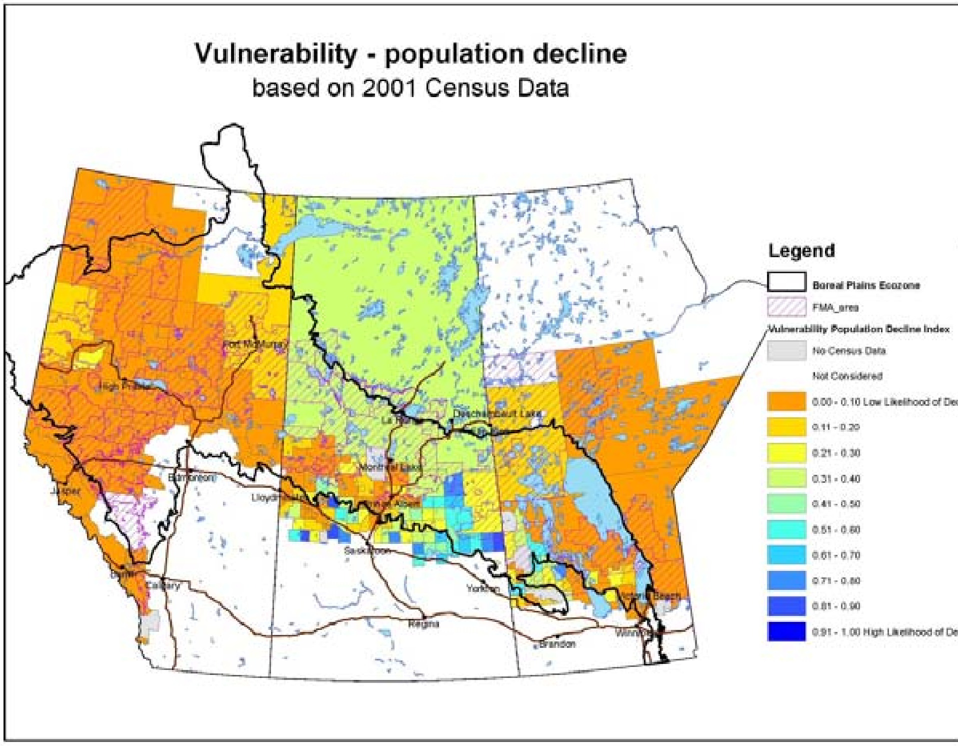

Figure 20. Vulnerability – Population Decline based on 2001 Census data (Data Source: Rural Secretariat ND)

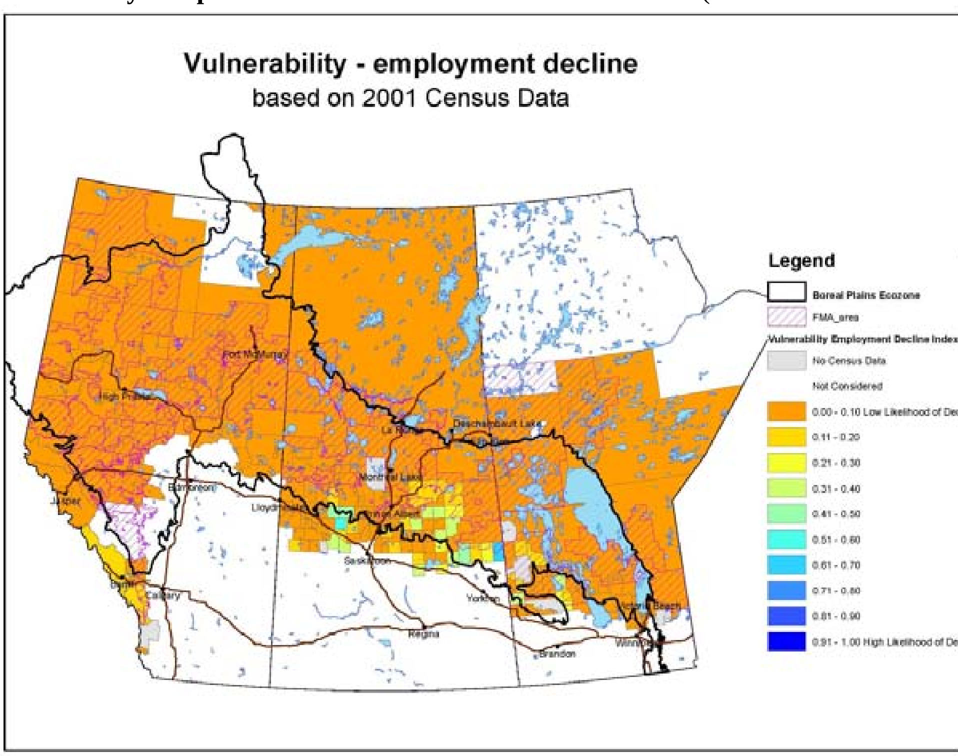

Figure 21. Vulnerability – Employment Decline based on 2001 Census data (Data Source: Rural Secretariat ND)

