Climate Change and National Parks in Ontario: A Screening Level Assessment

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Abstract

Simulations of climate change resulting from a doubling of atmospheric concentrations of carbon dioxide near 2050 project significant mean annual temperature increases and precipitation changes. The magnitude of change will have a significant impact on the species composition and distribution of ecoclimatic regions in Canada. The natural evolution of ecosystems within and across the stationary boundaries of national parks will severely challenge the legislated mandate of Parks Canada to maintain ecological integrity in representative Canadian landscapes.

This paper is drawn from an on-going analysis of the vulnerability of Canada's national park system to climate change. Climate change scenarios (based on the outputs of four General Circulation Model experiments) have been developed for the five terrestrial national parks in Ontario. A range of direct and indirect impacts on the abiotic features, species, ecosystems and visitor experiences in these parks are examined. The paper concludes with a brief discussion of the challenging questions climate change will pose for protected area management and policy in Ontario.

Introduction

Concern over anthropogenically induced climate change has increased over several decades. This has resulted in the formation of the Intergovernmental Panel on Climate Change (1988), the development of a Framework Convention on Climate Change at the 1992 United Nations Conference on Environment and Development (UNCED), and the more recent United Nations Framework on Climate Change in Kyoto, Japan. Such work is based on the recognition that industrial capacity and expanding consumption patterns have resulted in significant and accelerating increases in greenhouse gas (GHG) concentrations (e.g., carbon dioxide, methane, and nitrous oxide). For example, scientists have projected a doubling in the atmospheric composition of carbon dioxide within the next century (Abraham et al. 1997). A recent report of the Intergovernmental Panel on Climate Change (1996) projects a global surface temperature increase of between 1 to 3.5°C over the next 100 years. However, climate change is expected to be more pronounced near the poles. As a result, Canada is likely to experience change that is greater than the global average. Etkin et al. (1998) found that in continental areas of Canada, temperature change will be double the global mean at latitude 50°N, and amplified by a factor of 3.5 at latitude 80°N.

Ecosystems are greatly determined by climate. As climatic zones change so to will the composition and spatial extent of current ecosystems. For example, Rowe (1989) has suggested that shifts in vegetation belts in the interior of Canada could be as much as 450 km if temperatures warmed 3°C by the year 2030. While these early projections of ecozone shifts are unlikely to reflect the eventual composition and location of ecozones 100 years from now, they are illustrative of the magnitude of change protected areas may undergo and the importance of studying the potential impacts of climate change for Canada's national parks.

To address this issue, Parks Canada, Environment Canada (Environmental Adaptation Research Group) and the University of Waterloo have initiated a joint project to assess the potential impacts of climate change on Canada's national parks, the associated implications for ecosystem managers, and the development of effective adaptation strategies. The objectives of this project and paper are to:

1. assemble climate change scenario data from selected general circulation models (GCMs) for each national park in Ontario; and,
2. complete a preliminary assessment of how these changes are expected to impact abiotic features, species, ecosystems, and visitor experiences in each national park in Ontario.

It must be stressed that the identification of climate change impacts on the five national parks in Ontario, undertaken as part of this study, constitute a preliminary, screening level assessment. Time, budgetary and space constraints limited the amount of research that could be undertaken and the level of detail that could be incorporated into each park analysis. Impact prediction is also limited by scientific uncertainty associated with the climate change models and their implications for biodiversity, ecosystem structure and functional dynamics. However, effort has been made to identify the potentially significant impacts and issues of concern for ecosystem managers and policy makers.

Approach and Methods

A two-step methodological approach was utilized to undertake the analysis. First, the results from experiments performed at three climate modelling centres in Canada and the US were used to develop climate change scenarios for each of Canada's national parks (38 at the time of the research). Second, a screening-level impact assessment was performed for each park based on a review of regional and park-specific literature. Each of these steps is discussed below.

