The Vulnerability of Tourism & Recreation in the National Capital Region to Climate Change

Daniel Scott, Brenda Jones and Halim Abi Khaled

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Climate Change Action Fund (Impacts and Adaptation Programme)

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Daniel Scott[1], Brenda Jones[2] and Halim Abi Khaled[3]

1 – Canadian Research Chair in Global Change and Tourism, Faculty of Environmental Studies, University of Waterloo

2 – Post-Doctoral Research Fellow, Faculty of Environmental Studies, University of Waterloo

3 – Senior Corporate Research Consultant, National Capital Commission, Corporate Audit, Research and Evaluation Branch

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List of Acronyms

CCME	Canadian Council of Ministers of the Environment
CCIS	Canadian Climate Impact and Scenarios
CCSR	Centre for Climate System Research Model
ECHAM	European Center/Hamburg Model
GCM	Global climate model
GDD	Growing degree day
GTA	Greater Toronto Area
IPCC	Intergovernmental Panel on Climate Change
LARS	Long Ashton Research Station
NCAR	National Center for Atmospheric Research
NCC	National Capital Commission
NCR	National Capital Region
NIES	National Institute for Environmental Studies (CCSR **NIES**)
PCM	Parallel Climate Model (NCAR **PCM**)
TGCIA	Task Group on Scenarios for Climate Impact Assessment

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CHAPTER ONE

Introduction

At a global level, tourism grew an average of 4.7% per year between 1975 and 2000, and now contributes approximately C$680 billion to world trade (World Tourism Organization, 2003). In Canada, total tourism revenues exceeded C$52 billion in 2003, accounting for 1.9% of Canada's gross domestic product (Canadian Tourism Commission, 2003). Tourism is also the sixth largest employer in Canada (Statistics Canada, 2003). In addition to its economic importance, outdoor recreation is also essential to the social needs and health of Canadians.

Climate has a strong influence on the tourism and recreation sector. It affects the physical resources that are the foundation for many recreational activities (*e.g.*, snow cover, ice thickness, water temperature) and the length and quality of tourism and recreation seasons. Despite the importance of climate to tourism and recreation, there have been comparatively few investigations into the relationships between climate and tourism (Smith, 1993). The vulnerability of individual recreation industries and tourism regions to climate variability and future climate change has not been adequately assessed.

Winter tourism has been repeatedly identified as being particularly vulnerable to climate variability and change. Record warm winters in 1997/98 and 2001/02 in southern Ontario resulted in reduced ski seasons (~25% shorter) because of limited natural snowfall and temperatures that were too warm for snowmaking to be efficient (Scott *et al.*, 2002). The season lengths of activities that depend entirely on natural snowfall, such as snowmobiling and Nordic skiing, were affected to an even greater extent. Persistent warm conditions also made ice conditions dangerous on many area lakes, shortening ice fishing seasons. In eastern Ontario, the record warm temperatures in Ottawa during the winter of 2001/02 resulted in a 34-day skating season on the Rideau Canal Skateway, far shorter than its normal 60-plus day season.

Although winter recreation and tourism is important to Canada's economy, most of the country's outdoor recreation and tourism takes place during the warm-season. Approximately 43% of domestic and 62% of international tourism expenditures occurs during the third quarter (July, August and September) (Wilton and Wirjanto, 1998). Very little research has examined the potential vulnerability of warm-season tourism and outdoor recreation sectors to climate change. The potential for longer warm-season recreation seasons under climate change represents an opportunity for tourism and recreation in Canada.

The lack of systematic assessments that examine differences in the vulnerability of winter and warm-season recreation and tourism sectors in major tourism regions remains a significant barrier to our understanding of the net impact of climate change on the recreation and tourism industry and competitive relationships between tourism regions. This key information gap creates uncertainties with respect to the future sustainability of these industries in communities across Canada and future investment (public and private). For example, should communities or provincial governments continue to fund snowmobile trails as a tourism development strategy?

1.1 RESEARCH QUESTIONS AND APPROACH

The purpose of this study was to assess the potential impact of climate change on recreation and tourism in one of Canada's largest tourism destinations — the National Capital Region (NCC). The Ontario East Tourism Region, which is centred on the National Capital Region, is the second largest tourism destination in Ontario after Metropolitan Toronto, in terms of tourism expenditures (Ontario Ministry of Tourism and Recreation, 2002).

The National Capital Commission is highly involved in planning and promoting tourism and recreation in the region. Focusing on the National Capital Commission's extensive mix of natural and cultural recreation attractions, this study sought to examine two important questions:

1) How will climate change influence the seasonality of major winter and warm-season recreation and tourism segments?
2) What are the implications of climate change for major tourism event planning and programming?

In addressing these questions, this study will assess the disparate vulnerability of recreation and tourism segments to climate variability and change, identify risks and opportunities for recreation and tourism in the region, and explore management adaptation strategies. This study is the most comprehensive integrated climate change assessment of the recreation and tourism sector undertaken in one location to date. Building on the recommendations of Scott *et al*. (2002), this study is the first climate change impact assessment to examine seasonality changes of winter and warm-season recreation market segments (skiing, camping, golf, swimming and park visits). This study is also the first to focus on the implications of climate change for tourism event planning (Winterlude, Canadian Tulip Festival and Canada Day celebrations).

This study was undertaken in a number of phases. The first phase involved consultation meetings with staff from departments of the National Capital Commission to learn how weather and climate influenced recreation and tourism operations in the region and any climate adaptations they had made. Compilation of data and the construction of the climate change scenarios were completed next, followed by the climate change impact assessment. The climate change impact assessment results were reviewed by officials with the National Capital Commission regarding possible adaptation strategies and changes to tourism event planning that might be considered to deal with the impacts of climate change on recreation and tourism in the region. The final phase was the production of the technical report and separate executive summary.

1.2 NATIONAL CAPITAL REGION – RECREATION AND TOURISM SECTOR

Canada's National Capital Region was selected for this study for two reasons. First, the recreation-tourism sector is very important to the local economy, as it is estimated to be worth close to C$1 billion (NCC, 2001a). Second, climate is a well-known limiting factor for recreation and tourism in the region.

Located along the Ottawa River, the National Capital Region has a population of nearly 1.1 million people (NCC, 2004). The National Capital Region is comprised on of the City of Ottawa and its surrounding rural communities in eastern Ontario, and the city of Gatineau in western Quebec (Figure 1.1).