Table 4 Selected Indicators for Montreal Lake, Deschambault Lake, La Ronge and Victoria Beach (Rural Secretariat ND).

	4718802 Montreal Lake 106	4718802 Montreal Lake 106	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718041 La Ronge	4718041 La Ronge	4601078 Victoria Beach	4601078 Victoria Beach
INDICATORS	1996	2001	1996	2001	1996	2001	1996	2001
Community Type	-	-	-	-	-	-	-	-
Metropolitan Influence Zone (MIZ)	Rural weak	Rural weak	Rural weak	Rural weak	Rural weak	Rural Weak	Rural - No MIZ	Rural - No MIZ
Resource Reliance – Category	-	-	-	-	-	-	-	-
Population	-	-	-	-	-	-	-	-
Total Population	660	861	695	896	2985	2727	-	265
Male Population	340	445	375	465	1435	1350	135	130
Female Population	320	415	320	430	1550	1375	100	135
Population density	10.83	14.12	86.44	111.44	253.4	231.49	-	13.07
Population mobility	260	380	225	285	1435	1475	-	95
Immigrant population	0	-	0	-	110	80	-	0
Education	-	-	-	-	-	-	-	-
Not attending school	60	60	80	100	245	205	-	0
Attending school full-time	50	80	30	75	265	230	-	0
Attending school part-time	0	10	0	10	30	30	-	0
Less than grade 9	95	85	145	135	225	115	-	10
Grade 9 – 13	170	155	125	155	665	385	-	95
Trades certificate or diploma	25	55	25	15	50	330	-	60
University	35	40	25	30	450	380	-	15
Aboriginal Peoples	-	-	-	-	-	-	-	-
Total Aboriginal population	655	850	690	880	1530	1475	-	50
Income	-	-	-	-	-	-	-	-
Average family income $ - Male lone-parent families	0	20294	0	17613	0	27300	-	0
Average family income $ - Female lone-parent families	17169	16681	19432	16573	17075	24808	-	0

	4718802 Montreal Lake 106	4718802 Montreal Lake 106	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718041 La Ronge	4718041 La Ronge	4601078 Victoria Beach	4601078 Victoria Beach
Economic families - Low income	0	0	60	0	190	160	-	10
Economic families – Other	0	0	60	0	545	565	-	80
Economic families - Incidence of low income - %	0	0	52.5	0	26	21.9	-	0
Unattached individuals - Low income	0	0	15	0	100	75	-	0
Unattached individuals – Other	0	0	10	0	205	175	-	50
Unattached individuals - Incidence of low income - %	0	0	0	0	0	30.2	-	0
Total population in private households - Low income	0	0	330	0	855	620	-	35
Total population in private households – Other	0	0	360	0	2120	2075	-	235
Total population in private households - Incidence of low income - %	0	0	0	0	0	23	-	12.5
Average personal income – males	11094	11404	12290	10655	25509	29182	-	44988
Average personal income – females	11725	12661	11006	11822	17557	22706	-	15198
Average family income	24257	24051	27982	24965	43045	52932	-	65684
Composition of income (employment)	60	58.7	56.4	52.1	85.2	84.6	-	56.6
Composition of income (gov't transfer)	40.6	39.6	41.5	46.8	11.9	10.2	-	15.4
Composition of income (other)	0.2	0.8	0.8	0.2	2.9	5	-	27
Employment	-	-	-	-	-	-	-	-
Employment rate	27.8	31.6	20	23	68.7	68.2	-	57.8
Full-time employment	50	70	20	45	825	825	-	40
Self-employment	0	0	0	0	60	50	-	10
Not in the labour force - 15 years and over	210	255	230	300	515	435	-	85
Unemployed - 15 - 24 years	20	20	10	10	45	60	-	0
Employment to population ratio - 15 - 24 years	8.7	-	9.5	-	50.9	-	-	-
Employment rate - 15-24 years	-	10.7	-	13.9	-	49.5	-	0
Unemployment rate - 15 - 24 years	100	57.1	66.7	28.6	13.8	20.7	-	0
Employment to population ratio - 25 years and over	36.7	-	24.5	-	74.9	-	-	-
Employment rate - 25 years and over	-	40.9	-	29.7	-	74.7	-	60.5