Construction of Climate Change Scenarios for Canada's National Parks

Providing a range of possible future climate change scenarios or 'what if futures' is an integral first step for impact assessment and the consideration of adaptation strategies. Climate change scenarios are constructed from the results of general circulation models (GCMs).

GCMs are three-dimensional mathematical models designed to simulate the physical processes of the global climate system including the atmosphere, oceans, biosphere and cryosphere. These highly complex models represent our most sophisticated understanding of the climate system and are the best tools available for examining how increased greenhouse gases will perturb the global climate system.

Despite the complexity and growing sophistication of GCMs, climate scientists remind us that they still remain a coarse approximation of reality. At the macro-scale, there remain notable uncertainties regarding our understanding of atmosphere-ocean processes, greenhouse gas emission futures, and various positive and negative feedbacks such as the release of methane from melting permafrost areas. GCMs are currently incapable of incorporating micro-scale climatological influences and thus do not perform as well in coastal areas or areas with complex terrain. The climate change scenarios derived from GCM experiments should not be regarded as definitive forecasts of future climate, but rather as internally-consistent, physically plausible future climate outcomes from doubled carbon-dioxide equivalent atmospheric forcing.

GCMs simulate atmospheric starting conditions, greenhouse gas increases, sulphate aerosol effects, and atmosphere-ocean processes differently, and thus generate different projections of global and regional climate change. Currently, there is no empirical basis to suggest any single climate change scenario will better represent the future climate under enhanced greenhouse conditions. The results of more recent models are generally thought to be more reliable as they incorporate the most recent knowledge of the climate system. Ultimately, this is an imponderable problem until experience validates one GCM over others. Consequently, a sufficiently broad range of climate scenarios should be used in order to produce a more robust impact assessment.

There were two criteria for selecting the most appropriate GCMs for this exercise. A difficulty associated with providing scenarios from only the most recent GCM experiments is that there is a lag between these advances in the climate modelling community and the work conducted by the impact assessment community. This time-lag was an important consideration for this exercise, as none of the published impact assessment work that this study would rely on had been conducted with the most recent GCM experiments (i.e., those that include the effects of aerosols). A large majority of published climate change impact studies relevant to Canada have made use of one or more of the older experiments from Environment Canada's Canadian Centre for Climate Modelling and Analysis (CCC), Princeton University's Geophysical Fluid Dynamic Laboratory (GFDL) and NASA's Goddard Institute for Space Studies (GISS). It is deemed important to include scenario data that provides some measure of comparability and consistency with previous North American impact studies that are highly relevant to the national parks. The three older models included in this analysis are the CCC – GCM II (Boer et al. 1992), GFDL-91 (Manabe et al. 1991) and GISS-95 (Russell et al. 1995). The second criteria for GCM selection was to include scenario data from the most recent CCC experiments (CGCMI) that include the moderating effect of sulphate aerosols (Environment Canada 1999). This data represents the state of the art in global climate projections and will facilitate comparability with future impact assessments that use these scenarios.

One of the major difficulties of applying GCM projections to regional impact assessment studies is the coarse spatial resolution of even the most advanced GCMs.

GCMs produce estimates of climate variables for a network of grid cells that cover the globe and the distance between grid cell centroids is typically 200 to 1,000 kilometres. Converting the output of GCMs into more localized scenarios— or 'downscaling'—is a process undergoing much discussion and refinement. This analysis used a common method that assigns the value from the grids cell(s) in which the study area is located. For some larger parks this meant averaging the values of four grid cells. An important drawback of this technique is that national parks in close proximity with similar historic climates can have quite different future climates because they fall in different grid cells.

The projected seasonal temperature and precipitation change ranges were calculated for each of the five national parks in Ontario (Table 1). Figures 1 and 2 illustrate the range of temperature and precipitation scenarios for Pukaskwa National Park relative to the baseline climate.