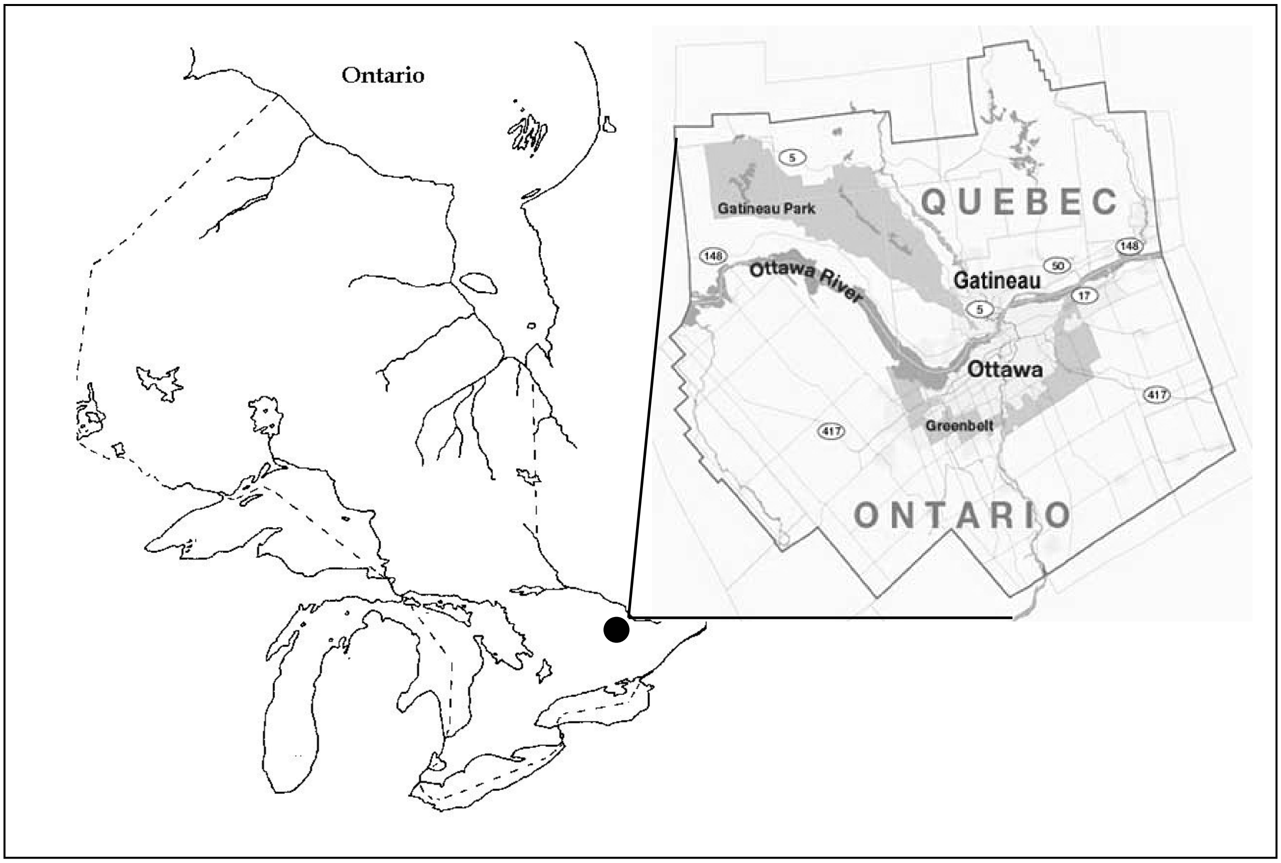

Figure 1.1 Study area — National Capital Region

Tourism is a vital component of the National Capital Region's economy. Approximately five million people visited the region each year between 1999 and 2002, generating between C$800 million and C$1 billion in direct visitor spending (NCC, 1999, 2001, 2002). According to Statistics Canada (2001), the National Capital Region was the fourth most visited urban region in Canada in 2001, ranking behind Toronto, Montreal and Quebec City.

Several high-profile events attract hundreds of thousands of visitors to the National Capital Region each year. Winterlude is one of the largest winter celebrations in North America and has been held each February in Ottawa since 1979 to celebrate the splendour of winter. Post-event evaluation surveys over the last 15 years reveal that Winterlude is the main reason many people come to the region in winter. The Rideau Canal Skateway, the quintessential symbol of Winterlude, also remains the event's most popular attraction (Coopers & Lybrand Consulting, 1988b; Gallup Canada, 1991; Ekos Research Associates, 1994, 2000). Over 1.5 million people attended Winterlude in 2000, generating over C$143 million in economic benefits (Ekos Research Associates, 2000). Second only to Winterlude in terms of visitors and economic impact in the region is the annual Canadian Tulip Festival. Ranked as the largest tulip festival in the world, more than one million tulips bloom each May on the region's federal lands (*e.g.,* Parliament Hill), tourism properties (*e.g.,* casinos, hotels) and other green spaces. The three-week Festival typically attracts between 500,000 to 700,000 people, and injects approximately C$30 million in to the local economy (Wood, 2003b). In addition, Canada Day celebrations are a major tourist draw in the summer. In 2003, over 300,000 people took in the festivities at one of the four official Canada Day sites across the National Capital Region. Total spending by Canada Day participants was estimated at C$18.9 million, resulting in a direct economic impact of C$19.4 million (Ottawa Tourism & Convention Authority, 2003).

An extensive mix of natural attractions also provides a wealth of recreation and tourism opportunities in the National Capital Region. There are more than 50,000 hectares of protected land and urban green space in the region, including a 20,350-hectare greenbelt surrounding the National Capital Region on the Ontario side of the Ottawa River (Figure 1.1). Some of the outdoor recreation resources available in the region's green spaces include:

- 170 kilometres of recreation pathways (*e.g.,* bike and walking paths) that link attractions (*e.g.,* Parliament Hill, museums)
- 40 kilometres of scenic parkways
- 90 kilometres of biking trails
- 50 lakes; six public beaches
- 165 kilometres of hiking trails
- 200 kilometres of Nordic skiing trails
- 25 kilometres of snowshoeing trails
- 10 kilometres of winter hiking trails
- alpine skiing
- more than 300 campsites (plus winter cabins)

Gatineau Park is the single largest urban green space in the National Capital Region. Occupying 7.7% of the region's total area (~36,000 hectares), Gatineau Park is the main outdoor recreation destination in the National Capital Region, receiving an estimated 1.7 million visitors annually (Del Degan, Massé et Associés, 2002). Of those recreation resources listed above, the latter seven occur within Gatineau Park. The Rideau Canal is also a popular resource. Recreational boating along the Rideau River is a common activity in the summer. In the winter, the Ottawa portion of the Rideau Canal is turned into the world's largest outdoor skating rink — the Rideau Canal Skateway. At a length of 7.8 kilometres, the Skateway winds through downtown Ottawa from Carleton University to the National Arts Building.

An important stakeholder in the recreation and tourism industry in the National Capital Region is the National Capital Commission. The National Capital Commission is a Crown corporation of the Government of Canada responsible for the stewardship of federal properties located within the National Capital Region. Its mandate is to build a great capital for Canadians, which it actively undertakes through three business lines. The first business line is programming. The National Capital Commission is responsible for promoting and planning public events in the region including Winterlude, the Canadian Tulip Festival and Canada Day celebrations. The second business line is Real Asset Management. As part of this business line, the National Capital Commission is involved in managing and protecting physical assets in the National Capital Region for future generations of Canadians. This involves protecting such properties as Gatineau Park and the greenbelt, and maintaining all the recreation activities (including the Rideau Canal) listed above. Planning is the third business line, and requires that the National

Capital Commission guide the development and use of federal land in the region. The three business lines keep the National Capital Commission highly involved in tourism and recreation in the region.

1.3 EFFECT OF CLIMATE VARIABILITY ON NCC RECREATION AND TOURISM OPERATIONS

The headlines in Table 1.1 demonstrate that tourism events in the National Capital Region are vulnerable to climate variability. The newspaper stories from which these headlines were drawn describe the positive and negative impacts of winter and spring conditions on the planning and overall success of the two most important tourism events in the National Capital Region. Through experience, National Capital Commission staff has implemented a diverse range of adaptation strategies to reduce the vulnerability of tourism events and other recreation segments it is responsible for to the negative effects of climate variability. A question to be explored in this research is whether these adaptations will be adequate to meet the challenges that climate change may impose on the National Capital Region's tourism and recreation industry and what new adaptations may be required. This section examines the effect of climate variability on two tourism events, and some of the related adaptive strategies that have been implemented, in order to provide context for climate change discussions and recommendations later in this report.

Table 1.1 Media depictions of the vulnerability of NCC operations to climate

Date	Newspaper headline
12/26/87	Warm weather delays canal opening
01/06/92	Weather closes Rideau Canal to skaters
02/23/97	Rain wrecks havoc on Waterlude: tourists disappointed by closing of canal
02/23/98	20th Winterlude makes splashy exit
04/16/98	A tulip festival without tulips? Star attractions expected to bloom too soon
05/17/99	Tulip festival floating on success, weather, new events draw record crowds
05/12/02	Tulip fest bows to rain, cold

1.3.1 Winterlude

The relationship that Winterlude has with climate variability, particularly the negative relationship, has received much attention from the media, as illustrated in Table 1.1. Over the last 30 years, weather and climate have influenced Winterlude and its activities in a number of ways. Early on, many Winterlude attractions (*e.g.*, ice sculptures) were located on the Rideau Canal Skateway, including the opening ceremonies, making them very vulnerable to poor ice conditions. During the 1985 Winterlude, 40,000 people came to the opening ceremonies that were held on Dow's Lake. The weight of the crowd itself, coupled with shifts in their position over the course of the ceremony, resulted in large cracks forming in the ice cover and flooding, compromising the safety of participants (Sinha, 1990; Tam, 1993). Since 1985, the opening ceremonies and other popular Winterlude attractions have been moved to land locations.