	4718802 Montreal Lake 106	4718802 Montreal Lake 106	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718041 La Ronge	4718041 La Ronge	4601078 Victoria Beach	4601078 Victoria Beach
Unemployment rate - 25 years and over	24	24.3	45	42.4	5.6	8.3	-	7.4
Employment to population ratio - Males 15 - 24 years	20	-	15.4	-	63.2	-	-	-
Employment rate - Males 15-24 years	-	13.3	-	11.1	-	53.5	-	0
Unemployment rate – Males 15 - 24 years	100	50	100	50	10	20.7	-	0
Not in the labour force - Males 25 years and over	45	60	65	70	85	100	-	20
Employment to population ratio - Males 25 years and over	40	-	24	-	82.6	-	-	-
Employment rate - Males 25 years and over	-	46.9	-	27.3	-	77	-	72.7
Unemployment rate – Males 25 years and over	31.2	30	46.2	55	5	10.1	-	11.8
Not in the labour force - Females 15 - 24 years	55	45	40	70	135	105	-	10
Employment to population ratio - Females 15 - 24 years	0	-	0	-	36.5	-	-	-
Employment rate – Females 15 - 24 years	-	16.7	-	11.1	-	44	-	0
Unemployment rate - Females 15 - 24 years	100	0	0	0	20.8	24.1	-	0
Not in the labour force - Females 25 years and over	75	90	75	85	210	160	-	55
Employment to population ratio - Females 25 years and over	29.2	-	21.7	-	68.6	-	-	-
Employment rate – Females 25 years and over	-	38.2	-	29	-	71.8	-	47.6
Unemployment rate - Females 25 years and over	22.2	18.8	25	33.3	6.2	8.1	-	0
Environmental Stewardship	-	-	-	-	-	-	-	-
Land area in square kilometres, 2001	60.96	60.96	8.04	8.04	11.78	11.78	20.28	20.28
Resource Reliance – Employment	14.29	11.11	22.22	9.68	5.72	6.41	-	0
Resource Reliance – Income	-	-	-	-	-	-	-	-
Engaged Population and Institutions	-	-	-	-	-	-	-	-
Local Institutional Capacity	6.31	9.71	0	7.79	8.37	11.35	-	1.12
Infrastructure	-	-	-	-	-	-	-	-
Education Services	20	30	20	20	165	185	-	10
Health and Social Services	15	35	10	25	195	190	-	0
Number of funded Community Access Program sites	-	1	-	1	-	3	-	1

	4718802 Montreal Lake 106	4718802 Montreal Lake 106	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718852 Kimosom Pwatinahk 203 (Deschambault Lake)	4718041 La Ronge	4718041 La Ronge	4601078 Victoria Beach	4601078 Victoria Beach
Number of occupied private dwellings	140	190	140	190	920	900	-	135
Tenant-occupied non-farm, non-reserve dwelling	0	0	35	0	450	460	-	0
Owner-occupied non-farm, non-reserve dwelling	0	0	10	0	470	440	-	135
Selected Community Indexes	-	-	-	-	-	-	-	-
Regional Disparity	0	0	0	0	0.000024	0.000017	-	0
Economic Stability	0.27	0.26	0.28	0.26	0.26	0.26	-	0.33
Social Progress	0	0	0	0	0	0	-	3.18
Economic Competitiveness	-0.34	-36.21	-0.52	-31.54	2.22	-5.93	-	0
Global Exposure and Integration	0	0.32	0	0.33	0.44	0.51	-	0
Industry Integration	0	0.13	0	0.14	0.16	0.26	-	0
Industry exposure - export proportion of total trade	0	0.27	0	0.26	0.28	0.24	-	0
Industry exposure - export proportion of GDP	0	0.58	0	0.58	0.87	1.03	-	0
Vulnerability - population decline	-	0.3902	-	0.3902	-	0.3902	-	0.0482
Vulnerability – employment decline	-	0.0794	-	0.0794	-	0.0794	-	0.0132
1996-2001 Change	-	-	-	-	-	-	-	-
Population Change, 1996-2001	-	30.45	-	28.92	-	-8.64	-	-
Population Mobility Change, 1996-2001	-	46.15	-	26.67	-	2.79	-	-
Immigrant Population Change, 1996-2001	-	-	-	-	-	-27.27	-	-
Average Personal Income Change - Males, 1996-2001	-	2.79	-	-13.3	-	14.4	-	-
Average Personal Income Change - Females, 1996-2001	-	7.98	-	7.41	-	29.33	-	-
Average Family Income Change, 1996-2001	-	-0.85	-	-10.78	-	22.97	-	-
Full-time Employment Change, 1996-2001	-	40	-	125	-	0	-	-
Self-employment Change, 1996-2001	-	-	-	-	-	-16.67	-	-
Education Services Change, 1996-2001	-	50	-	0	-	12.12	-	-
Health and Social Services Change, 1996-2001	-	133.33	-	150	-	-2.56	-	-