Screening Level Impact Assessment

To undertake a screening level impact assessment of potential climate change impacts on national parks in Ontario, a guideline checklist of potential impacts was developed. This guideline provided a useful, though not exhaustive, list of potential biophysical and socioeconomic variables that could be influenced by predicted climate change.

With this checklist in mind, a regional and park-specific literature review on the general implications of global climate change was undertaken and the information used in conjunction with climate change scenarios developed for each park. The results are a coarse-scale assessment of the potential impacts of climate change on the hydrology, geomorphology, flora, fauna, and visitor experiences for each park. It is important to note that this assessment is not comprehensive, nor is it intended to draw general conclusions about the implications of climate change on the national parks system as a whole. Rather, the purpose of this exercise is to identify key issues that may be of concern to park managers and planners of individual parks, and to make recommendations for future research. We therefore acknowledge that not all links and feedback loops have been identified or discussed.

Furthermore, several data limitations were encountered for this screening-level assessment. First, due to the high uncertainty and resulting inconsistency in climatic predictions within the literature, many implications of climate change are poorly understood and speculative. In addition, data for some parks were limited, thereby compromising a full discussion on the implications of climate change on these parks.

Assessment of Potential Climate Change Impacts in National Parks in Ontario

Given the biophysical variation among the five national parks in Ontario, for example, karst topography at the Bruce Peninsula National Park versus sand dunes and sand spits at Point Pelee National Park, a diversity of impacts is projected. A brief summary of these potentially diverse impacts is provided in Table 2.

National Park	Winter		Spring		Summer		Fall	
	Temp (°C)	Precip. (%)	Temp (°C)	Precip. (%)	Temp (°C)	Precip. (%)	Temp (°C)	Precip. (%)
Bruce Peninsula	2 to 6	1 to 17	1 to 6	6 to 24	1 to 4	-14 to 6	2 to 3	-23 to 2
Georgian Bay Islands	2 to 6	1 to 17	1 to 6	6 to 24	1 to 4	-14 to 1	2 to 3	-23 to 1
Point Pelee	1 to 7	-4 to 11	1 to 8	7 to 17	1 to 5	-10 to -2	1 to 3	-36 to 3
Pukaskwa	2 to 6	5 to 25	1 to 3	2 to 26	1 to 4	1.5 to 5	2 to 4	-9 to 1
St. Lawrence Islands	2 to 5	8 to 14	1 to 4	2 to 20	1 to 4	-18 to 5	2 to 3	10 to 5