The 1990 and 1991 Winterludes were negatively affected by climate variability. In 1990, above-average temperatures in early February (~+5^{o}C)[1] contributed to the early demise of snow sculptures, delayed the opening of ice slides, caused the cancellation of some events and led to the early closure of the Rideau Canal Skateway. Only one-half of the total number of expected visitors participated in the 1990 Winterlude (Tolson, 1991a). The economic impact of the mild weather is best illustrated by the earned income of vendors that sell foodstuffs along the Skateway. The owner of the Beaver Tail concession lost C$30,000 during the 1990 Winterlude because of repeated canal closures (Tolson, 1991b). Similar warm temperatures plagued the 1991 Winterlude. The Rideau Canal Skateway was closed seven of the 10 event days because daytime temperatures around +5^{o}C weakened the ice surface. The event also only generated C$28.6 million in 1991 (Gallup Canada Inc, 1991), far less than the C$40 million generated three years earlier when February temperatures were more seasonal (Coopers & Lybrand Consulting, 1988). In response, the National Capital Commission established the Winterlude Plaza, an outdoor skating rink, as a means to weatherproof the event. Ice in the Plaza is engineered to remain operational to +15^{o}C, so any event scheduled for the Skateway could be moved to the Plaza if necessary (Tolson, 1991a). In 1994, officials also decided to convert Winterlude from a 10-day event to a three-weekend event to better protect against climate variability.

The impact of climate variability on the 2002 Winterlude likely received the most media attention since the event began three decades ago. The 2002 Winterlude was defined by the media as the year there was almost no Skateway. Above normal temperatures between November and the end of January resulted in delaying the opening of the Rideau Canal Skateway until Winterlude's opening weekend, and wet and mild weather throughout the event resulted in the Skateway being closed before the third weekend (Staples, 2002). The 2002 skating season was one of the shortest on record (only 34 days) and officials estimated that only 196,000 skaters had the opportunity to skate the world's largest skating rink during Winterlude, approximately 50% fewer than in previous years (La Fleur de la Capitale, 2004). Ice sculptures for the popular ice sculpture contest were also carved in refrigerated transport trucks because the blocks of ice were melting before carvers could complete their designs (Campbell, 2002).

1.3.2 Canadian Tulip Festival

Ottawa's annual Canadian Tulip Festival has also been influenced by weather and climate. Horticulturalists with the National Capital Commission have learned over the years that maximum temperatures between 10^{o}C and 15^{o}C are ideal to maintain blooms, while daily maximum temperatures warmer than 20^{o}C tend to shorten the lifespan of tulip blossoms. Frost also tends to shorten bloom time because it can cause tulips to shrivel. Overall, cool nights and mild days produce the best conditions for an optimal showing of tulips. In 1997, tulips in the National Capital Region reached their peak late (end of the Festival), due in large part to cold, wet conditions in April that delayed bud formation; in 2003, most tulips had not even bloomed by the start of the Festival (Wood, 2003a). By comparison, the 1998 and 1999 Canadian Tulip Festivals experienced a shortened period of bloom display because above normal temperatures in April and May resulted in the peak bloom occurring early in the Festival, with many of the tulips wilting in the heat before the Festival ended (Gray, 1998; Younger-Lewis, 1999).

[1] 1961-90 average mean temperature for February is -9.2^{o}C

Consultation with the National Capital Commission revealed that a number of adaptations have been undertaken to deal with the effect of climate variability on the timing of emergence and bloom of the region's tulips. For the most part, these strategies revolve around slowing down the increase in soil temperatures during the critical 'bulb activation' period. For instance, tulip bulbs have been planted in the shady areas where soil temperatures typically take longer to warm, which serve to delay the activation of bulbs. Another more common practice across the region is to heavily mulch flowerbeds in the fall, or ensure a deep layer of snow collects (using snow fences) and covers the bulbs later into spring. During some warm springs, staff has also employed irrigation and snowmaking on the flowerbeds to lower soil temperatures in order to slow the initial growth of tulips.

1.4 CLIMATE TRENDS AND PROJECTIONS

Nearly a century after the link between increasing concentrations of greenhouse gases from industrial emissions and a changing global climate system was first theorized, the United Nations Intergovernmental Panel on Climate Change (IPCC, 1995) declared that the balance of scientific evidence indicates a discernable human influence on the global climate. Data from climate stations around the world has shown that the Earth's mean temperature has increased 0.6^{o}C over the last century (IPCC, 1995, 2001) and the IPCC (2001) has concluded that the 20th century was the warmest century in the past 1,000 years.

In Canada, some noticeable changes have occurred in temperature and precipitation over the last century. Warming in Canada has amounted to an average mean annual temperature increase of 1.1^{o}C (Environment Canada, 2003a) since the 1940s, and five of the warmest 10 years have occurred between 1993 and 2003. The magnitude of change varies regionally. Average mean temperatures have increased 2.0^{o}C in the Northwest Territories, 1.3^{o}C in the Prairies and 0.4^{o}C in southern Ontario, while Atlantic Canada has experienced a general cooling (Environment Canada, 2003b). In terms of precipitation, Canada has experienced above normal annual precipitation since the 1970s (Environment Canada, 2003a). The wettest year between 1948 and 2003 was 1996 (+9.1% above normal) and among the driest was 2001 (-4.3% below normal) (Environment Canada, 2003c).

In addition to climate station data, a growing range of evidence is illustrating that the climate in Canada is changing (Government of British Columbia, 2002; CCME, 2003). The duration of ice cover on many of Canada's lakes and rivers has diminished over the last century. Assembly of data for Lake Simcoe, the only known lake in Ontario with records dating back more than 100 years, indicates a trend towards later winter freeze-up and earlier spring break-up. It is estimated that Lake Simcoe currently freezes 13 days later than it did 140 years ago. Similarly, the annual spring break up is occurring, on average, four days earlier (CCME, 2003). A climate change impact assessment of ice cover at 209 locations in the United States also suggests a trend towards less ice cover. Small lakes in the Great Lakes region of the United States are projected to freeze, on average, 14 days later and break up 30 days earlier by the middle of this century (Fang and Stefan, 1998). Assuming that the conditions on Lake Simcoe and in the US border states are reflective of other major water bodies in the province of Ontario (*e.g.*, lakes and canals), continued reductions in the ice season will certainly have a negative impact on communities that depend on ice cover for tourism and recreation. Evidence of plant phenology also suggests that the timing of different stages of plant development in many areas of Canada has changed. The average date when lilacs bud in southern Canada is six days earlier than it was in the 1960s, and the Boreal forest is budding several days earlier and losing its leaves several days later than it did two decades ago (CCME, 2003).

National climatic trends are reflected in the National Capital Region's climate. Figures 1.2 to 1.4 illustrate the long-term trends in mean temperature and total annual precipitation for the period 1939 to 2003. Mean annual temperatures have warmed 0.7°C in the last six decades, with minimum temperatures showing the largest magnitude in change (~+1°C). Four of the last six years have been at least 1°C warmer than Ottawa's 1961–90 average (1998, 1999, 2001 and 2002). Mean winter temperatures are currently 1.5°C warmer than they were six decades ago. Four of the last six winters were warmer than the long-term average (1998, 1999, 2000 and 2002); the winter of 2001/02 was on average 5.1°C warmer than Ottawa's 1961–90 average. A range of global climate models project mean annual temperatures to increase between 2.6°C and 6.5°C by the middle of the century over baseline conditions (CCIS, 2004).