Conclusions and recommendations

The CID will be a useful but limited tool in determining adaptive capacity. It supplies much of the information required by the adaptive capacity models. The two major areas it is missing are technological information and peoples' attitudes and perceptions to for example extreme events.

Most of the adaptive capacity models do not allow for bio-physical information but communities and stakeholders require bio-physical information. The communities require it to assist in determining adaptive strategies for potential extreme events and the lumber industry require bio-physical information because of the impacts to their timber harvesting schedules (see Wheaton 2008 "Scenarios of Future Climates"). Therefore, it is recommended that the CID is combined with the bio-physical information that was available in 1996 and 2001. This would allow for the development of a more comprehensive adaptive capacity model because of local bio-physical influences on a region.

Acknowledgements

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APPENDIX ONE (CONTINUED)

1B CID Downloading Procedures

Downloading information from the CID database using the following steps (http://data2.beyond2020.com/agcan/ThematicMaps/mapView.aspx):

- Select a province from the map of Canada. The web site does not allow for more than one province selection at a time.
- Use the rectangular selection capability to select census sub-divisions within the appropriate study area (i.e., Boreal Forest Ecozone) within the selected province.
- Select "view as table"
- Select "geography" to further refine the census sub-divisions. Due to the rectangular section (above) some areas were selected that should not have been and vice versa. This step allows for further refinement of the selected census sub-division.
- Select the "indicators" of interest (Table 1). Indicators were chosen based upon expert judgement (Williamson p. comm. 2008). Indicator definitions are in Appendix 2 and on the CID website: http://www.cid-bdc.ca/.
- Select the time period of interest (1996 and 2001)
- Download the data in comma delimited ASCII format to be imported into Excel.
- Combine three provinces into one excel spreadsheet.
- Create base map using the Boreal Plains Ecozone and the Forest Management Area
- Import CID information into ArcInfo.
- Create overlay maps for each of the selected indicators (Appendix 3).

APPENDIX ONE (CONTINUED)

1C Brief Indicator Definitions for the CID (Rural Secretariat ND).

Not all of the indicators nor sub-indicators have definitions. For more complete definitions see the Rural Secretariat website (http://www.cid-bdc.ca/) :

Community Type:

Metropolitan Influenced Zone – is a concept that geographically differentiates the area of Canada outside census metropolitan areas and census agglomerations. Census subdivisions are assigned to a MIZ category based on the percentage of their resident employed labour force that has a place of work in the urban core. The strong MIZ category includes CSDs with a commuting flow of 30% or more (at least 30% of the total employed labour force living in the CSD work in any CMA/CA urban core). The moderate MIZ include CSDs with a commuting flow percentage between 5% and 30%. The weak MIZ category includes CSDs with a commuting flow percentage f more than 0% but less than5%. The No MIZ category includes those CSDs with either fewer than 40 people in the resident labour force or no people commuting to work in CMA/CA urban cores.

Resource Reliance – Classification used for 5 sectors: agriculture, energy, fishing, forestry, mining.

Population:

Total Population – Based on the number of persons of Canadian citizenship in 1996 and 2001. The population data for the 1996 and 2001 censuses for a specific region represent the number of Canadians that usually reside in that same region, wherever they are on census day

Population density – is the number of persons per square kilometre and is calculated by dividing the total population by land area. The calculation for population density is total population divided by land area. The data is available for all standard geographic areas.