Table 1: Projected Seasonal Temperature and Precipitation Change Ranges

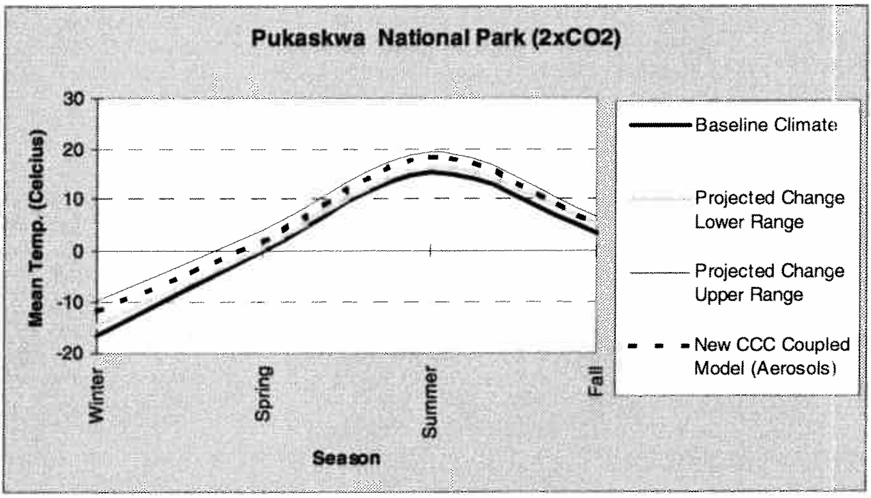

Figure 1: Pukaskwa National Park Temperature Senario

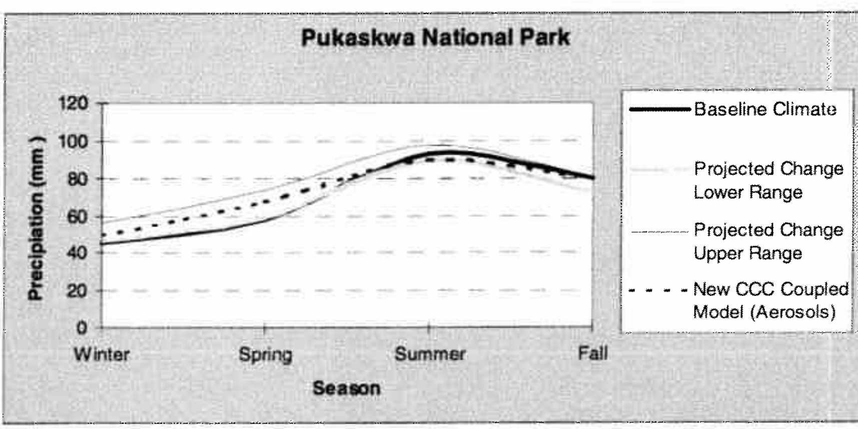

Figure 2: Pukaskwa National Park Precipitation Senario

Park	Key Issues
Bruce Peninsula	Lake Huron water levels may decline between 1.0 m and 2.4 m. Wetlands will become drier and lake infrastructure such as docks may need to be redesigned. Decreased precipitation and warmer temperatures may increase drought conditions, changing the forest fire regime within the park by increasing the amount of available fuelwood. Drought tolerant species will likely benefit from climate changes. A greater incidence of forest pests such as spruce budworm is also anticipated. Finally, an increase in the length of the visitor season and change in activities (e.g., camping, hiking) can be expected with climate change.
Georgian Bay Islands	Decreases in Lake Huron water levels (e.g., a 1.0 m to 2.4 m) could impact wetlands throughout the park as a result of changes to hydrology, geochemistry, ecological function, water quality and groundwater recharge. Various fish species currently at their northern limit may expand their range (e.g., black bass and sunfish). Others at their southern limit may retreat to colder waters where available as temperatures increase (e.g., walleye and yellow perch). Climatic changes are expected to cause a northerly shift in the boreal forest biome. Wildfire frequency and intensity may also increase given the greater fuel supply and changes in temperature and precipitation.
Point Pelee	Lake Erie may experience a mean annual water level decrease of 0.9 m to 1.9 m with climate change. The marsh complex on the east side of the point will dry out more frequently, favouring less hydric species of flora. The lower lake level may also trigger a drop in the water table with consequent implications for the ecological communities on the point. The avian and butterfly migrations for which Point Pelee is famous will likely be impacted as migrations may start earlier in the spring and later in the fall. Also, the impacts of climate change at overwintering locations in the south may affect survival rates of some species. Forest fires may become more of a hazard with increased drought.
Pukaskwa	Changes in hydrology will have significant effects on several key features in the park. Increases in atmospheric CO_2 and precipitation will add to the stress of the already acid sensitive lakes of Pukaskwa. The Arctic alpine flora present almost 1,000 km. south of its range, will be affected by lake level fluctuations. Fire frequency and intensity are expected to increase in the boreal forest, reducing the area of mature forest but increasing forest diversity. As climate warms, more southerly species may be favoured and vegetation shifts may be possible. The implications of biome shifts, temperature, and precipitation changes on wildlife (especially the woodland caribou) should be examined.
St. Lawrence Islands	Acid rain has already been identified as an issue of concern for SLINP. Projected increase in precipitation will add to this current stress. The presence of extensive wetlands will likely be sensitive to water level fluctuations. Many species rare to Canada (e.g., Pitch Pine and Black Rat Snake) are present due to the moderating effects of the water. Changes to climate and other environmental conditions due to global warming will have implications for the species present in SLINP. The park acts as a land bridge for many species across the St. Lawrence River and any negative ecological