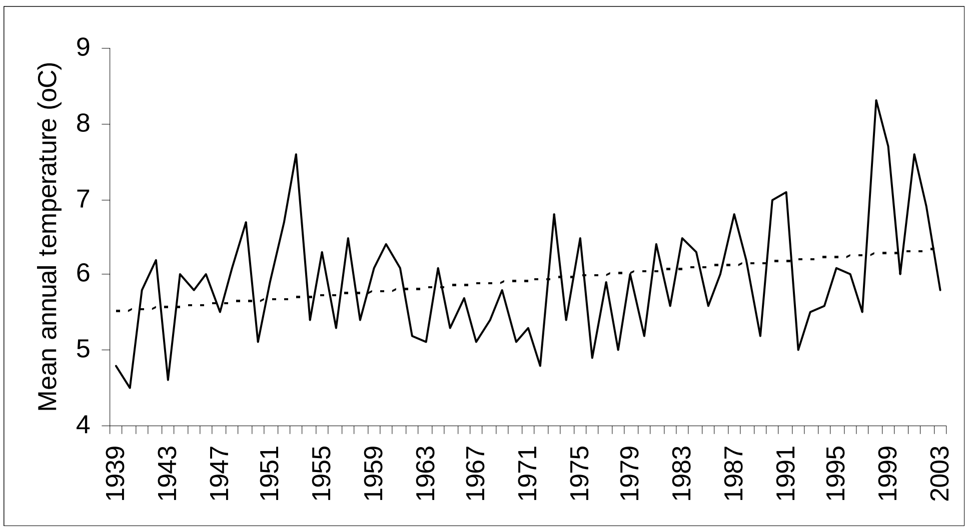

Figure 1.2 Long-term trend in mean annual temperature in the Ottawa region (1939–2003)

Figure 1.4 illustrates the long-term trend in total annual precipitation in the National Capital Region. The long-term trend has been towards higher amounts of precipitation. The Capital Region has experienced, on average, a 13% increase in precipitation since 1939. Annual precipitation has been greater than Ottawa's 1961-90 average three of the last six years (1999, 2000 and 2003). Global climate models project a 2% to 25% increase in annual precipitation in the Ottawa area as early as the middle of the century (CCIS, 2004).

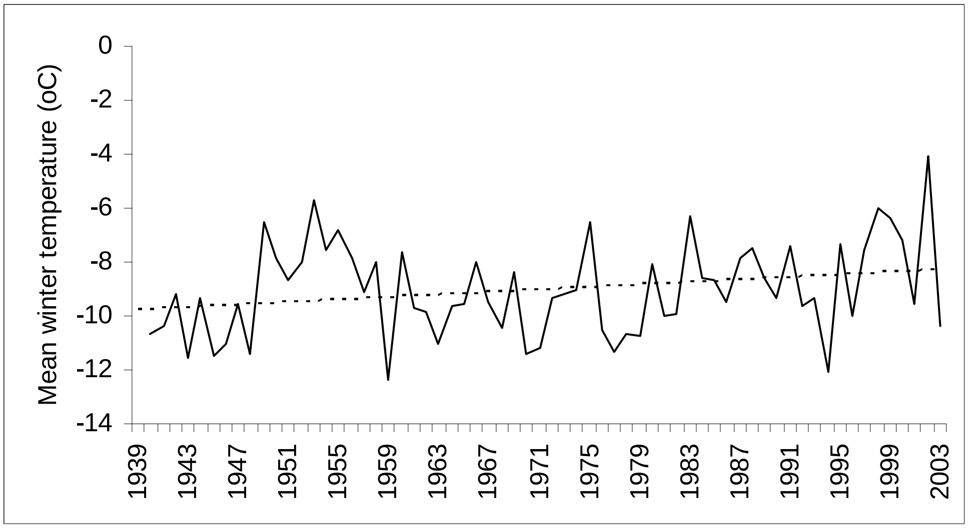

Figure 1.3 Long-term trend in mean winter (DJF) temperature in the Ottawa region (1939–2003)

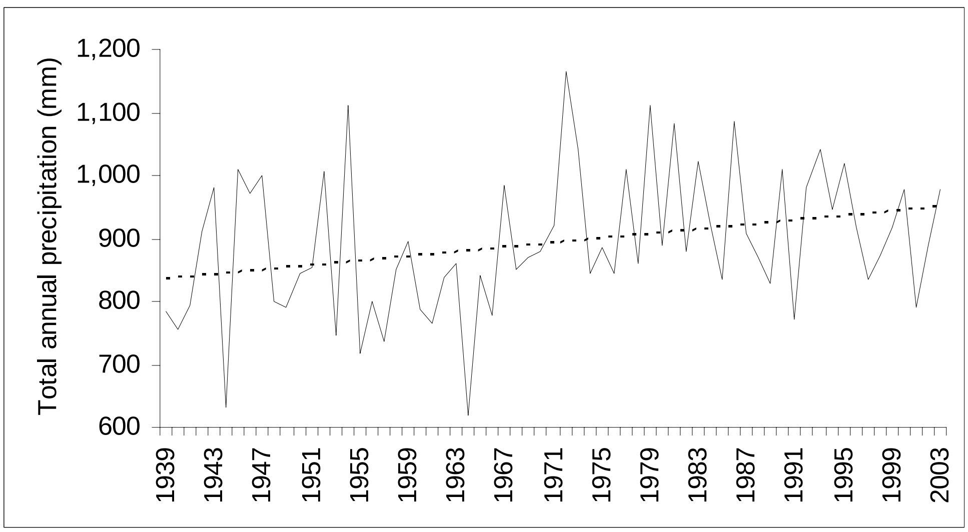

Figure 1.4 Long-term trend in annual precipitation in the Ottawa region (1939–2003)

1.5 SUMMARY

The National Capital Region's mix of natural and cultural attractions draws millions of tourists to the region every year, making it one of the most important tourism regions in Canada. Climate and weather are fundamental to the quantity and quality of winter and warm-season tourism and recreation segments in the region, thus the National Capital Region could have a great deal at stake from any changes in the climate.

The remainder of this report is divided into three chapters. Chapter Two outlines the methods used in the climate change impact assessment. Chapter Three presents the results. The projected impact of climate change on the region's major tourism events and winter and warm-weather recreation are discussed. The final chapter (Chapter Four) explores the implications of the climate change impacts for tourism event planning in the National Capital Region and possible adaptive strategies that could be implemented.

CHAPTER TWO

Research Methods

The previous chapter provided the foundation for the current study, which examines the potential vulnerability of outdoor recreation and tourism event planning in the National Capital Region to climate change. In this chapter, the methods used to conduct the climate change impact assessment are discussed. An overview of the research design is provided, followed by a more detailed description of the methods in each phase of the project. Climate and recreation data compilation, climate change scenario construction, climate change indicator selection and statistical analysis used in the assessment are explained as well.

2.1 RESEARCH DESIGN

An overview of the research methodology for the climate change impact assessment is provided in Figure 2.1. The nature of the physical resources (*e.g.*, snow, temperature) that defined the sensitivity of various recreation segments to climate and the availability and reliability of recreation data required the development of different research designs for non-snow-based activities (*e.g.*, swimming, camping) and for snow-based activities (*e.g.*, skiing).

The methods to assess recreation and tourism activities that did not rely on snow required two distinct approaches. When reliable recreation participation data were available from stakeholders in the National Capital Region, statistical analysis was undertaken to develop a relationship between climate variables and the respective activity. Statistical models were then validated against observed records to determine how well the climate-defined recreation model performed. When no reliable source of recreation data was available, climatological thresholds for climate change indicators were established based on consultations with experts from the National Capital Commission and, where appropriate, the scientific literature. Once the statistical model and indicator thresholds were established, recreation seasons were simulated for the 1961–90 baseline period, and used to project recreation season lengths in the 2020s, 2050s and 2080s under climate change scenarios (see sections 2.3 and 2.4.1).

The methods used to assess the impact of climate change on snow-based recreation segments were based on those developed by Scott *et al*. (2002 and 2005). A recreation season model was developed using climate thresholds developed through discussions with industry stakeholders and was validated against observed ski recreation data. A snow depth model, parameterized to a local climate station, was created to model natural snow cover in the region and used to simulate snow-based recreation seasons for the 1961–90 period. A snowmaking module was integrated with the natural snow model to accommodate the climatic adaptation of ski areas; technical capacities were derived from communication with industry stakeholders. The recreation season simulation model was then applied to the climate change scenarios to project snow-based recreation season lengths in the 2020s, 2050s and 2080s (see section 2.4.2).