Population mobility – mobility status is an indicator that expresses an absolute number of migrants within a given period of time. Migration is a derived variable referring to the types of migrants that can generally be classified in two categories: movers who were residing in a different CSD one year earlier (internal migrants) or movers who were living outside Canada one year earlier (external migrants).

Immigrant population – provides information about the whole immigrant population, specifically with respect to its size, geographic distribution, origins and demographic characteristics. The indicator also identifies the number of immigrants who have obtained Canadian citizenship or who hold a dual citizenship including Canadian citizenship.

Aboriginal Peoples:

Total Aboriginal Population – Included in the aboriginal population are those persons who reported identifying with at least one aboriginal group, that is, 'North American Indian', Metis, Inuit and/or who reported being a treaty Indian or a registered indicant as defined by the Indian Act of Canada and/or who reported they were members of an Indian band or First Nation.

Education:

Post-Secondary Qualifications – the main subject area of a person's degree, certificate or diploma after high school.

Income:

Average family income – average income of census families or non-family persons refers to the average total income of census families or non-family persons for the previous year. A higher dollar amount indicates a higher average total income for families (weighted mean). For example, an indicator where the amount reaches $25,000 in a given census division shows that the average family income within that given community is $25,000 annually.

Average personal income – reported for population 15 years of age and over with income, excluding institutional residents (e.g., hospital, senior citizens' home, jail) and is expressed as a dollar value.

Composition of Income (employment) – refers to the relative share of each income source or group of sources, expressed as a percentage of the total income of that group or area (aggregate total income). Sources of income are employment income, investment income and transfer income (e.g., Old Age Security, Pension, Child tax credit). Represents the aggregate share of a particular income group for a specific area, where a higher percentage means higher reliance on a particular source of income. For example, if the composition of income (government transfer) data point for a community displays 18%, this means that the community is reliant on government transfer for 18% of its total income.

Employment:

Full employment – is expressed as a number of persons occupying a full time job and is calculated monthly. Full time (30 hours or more per week); part time (1 to 29 hours per week).

Self employment – are working owners of an incorporated business, farm or professional practice or working owners of an unincorporated business, farm or professional practice. It refers to population 15 years of age and over, excluding institutional residents. Self employment activity includes all workers who are self-employed in their main job as well as employees earning self employment income from a farm unincorporated business or professional practice outside their main job. Self-employed workers can be further subdivided by those with or without paid help. Also included among the self employed are unpaid family workers. They are persons who work without pay on a farm or business owned and operated by another family member living in the same dwelling. This indicator can be expressed by a number of self-employed workers or a percentage.

Employment Rate – the number of persons employed during the week (Sunday to Saturday) prior to census day expressed as a percentage of the total population 15 years of age and over. The employment rate for a particular group is the number employed in that group expressed as a percentage of the population for that group. The employment rate is a statistic derived from the Labour Force Activity variable. It is expressed as a percentage and is calculated monthly.

Environmental stewardship:
Resource reliance refers to the relationship between social and natural resource systems. It can be defined as the proportion of activity in the resource sector activities that contribute to an area's total basic economic activity. The type of industry seems to play a significant role, for example, some researchers have found that forest sector reliant communities have higher rates of unemployment, poverty, divorce and even higher crime rates (from Stedman et al., 2004).

Resource Reliance – Employment – refers to the relationship between social and natural resource systems. It reflects the extent to which the social system is reliant on one or more natural resources. Resource reliance can be defined as the proportion of activity in the resource sector activities that contribute to an area's total basic economic activity. Resource sector activities include agriculture, forestry, logging, mining and oil and gas-related industries. Results from the index are represented as percentages and can range from 0% to 100% with 0% meaning absolutely no resource reliance is present in a CSD to 100% meaning completely resource reliant CSD.

Resource Reliance – Income – resource reliance is a measure of the relative importance of a resource sector to a particular community. Natural resources form the basis of the economy for much of Canada outside the large cities and main regional centres. This includes the production and initial process of five types of natural resources. The economic impact of these resources is measured in terms of the employment income directly generated by their exploitation, processing and distribution. Employment income is data collected by the Census of Population; it is based on activities in the year prior to the Census, which means that this indicator shows the status of activities in 2000. The indicator shows the degree of reliance for all communities with over 30% of their employment income in resource sectors. A higher share of reliance in resource sector means a higher degree of reliance on natural resources. For communities with resource reliance on more than one sector, only the dominant sector is represented.