Table 2: Summary of Climate Change Impacts and National Parks in Ontario

However, there are also several similarities and cross-cutting climate change issues. For example, although water level fluctuations will continue, average Great Lakes water levels will decline (Hofmann et al. 1998). In the case of Lake Huron, mean annual water levels could decrease by 1.0 m to 2.4 m over the coming decades. In Lake Superior, mean annual water levels could decrease from 0.2 m to 0.5 m, while water levels in Lake Erie could decrease by 0.9 m to 1.9 m. Mean annual water levels in Lake Ontario and in the St. Lawrence may decrease by 1.3 m (Hofmann et al. 1998).

Being climate dependent, forest fires will likely respond to temperature increases with greater frequency and intensity. Forests in national parks throughout Ontario will likely be affected (Suffling 1991). For example, in Pukaskwa National Park, increased fire frequency may shift forest seral stage distributions towards younger stands. This transition to young regenerating forests is a concern for wildlife species that require mature forests (e.g., fisher). Finally, increasingly dry conditions will likely alter wetland structure, species composition and extent in all national parks in Ontario. Indeed, the presence of extensive wetlands in and adjacent to St. Lawrence Islands National Park will be sensitive to water level fluctuations and hydrological changes that result from a combination of precipitation change, increased temperature and increased evapotranspiration.

Conclusions and Recommendations

The preliminary assessment summarized above reveals a wide range of potential climate change impacts on Canada's national parks. The impacts identified are both direct and indirect and have both immediate and long-term implications. These impacts include: possible alterations to local and regional hydrological processes; Great Lake water level declines; increased fire frequency and intensity; wetland alterations as a result of drier summer and fall conditions; sedimentation; and, erosion. In turn, these impacts have a range of implications associated with: the maintenance of habitat; shifting biome boundaries; changes in species composition, distribution and abundance; loss of critical nesting and breeding grounds; changes in species interactions such as predator-prey relationships; alterations to trophic webs; and, water quality change.

Park planning and management under such conditions of uncertainty and change will become an increasing challenge. For example:

1. Park boundaries and zoning are relatively static concepts. Therefore, how effective will such management zones be given projected biogeographical shifts (see Rowe 1989);
2. What criteria will be utilised to define an invasive species as climatic conditions change and species migrate and adapt;
3. How active a management role will Parks Canada take to mitigate—where possible— these changes, for example, the physical relocation of wildlife unable adapt quickly enough to shifting biomes; and,;
4. What level of certainty regarding climate impacts is required before active management decisions are made.

In response to some of these issues, park planners and ecosystem managers will be required to develop adaptive strategies that involve a continuous cycle of problem identification, research, planning, management, monitoring, and learning. Based on the information generated as a result of the preliminary impact assessment and analysis outlined above, a range of research needs, planning options and management strategies have been identified. It is hoped that the identification of these needs, options and strategies will contribute to the development of flexible and appropriate adaptation responses (see Peters and Darling 1985; Rowe 1989; Bridgewater 1996). Several key recommendations are as follows:

1. Incorporate climate change issues in park management plans and environmental impact assessments (e.g., planning infrastructure development in the context of declining lake levels).
2. Undertake research oriented towards climate change issues (e.g., the impact of lake level declines on wetland composition and integrity, identifying appropriate adaptation responses to climate change impacts).
3. Incorporate climate change issues in park interpretive programs in order to educate the public and improve awareness.
4. Further expand the current landscape or greater ecosystem planning approach in order to better address transboundary climate change impacts (e.g., biogeographic shifts, species migration).
5. Adapt monitoring programs to include appropriate indicators that address climate change impacts.

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