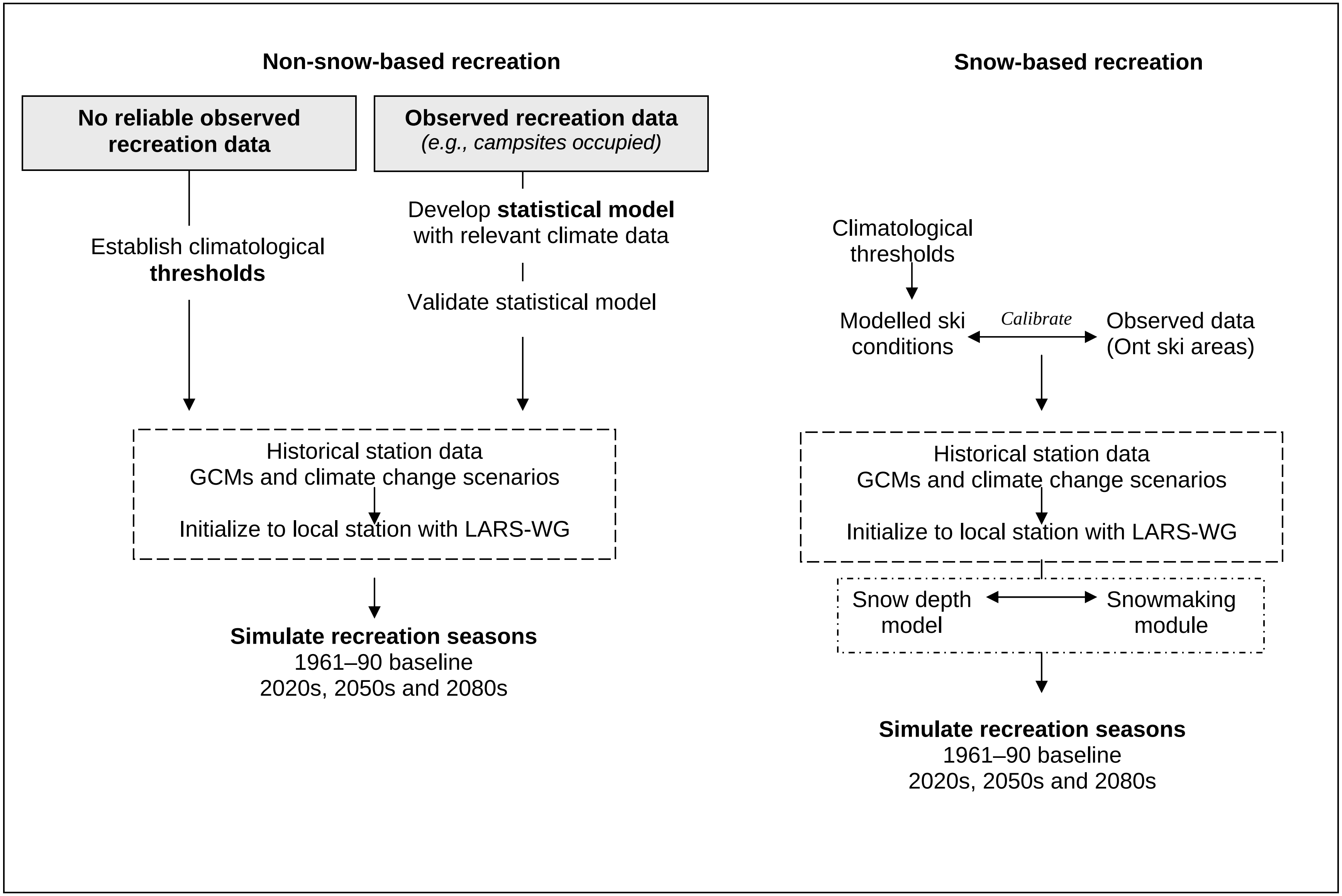

Figure 2.1 Research methods —overview

2.2 CLIMATE DATA AND CLIMATE CHANGE SCENARIOS

The Meteorological Service of Canada has archived data for 23 climate stations in the National Capital Region, but the length of record varies substantially among them. A sample of stations and their years of record include: Alta Vista (1961–1963), Britannia (1972–1984), City Hall (1966–1975), Gatineau (1953–1973), Lemieux Island (1953–1979), Lac des Loups (1956–1967), Luskville (1980–2004), Rockcliffe (1942–1964), St. François (1963–1985) and Wakefield (1963-1993). The climate station selected for use in this study was based on two criteria. First, it had to possess a quality record for the period 1961–90, reflecting the 30-year record required for modelling baseline conditions in the climate change impact assessment. Second, the climate station had to be operational so that recently archived data could be obtained to conduct statistical analyses where necessary. Only the Ottawa MacDonald-Cartier International Airport climate station (1939–2004) met these criteria, and daily temperature and precipitation data were obtained from the Meteorological Service of Canada for this station.

The climate change scenarios used in this study were obtained from the Canadian Climate Impacts and Scenarios (CCIS) Project. The scenarios provided by CCIS have been constructed in accordance with the recommendations set out by the Intergovernmental Panel on Climate Change (IPCC) Task Group on Scenarios for Climate Impact Assessment (TGCIA). The scenarios available from CCIS were derived from climate change experiments undertaken at six international climate-modelling centres that have met criteria established by the TGCIA. The climate change scenarios are based on 30-year means reflecting three future timeframes (2020s represent the period 2010–39; the 2050s represent 2040–69; and, the 2080s represent 2070–99), and represent temperature and precipitation changes with respect to the 1961–90 baseline period.

A comparison of the magnitude of change in mean annual temperature and precipitation projected by the global climate models (GCM) scenarios considered in this study is presented in Figure 2.2 for the 2050s. The CCIS Project strongly suggests that researchers employ a number of scenarios in their climate change impact assessments in order to capture the probable range of future climates. Three global climate models (GCMs) and climate change scenarios were selected for use in this study. The three GCMs used were the National Center for Atmospheric Research (NCAR) model, the Center for Climate System Research (CCSR) model and the Max Planck Institute of Meteorology (ECHAM) model. The specific climate change scenarios used were the NCARPCM B21, the CCSRNIES A11 and the ECHAM4 A21. These scenarios were selected from 19 available scenarios to represent a range of projected temperature and precipitation changes in the National Capital Region (Figure 2.2). In terms of temperature, the NCARPCM B21 scenario generally projects the smallest increase in annual mean temperature, while the CCSRNIES A11 scenario projects that largest magnitude increase in annual mean temperature. The ECHAM4 A21 scenario is considered a middle-of-the-road scenario.

Climate change scenarios provide monthly level changes in temperature and precipitation, but many of the recreation activities examined in this study were analyzed at a much finer temporal resolution (*e.g.*, weekly — golf). To accommodate this level of analysis, monthly climate change scenarios from the GCMs were downscaled and parameterized to the study area using the Long Ashton Research Station (LARS) stochastic weather generator to produce daily temperature and precipitation values for the 2020s, 2050s and 2080s. Stochastic weather generators such as LARS are inexpensive computational tools that produce site-specific, multiple-year climate change scenarios at the daily timescale (Semenov *et al.*, 1998). When completed, the daily temperature and precipitation data set for the Ottawa MacDonald-Cartier International Airport station included 1961–90 (observed) and 2010–99 (modelled).