Engaged population and institutions:
Local Institutional Capacity – is the aggregated capacities of individual institutions in a given census sub-division (CSD) or census consolidated sub-division (CCS), where institutional capacity is characterized by the competence (demonstrated practical ability) and autonomy (legal and structural ability) of institutions in the following activity areas:

- Assessing and managing resources (financial, human and technical, including accessing and managing information);
- Carrying out key functions (providing information, services and training; contributing to social and economic progress);
- Initiating structural reform when necessary in order to maximize the first two capacities and to ensure institutional sustainability (through internal governance and inter-institutional relations).

Local institutional capacity (LIC) –

- % of bilingual individuals
- % with post-secondary education
- % employed in intellectual and managerial occupations
- % self-employed workers
- % employed in education
- % employed in government
- % employed in health and social services

Results at the CSD level can range from a low of -18% indicating very low capacity to a high of 18% indicating very high capacity.

Selected community indexes:
Regional Disparity – Disparity refers to differences in rank, conditions or excellence. When this term is applied to socio-economic conditions of regions or territories, the term disparity can be used to describe the "variations in wealth and socio-economic conditions and opportunities among units of observation." In order to measure these variations between regions, geographic concentration indexes are most often used. These indexes are intended to measure the extent to which a small area of national territory accounts for a large proportion of a certain economic phenomenon. Thus, a high concentration index would suggest a high degree of disparity (a few places hold most of the resources), whereas a low index indicates a low degree of disparity (resources are spread out among many places). Results at the CSD level range from a low of 0% indicating that there is no contribution to regional disparity to high of 23% indicating a high percentage of regional disparity.

Economic Stability – minimal fluctuations in output, unemployment and inflation. Output can be defined as Gross Domestic Product (GDP) and account for inflation by using Real GDP. Employment trends can be represented by using labour force survey estimates to calculate GDP per capita and CSD industry shares in order to measure economic stability at the regional level. Results from the economic fluctuation index range from 0 to 1 with zero indicating no economic fluctuation (i.e. high economic stability) and one indicating a high degree of economic fluctuation (i.e. low economic stability).

Social Progress – Economic, social and environmental variables may be considered in determining social progress as well as basic human rights within the three realms. Within the term "social progress" it is evident that the consideration of human needs must go beyond economic and should include social and environmental aspects. Social Progress Index - % with grade 9 education or higher; average life expectancy in number of years; % population change; young dependency ratio (represents the number of dependents, under the age of 20, for every 100 people in the working age population (20-64); % below low-income cut-off; unemployment rate. Results range from a low of -14% indicating very low social progress to a high of 19% indicating very high social progress.

Economic Competitiveness – is defined as the capacity of firms and industries located in the CD to achieve sustained income and employment growth relative to other communities. Two related indicators of competitiveness could be derived from this definition: income and employment. Both indicators are used to provide alternative measures of the competitive strengths of various industries and the regions in which they are located, relative to their counterparts in a country. Results from the competitiveness index are measured in terms of income growth in millions of dollars. A high income growth or competitiveness effect would imply a high level of competitiveness; whereas, a low or negative competitiveness effect would imply that these CSDs are less competitive.

Global Economic Exposure and Integration Indicator, Industry Integration, Industry exposure – export proportion of total trade, Industry exposure – export proportion of GDP – Global economic integration is defined as the degree to which industries are characterized by international linkages, as measured by the level of intra-industry trade. Results from the indices range from 0 to 1 with zero indicating there are no global exposure and integration or connectedness and one indicating "complete" global exposure and integration.

Vulnerability – Population Decline – indicates the likelihood of long-term population decline for the community. The index values range from 0 to 1 with high values indicating a greater likelihood of population decline.

Vulnerability – Employment Decline – indicates the likelihood of long-term employment decline for a community. The index values range from 0 to 1, with high values indicating a higher likelihood of employment decline.