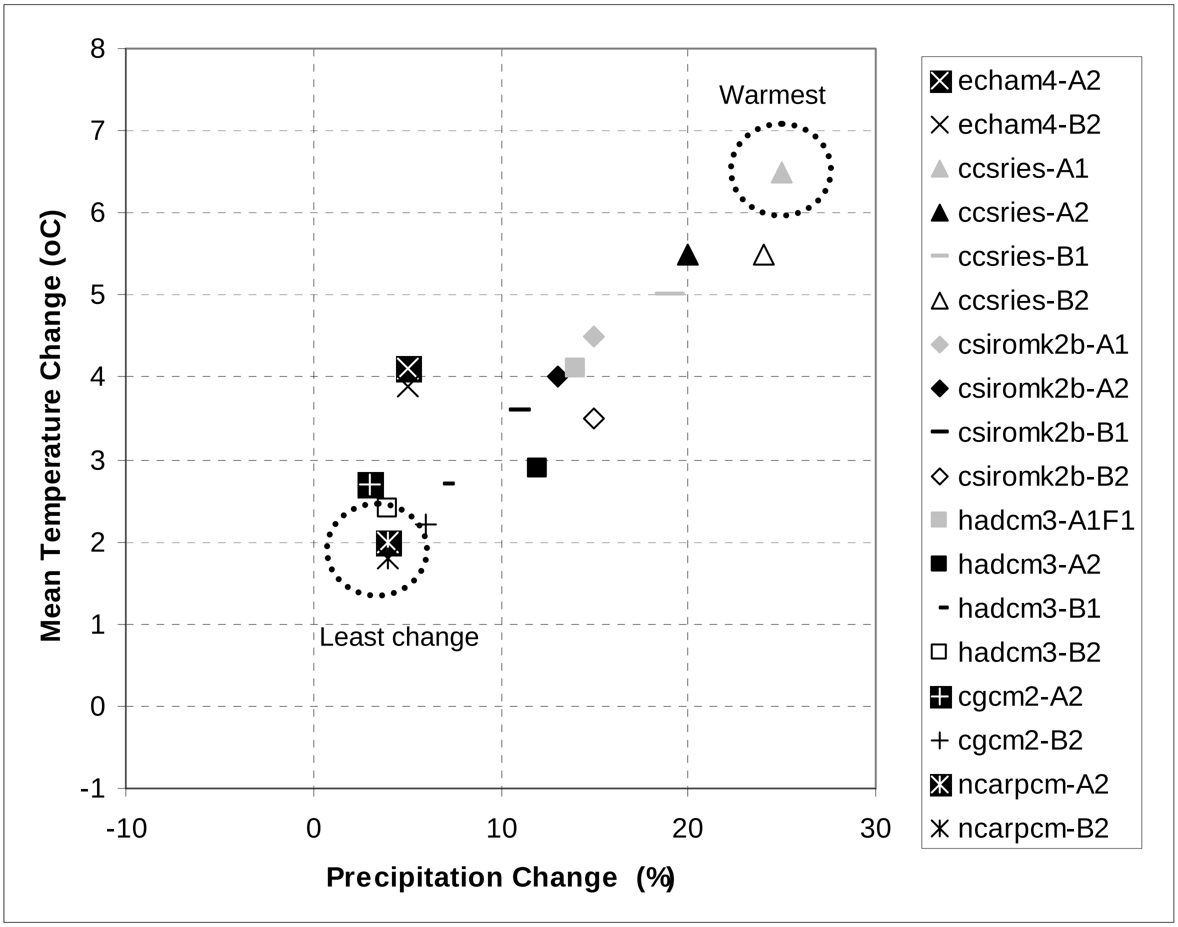

Figure 2.2 GCM comparison (2050s): projected annual climate changes in the Ottawa region

2.3 RECREATION DATA

In this study, reliable, multi-year recreation data were obtained for four recreation sectors. Table 2.1 summarizes the type of data obtained, the period of record, and their data sources.

Table 2.1 Summary of obtained recreation data

Activity	Data obtained	Observed record	Source
Public skating on Rideau Canal Skateway	Days open/season Opening day	1994–2004 1989–2004	La Fleur de la Capitale
Camping	Campsites occupied	2002–2004	La Fleur de la Capitale
Golf	Rounds played	2002–2003	Golf course in the GTA[a]
Visits to Gatineau Park	Visitors	1989–2003	Ontario Ministry of Natural Resources

[a] Identity of the golf course remains confidential at the request of course management

Winter operation data obtained for the Rideau Canal Skateway consisted of seasonal information pertaining to two important facets of canal operations — opening/closing day and season length. Calendar dates for the official opening and closing of the Skateway to public skating and the number of days the canal was open for skating (*i.e.*, season length) were obtained for the period 1970/71 to 2003/04. Staff at La Fleur de la Capitale indicated that the method used to calculate season length changed in the mid-1990s. Prior to 1994/95, season length was defined as the total number of days between the Skateway's opening and closing date, including days the canal was closed due to poor ice conditions. After 1994/95, season length excluded those days when the Skateway was closed between the opening and closing dates. As a result, only data for 1994/95 to 2003/04 were used in this study.

Daily site occupancy data from Gatineau Park's largest campground, Philippe Lake, was made available to this study by La Fleur de la Capitale. The data recorded the total number of Philippe Lake's 262 campsites that were occupied each night from January 1 to December 31 for the 2002 to 2004 operating seasons. Unfortunately, there were a number of caveats that limited use of the entire three-year camping data set. At the time of the analysis, data for the latter part of the 2004 operating season were not yet available; 2004 climate data were only available up until September. Due to a number of equipment malfunctions, camping data for September to December 2003 were also unavailable. Comparison of all three years of data also revealed that there was no campsite occupancy during the winter of 2002. Without a reasonable explanation for the zero occupancy at the time of analysis, January to March 2002 was excluded from further consideration. As a result, the camping data analyzed in this study included only the periods of April to December 2002, January to August 2003 and January to September 2004.

The National Capital Region has more than 20 golf courses, including several that are located on National Capital Commission lands. Despite repeated efforts to acquire data (*i.e.*, rounds played) from golf courses in the National Capital Region (see Appendix A) none could be obtained. Golf course managers indicated that the proprietary nature of the information restricted their desire to release operations data for analysis. Consequently, proxy golf data from the Greater Toronto Area (GTA) were used in this study. Daily recorded golf data for the 2002 and 2003 seasons from a private golf course in the GTA was used to develop a statistical model of climate and golf participation. The course used was a regulation 18-hole course (par 72, maximum 7,043 yards), centrally located in the GTA. Green fees averaged about C$90 per 18-hole game, which was in the low range of the green fees charged by other premium private courses in the local area (C$120–$180). The GTA golf course superintendent indicated that the influence of climate on course operations and participation was representative of mid-to-high quality golf courses in the Toronto region, and was considered generally representative of the same class of golf course in the National Capital Region.

Reliable daily or monthly visitation data for Gatineau Park were also unavailable for two main reasons — unreliable methods used by consultants to estimate visitation in 2001 and limited data (*i.e.*, only three months) in a more recent visitation study conducted for the National Capital Commission. As a result of these data limitations, this study instead used visitation data from Fitzroy Provincial Park (Eastern Ontario) to develop a statistical model of climate and park visitation. The visitation data for Fitzroy Provincial Park consisted of the total number of people entering the park each month between 1989 and 2003. Fitzroy Provincial Park was used as a proxy for Gatineau Park because it was the nearest provincial park to the city of Ottawa (~50 kilometres west) and was situated in the same climate zone. It was hypothesized that changes in visitor demand brought about by climate change at Fitzroy Provincial Park would also be experienced at Gatineau Park.

2.4 STATISTICAL ANALYSIS

2.4.1 Regression Analysis

Regression analysis is a common statistical technique used to quantify the nature and strength of a relationship between two or more variables. The relationship is expressed in the form of a function (equation) for the purpose of making predictions about future values, and is visually represented by fitting a line through all data points such that they are evenly distributed about the line. Regression analyses were employed in this study to determine the explanatory power of climate in a range of recreation sectors in the National Capital Region. The recreation sectors for which regression analysis was employed are summarized in Table 2.2, including the type of relationship sought and the variables used.

Table 2.2 Summary of regression analyses

Activity	Observed data	Variables examined	Model created	Temporal level	Climate variables
Rideau Canal Skateway	1994–2004 1989–2004	Days open/season Opening day	Season length Opening day	Days Day	12[a]
Camping	2002–2004	Number of campsites occupied	Occupancy rate	Monthly	4[b]
Golf	2002–2003	Rounds played	Rounds played	Weekly	4[b]
Park visits	1989–2003	Number of visitors	Number of visitors	Monthly	4[b]

[a] 12 variables (*By month*: Mean, minimum and maximum temperature; precipitation; number of days with mean temperatures >0°C; number of days with mean temperatures >-5°C; number of days with mean temperatures <-10°C; number of days with maximum temperatures >0°C and minimum temperatures <0°C; number of days with minimum and maximum temperatures >0°C); (*Other*: average seasonal (DJFM) temperature; mean temperature during the last 14 days of December; mean temperature during last seven days of December)

[b] 4 variables (Mean, minimum and maximum temperatures, precipitation)

The statistical analysis undertaken in this study was identical for all four activities, so for brevity, only the general procedure is outlined here. In each case, regression analysis was performed on the climate variables and observed recreation data to establish a mathematical relationship. Once the regression model was established, it was validated against the available observed recreation data to determine how well the model reproduced observed values, and then was used to simulate a 30-year (1961–90) baseline period. The regression model was run with the climate change scenarios to project changes in the respective recreation sector in the 2020s, 2050s and 2080s.

2.4.2 Snow Model

The availability of snow is an important factor in determining the success of many winter recreation activities in the National Capital Region. For example, snow influences the season length of alpine and Nordic skiing in Gatineau Park and the need for machine-made snow during Winterlude to sustain certain attractions. Using methods developed by Scott *et al*. (2002), a snow depth model was developed for the National Capital Region to assess changes in the season length of snow-based recreation activities (*e.g.,* skiing, Winterlude attractions).

A natural snow-depth model was developed and locally calibrated for the National Capital Region using methods developed for the *Canadian Daily Snow Depth Database* and *Water Balance Tabulations for Canadian Climate Stations.* The technique involved estimating three parameters: 1) amount of precipitation that falls as snow and rain, 2) snow accumulation, and, 3) snowmelt. Historical precipitation data from the Ottawa MacDonald-Cartier International Airport climate station were used to determine the minimum, maximum and/or mean daily temperature thresholds that best predicted precipitation type (snow or rain). Snowfall was added to the snow pack assuming a constant snow pack density of $400 kgm^{-3}$, which is an acknowledged compromise, as the density of both natural and machine-made snow can vary substantially. An empirically derived equation, originally developed by the US Army Corps of Engineers (1956), was used to estimate daily snowmelt. The Ottawa MacDonald-Cartier International Airport climate station is an open-field site and thus the snow model represents snow conditions on open field ski areas or recreation trails. Snow cover generally lasts longer and is deeper on trails that are in forested areas. The climate change impact assessment results are therefore for the most vulnerable portions of ski areas and recreation trails.

The value of the snow model was evaluated by comparing the predicted and observed number of days when snow depth met or exceeded two, 15 and 30 centimetres over the 1961–90 baseline period (Scott *et al*., 2002). Daily temperature and precipitation data derived from LARS weather generator were then used to drive the snow depth model under climate change conditions in the 2020s, 2050s and 2080s.

Some recreation sectors (*e.g.*, alpine skiing) in the National Capital Region have undertaken climatic adaptations, specifically snowmaking, to overcome the impact of climate variability on natural snow cover. To account for this climatic adaptation in the climate change impact assessment, a snowmaking module was integrated with the natural snow cover model. The goal of the snowmaking module in the alpine skiing analysis was to build and maintain a 60-centimetre snow base between November 22 and March 30, defined in this study as the ‘snowmaking window’. The snow depth threshold of 60 centimetres was based on an analysis of reported snow base depth at ski areas in Ontario during the 1990s, the period when most snowmaking systems were implemented across the province. If natural snowfall had not produced suitable natural snow depth for skiing (*i.e.*, at least 30 cm) by November 22, the snowmaking module would begin producing snow on days when it was technically feasible; the snowmaking module would continue until a 60-centimetre base was achieved. The calendar dates for the snowmaking window were established by reviewing opening and closing dates for ski areas in central Ontario during the past 20 years using data from the Ontario Ministry of Tourism, Culture and Recreation.

2.5 CLIMATE CHANGE IMPACT INDICATORS

Weather and climate are interconnected with recreation and tourism in many different ways. Yapp and McDonald (1978), Mieczkowski (1985) and Harlfinger (1991) have all explored the use of recreation-climate indices to evaluate the recreation climate potential of a selected region. Correlating actual recreation data with climate data to develop empirical relationships and validate thresholds is a research need, and this study has employed this approach where reliable data were available (see section 2.4). Other recreation climatology research has endeavoured to define climatic thresholds for individual recreation activities (Gates, 1975; Crowe *et al.*, 1977). Where reliable multi-year recreation data were not available in this study, climate indicators were selected and associated thresholds established for specific activities in order to project changes in recreation seasons and tourism event planning under climate change.

Indicators are simple things that can be used to measure and understand something that is more complex. For example, blood pressure is an indicator used to measure the state of a individual's health. For a climate indicator to be valuable in this study, its influence on the recreation activity or tourism event had to be clear, and it had to possess some relevance to management and staff with the National Capital Commission. Consultation with staff from various departments at the National Capital Commission provided insight into temperature and precipitation indicators that were important in influencing recreation season lengths and visitor satisfaction, including climatic thresholds that serve as important benchmarks for event planning. The indicators and thresholds used in this study are summarized in Table 2.3; a detailed description of each is provided in this section, including the rationale for their selection.

2.5.1 Tourism Events

Winterlude

Residents and visitors to the National Capital Region during Winterlude can take in a number of attractions, including ice sculptures and the ice slides at Snowflake Kingdom in Jacques Cartier Park. The nature of the physical resources (*e.g.*, snow, ice) that define the climate sensitivity of different recreation activities required the development of different climatic thresholds to reflect conditions suitable for their individual occurrences. The Winterlude activities examined included the ice-sculpture contest, snow slides at Snowflake Kingdom, the Keskinada Loppet Nordic ski race and general attendance.

Two climate indicators were used in this study for Winterlude activities — temperature and snow depth. Temperature was used to define suitable conditions for all four events identified above except the Keskinada Loppet race. With respect to the ice sculptures, officials with the National Capital Commission suggested that temperatures colder than -5^{o}C were ideal for maintaining the sculptures during Winterlude. Daytime temperatures warmer than -5^{o}C generally require some sort of intervention to protect the sculptures from melting. In this study, the number of days with maximum temperatures colder than -5°C during Winterlude (February 1 to 21) was examined, along with the number of days between -5°C and +5°C, and warmer than 5°C. The latter two thresholds were used to determine whether ice sculptures could be maintained in the future.

Table 2.3 Summary of climate impact indicators and thresholds used in this study

	Event / activity	Indicator criterion	Specific thresholds	Period examined
TOURISM EVENTS	**Winterlude**			
	Ice sculptures	Maximum temperature	<-5°C, -5°C to +5°C and >+5°C	Feb 1 to 21
	Snowflake Kingdom (snow/ice slides)	Minimum temperature	<-5°C and < -10°C	Jan 1 to 31 and Feb 1 to 21
	Keskinada Loppet ski race	Snow depth	8 cm and 15 cm	Feb 1 to 21
	General attendance	Maximum temperature	<-30°C, -30°C to -20°C, -20°C to -10°C, -10°C to 0°C and >0°C	Feb 1 to 21
	Canadian Tulip Festival	Maximum and minimum temperature Growing degree days (GDD)	 GDD>20; GDD>120	Apr 16 to 30 and May 1 to 21 Begin Jan 1
	Canada Day	Mean temperature Maximum temperature	 >=30°C	1 week before and after Jul 1 1 week before and after Jul 1
GATINEAU PARK	Alpine skiing	Snow depth	30 cm	Nov 1 to Mar 31
	Nordic skiing	Snow depth	8 cm and 15 cm	Nov 1 to Mar 31
	Swimming (lake)	Maximum temperature	>=23°C	Jan 1 to Dec 31
	Beach use	Maximum temperature	>=15°C	Jan 1 to Dec 31

The ice and snow slides at Snowflake Kingdom require a large volume of snow. In previous years, machine-made snow has been used to build and maintain the attraction when February temperatures were above normal or when there was a lack of natural snow. With current technology, snowmaking is feasible at minimum temperatures of approximately -5°C, but is generally considered most efficient at minimum temperatures below -10°C. The number of days with minimum temperatures colder than -5°C and -10°C were calculated in this study for two periods. The first was for the 21 days of Winterlude (February 1 to 21) to determine if snowmaking would be feasible during the event. The second was the month-long period before Winterlude (January 1 to 31), which was used to determine if snowmaking opportunities would be available leading up to the event (main snowmaking period) to accommodate possible deficiencies in natural snow cover. Average daily maximum temperature during Winterlude was also considered as a means to assess changes in general climate conditions during the event.