APPENDIX ONE (CONTINUED)

1D Canadian Boreal Plains Ecozone - Community Information Maps (Data Source: Rural Secretariat ND)

Community Type

Population

Education

Income

Employment

Environmental Stewardship

Engaged Populations and Institutions

Infrastructure

Community Indices

APPENDIX TWO

Questions used to guide the discussions with forest managers in the Boreal Plain Ecozone

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Part A. The state of forest management in Canada

One of the main purposes of this study is to understand factors that contribute to, or limit the ability of forest management and forest managers to adapt and prepare for climate change. However, climate change is only one of many issues that are - and will in the future - impact forest management in Canada. For the first few questions we would like to ask you about major events or changes that are affecting forest management in your FMA.

1. What are the major issues, challenges and/or changes currently affecting forest management in your region and in Canada?

2. What will be the major issues, challenges and/or changes affecting forest management in the next 20 to 30 years?

3. How concerned are you about climate change in comparison to other issues affecting forest management?

Part B. Recent climate change

A useful approach for discussions about future climate change is to begin with a discussion of current climate and/or recent trends in climate and how forest managers have adapted to these changes in the past.

4. Do you feel the climate in your area has changed over the last 20 – 40 years and if so how have these changes impacted forest management in your area?

5. Have you, your company or your organization made specific changes to adapt to these changes and if so please describe them?

Part C. Future climate change impacts on forest outputs and forest management.

The purpose of this section is to identify important climate change factors for forest management and to obtain information about ways that climate change might affect forests, forest outputs, and forest management in your area.

Note: specific impacts on forest management and forest operations resulting from changes discussed in this section will be discussed in the next section of questions.

6. Please discuss the kinds of climate changes that may be particularly important from a forest management perspective in your area.

For example:

- Increase in climate variability
- Increase in extreme weather including high winds
- Shorter winters
- Etc.

7. How might forests and forest outputs in the area be impacted by climate change between now and the year 2050 and what are the main implications for forest management?

For example:

- Increase (decrease) in wildfire activity and other disturbances
- Regeneration failure
- Change in quantity and quality of wood supply
- Increased uncertainty in wood supply (increased risk)
- Change in delivered wood costs
- Change in ability to achieve non-timber related forest management objectives
- Etc

Part D. Potential ways that forest managers might adapt to climate change

In this section we would like the respondents to identify and discuss various types of strategies and actions that they think could be taken to adapt to climate change in their specific context. They should not be confined to discussion of only those actions that are allowed under current tenure arrangements but should be allowed to think outside the box.

8. What are some strategies and/or ways that you would recommend or consider adopting in order to reduce the impacts of future climate change and what are some of the things that the forest management community in Canada in general needs to do in order to adapt?

Part E. Assessing current capacity to adapt

The purpose of this section is to identify and discuss features, assets and institutional factors that influence (positively and negatively) the ability of Canadian forest managers to adapt to climate change. According to the Intergovernmental Panel on Climate Change, the capacity to adapt to climate change is determined by:

- Awareness,
- The range of technological options available to decision makers,
- Economic resources (or wealth of decision makers),
- Institutional design and structure (i.e. flexibility, able to efficiently allocate resources to adaptation, degree of autonomy of adaptation choices),
- Human and social capital of adaptors,
- Ability to manage risk, and
- Knowledge and access to information (adequacy of current knowledge and management of new knowledge and information).

Awareness / perceptions of urgency:

9. Do you feel that climate change is real?

10. How concerned are you about climate change and why?

11. How urgent is it that forest managers begin to address climate change in decision making and in planning?

12. Do you feel that the local effects of climate change on forest ecosystems are well understood by forest managers in your area?

Science and technology:
Climate change implies significant uncertainty. Lack of knowledge or tools about possible future impacts (e.g. effects on growth and yield) may be limiting the ability of forest managers to adapt.

13. Does uncertainty and lack of tools about future impacts prevent you as a forest manager from implementing changes in how you manage forests in anticipation of climate change and if so how? (i.e. What knowledge and tools would you need that you do not already have in order to begin adapting to climate change?)

14. Is there sufficient capacity (financial, skills, researchers, etc) to develop and implement innovative ways of managing forests in response to climate change?

Economic Resources, Institutions and Governance:
Adaptation will require funding and financial resources. It will also require that forest managers, forest based companies and forest land owners (i.e. provinces) have an incentive to invest in adaptation. Incentives are usually defined in the context of current institutional designs. Incentives may be in the form of rewards (e.g. financial return) or sanctions (e.g. penalties for not following a particular rule).

15. In your view, does the financial state of the Canadian forest industry in anyway limit or constrain our ability to begin adapting to climate change?

16. What would be required in order for companies to justify making investments in adaptation?

17. Forest companies operating on public lands have certain responsibilities under their tenure arrangements. Which of these responsibilities will be impacted by climate change?

18. Do companies have the ability within current tenure systems to adapt in a way that company responsibilities are not compromised and what are the barriers (if any)?

Risk management:
Climate change will likely result in increased risk relative to timber supply, infrastructure, forest management investments (e.g. plantations) and relative to other objectives (e.g. wildlife, sustainable forests, multiple use). An increase in risk has an economic cost. It also means that foresters may need implement new approaches in order to manage risk (e.g. through portfolio diversification, shorter rotations, hedging, etc).

19. In what ways does climate change have implications for risk relative to forestry objectives?

20. Do you have the ability to manage risk in your current setting?

21. If you could manage risk better, what risk management strategies would you employ?

Human capital:
Human capital is a measure of the skills, education, experience and knowledge of individuals and groups. The collective amount of human capital within a group is an important measure of the capacity of that group to adapt to some external change.

22. Do Canadian forest managers possess the knowledge, skills, education, experiences and general abilities appropriate for adaptation? How could this be improved? (e.g. forestry curriculums, forestry extension. professional development and training)

Social capital:
Social capital measures the size, density and characteristics of an individual's or organization's network. High levels of social capital may facilitate improved access to information, collective actions and responses and access to resources that an individual or organization would not otherwise have access to. Trust is an important feature of functioning networks.

23. Please identify and describe the forestry related groups, associations or organizations (e.g. professional foresters, CIF, forestry association, etc.) that you are a member of.

24. How important are these networks to you in terms of solving forest management related problems.

25. Is there a need for a specific climate change and forestry network to share information and knowledge about climate change impacts and adaptation?

Information management:
Information management pertains to the effectiveness of policy makers, regulatory agencies, companies, professional organizations and research organizations in obtaining, developing, managing and communicating information about climate change. This includes the processes by which information is acquired, assessed and communicated. This contributes to increased awareness of climate change, more confident decision making and better informed decision makers.

26. Do you think existing systems for acquiring and assessing information regarding climate and climate change in forest management are adequate and if not how would you change them?

27. Do you think there is a need to reassess the measures and indicators we use to assess sustainable forest management (e.g. certification and C and I)?

APPENDIX THREE

Companies Surveyed and strategic questions for surveys of CEOs (Chapter 8)

Companies surveyed

Abitibi Bowater
Alpac
Canfor
Catalyst
Louisiana Pacific
Tolko
West Fraser

Associations
COFI
FPAC

Strategic Questions/topics

1. For forest product firms operating in the boreal what risks do you see from climate change?

- Operational risk for the company
- Regulatory risk from government
- Competitiveness risk (changes relative competitive position vis-à-vis other firms, countries)
- Market access risk (ENGO’s?)

2. Do you see any opportunities?

- Potential market for bioenergy and residual fibre
- Perhaps increases in productivity in certain sites
- Perhaps changes in harvesting practices that can generate carbon credits

3. How can companies respond to the risks and/or opportunities?

- Is it through technological means? New equipment, modification of equipment or operational practices?

- Does it involve strategic considerations? Consideration of new products? Diversifying geographically? Reinvesting in new facilities?

4. What internal factors affect the ability of the company to respond?
- Access to capital
- Available staff time and resources
- Expertise in the issues within the company
- Type of equipment, age of the equipment (capital vintage)

5. What external factors affect the ability of the firm to respond?
- Government policies around resource access (tenure), stumpage
- Rigid regulatory frameworks (e.g. strategic objectives that are required to be met in forest management plans that involve fixed requirements that don't take into account the impact of climate change?)

6. How does your company deal with something like climate change?

- Who's responsible? Does it involve working groups or any kind of institutionalized procedure (periodic meetings, agenda item at company meetings)?

- Given how climate change is framed (e.g. how risks and/or opportunities are framed), how well does it fit with standard decision-making procedures (e.g. fit into budgeting practices, investment decisions, etc.)

- What is general awareness within the company?

- What sources of information do you use?

6. Do you view your operations in the boreal or the particular products you manufacture in those operations as more or less impacted by climate change than other firms operating elsewhere (outside of the boreal)?

7. In your view what would motivate your firm to take action?

8. What is your vision for the future for the forest sector in the boreal?