The final Winterlude activity defined by temperature was general attendance. Event organizers with the National Capital Commission have noticed temperatures colder than -20^{o}C tend to limit the number of people who come out to the attractions. Temperatures between -10^{o}C and -20^{o}C are good for attendance, but temperatures above 0^{o}C are even better. Maximum temperature was used to define thermal comfort levels for general attendance. The number of days between February 1 and 21 with maximum temperatures colder than -30^{o}C, between -30^{o}C and -20^{o}C, between -20^{o}C and -10^{o}C, between -10^{o}C and 0^{o}C, and warmer than 0^{o}C were calculated. Average maximum temperature during Winterlude was also considered, again, as a means to assess changes in general thermal conditions during the event.

Suitable conditions for the Keskinada Loppet Nordic ski race were defined by natural snow depth. The Keskinada Loppet is a Nordic ski event involving about 2,000 skiers racing through a 25, 35 or 55-kilometre course, usually on the last weekend of Winterlude. Since it is impossible to project what climatic conditions will be like on a specific weekend, snow conditions for the three-week period during Winterlude (February 1 to 21) were examined to determine whether suitable snow conditions would be available for the race.

Event organizers could not confirm what snow-depth threshold was required to run the Keskinada Loppet ski race, so snow thresholds used for Nordic skiing generally were employed in this analysis. In the National Capital Region, Nordic track setters require a 15-centimetre snow base to set a regulation five-centimetre deep track. However, officials with the National Capital Commission have adapted a track setter to require only eight centimetres of snow to produce a non-regulation 2.5-centimetre deep track, which allows the agency to groom trails earlier in the winter season. To account for this adaptation, both the eight and 15-centimetre snow depth thresholds were evaluated to determine whether the race could be held during Winterlude.

Canadian Tulip Festival

Tulips are among the first flowers to emerge and bloom in the spring, and have been used as an indicator for spring's northward progression across North America. Horticulturalists with the National Capital Commission cited a number of air and soil temperature-related conditions that they have noticed influence the growth and maintenance of tulips. For example, tulips tend to become active when soil temperatures are between +10^{o}C and 15^{o}C. During the Festival itself, daily maximum temperatures between 10^{o}C and 15^{o}C are considered ideal to maintain blooms, while daily maximum temperatures warmer than 20^{o}C tend to shorten the lifespan of tulip blossoms. Frost also tends to shorten bloom time because it can cause blooms to shrivel.

Drawing mainly on consultations with staff from the National Capital Commission, a range of climatic thresholds was used in this study to define suitable climatic conditions for the growth and development of tulips prior to the Canadian Tulip Festival, and maintenance of their blooms during the Festival. Specific attention was given to the timing of the tulips' first emergence from the ground and peak blooms, as these two events were considered important for the planning of the Festival. Two types of thresholds were employed in this study — air temperature and growing degree days

The timing, duration and quality of tulip blossoms are sensitive to climatic conditions, particularly air temperatures. Three air-related temperature thresholds were used in this study.

The first was the mean maximum and mean minimum daily temperature during the two-week period before the start of the Canadian Tulip Festival (April 16 to 30)[2], which was used to evaluate thermal conditions during the final stages of tulip development. The second was the mean daily maximum temperature during the three weeks of the Festival (May 1 to 21), which was used to assess whether conditions would support optimal bloom. The final air-temperature threshold was the number of days in the two-week period before the Festival and during the Festival with frost (minimum temperatures colder than or equal to $0^{o}C$).

It is a well-established fact that plant development is temperature dependent. Tulips, like all other plants, require a specific amount of heat to develop from one stage in their life cycle to another. Growing degree days provide a measure of the energy (heat units) available to plants, and are a form of phenology indicator routinely used to estimate the timing of various stages of plant development during the growing season. With no observed data available from the National Capital Commission on the timing of tulip development in Ottawa, growing degree days were considered a viable indicator for tulip emergence and bloom. Climatic thresholds were established based on phenology information from the midwestern and northeastern regions of the United States. Data synthesized from state agricultural sources (Cornell University, 2004; Penn State, 2004; University of Massachusetts, 2004; University of Wisconsin, 2004) revealed that tulips tend to emerge at 15 to 20 growing degree days, and are generally in full bloom anywhere between 90 to 120 growing degree days. It was assumed that tulips in Ontario would emerge and bloom under similar conditions as that reported in the United States, but would be delayed by several weeks until the necessary heat units had accumulated in latitudes that are more northerly. For the purposes of this study, a minimum of 20 growing degree days was used to define the day when tulips would first emerge from the ground. The timing of full bloom was defined as at least 120 growing degree days. Growing degree days were calculated from January 1 using a base temperature of $5^{o}C$.

Canada Day

Event planners with the National Capital Commission must plan for heat-related emergencies during Ottawa's Canada Day celebrations. Contingency plans typically involve having cooling systems (*e.g.*, shade tents, misting towers and water stations) and medical staff on site to treat individuals who experience heat-related stresses. Event co-ordinators use the same temperature threshold as that in Toronto's Heat Emergency Plan for preparing for heat-related emergencies on July 1. Toronto's Heat Emergency Plan relies on a computerized system that takes into account a number of variables including temperature, humidity, air mass type and source, and the duration of synoptic weather conditions. Alerts and emergencies are issued based on the probability of an increase in heat-related mortality among vulnerable populations. Subsequently, it is difficult to determine a specific base-temperature threshold to employ as a heat-emergency indicator.

As a result, an important consideration was the establishment of an indicator and related thresholds that would be useful to Canada Day event planners at the National Capital Commission. For the purposes of this study, two temperature thresholds were employed. The first was the average mean temperature during the one-week period before July 1 and the one-

[2] It is recognized that the Canadian Tulip Festival will start and end on different days depending on the year. The dates used in this study reflect the average festival period.

week period after July 1. The second was the number of days with maximum temperatures greater than or equal to 30^{o}C one week before July 1 and one week after the national holiday. The latter criterion was considered a reasonable dry bulb temperature proxy for heat discomfort, and it was used to define a 'heat emergency day' (Mills *et al*., 2002). As it is impossible to project what conditions will be like on a specific day, the use of both criterions will provide insight into thermal comfort levels in the two-week period around Canada Day.

2.5.2 Gatineau Park and Other NCC lands

Winter Recreation

Studies in the recreation climatology literature have attempted to define climatic thresholds for winter recreation, especially skiing. For example, Crowe *et al.* (1977) defined a suitable alpine ski day as one with at least six hours with 2.5 centimetres of snow, an air temperature between -2^{o}C and +5^{o}C, wind speeds less than 6.5 ms^{-1} , no liquid precipitation and visibility less than 800 metres. The alpine ski season was defined as the number of days between the first and last days with recorded snow depths of 2.5 centimetres (Crowe *et al.,* 1977). These types of climatic thresholds have been used previously in climate change sensitivity analyses of winter recreation (McBoyle and Wall, 1987, 1991; Wall, 1988), but were found to be inadequate for analyses of skiing in Ontario (Scott *et al.,* 2002). In this study, temperature and precipitation-based climatic thresholds derived by Scott *et al.* (2002) were used to establish the season length of alpine skiing at Gatineau Park's Camp Fortune ski area and other alpine ski areas in the region.

Season length was calculated for the period between November 1 and March 31, and the economic goal of most ski resorts in the region is to operate for at least 12 weeks, encompassing the major winter holiday periods (Christmas and New Year — late December; Spring Break — mid March). For the purpose of this study, alpine ski areas were modelled to close when maximum temperatures exceeded 10^{o}C for two consecutive days and were accompanied by liquid precipitation or the two-day liquid precipitation exceeded 20 millimetres.

Nordic skiing typically requires less snow than alpine skiing to be operational. As mentioned earlier, the standard Nordic track setter for grooming trails in the National Capital Region requires a 15-centimetre snow base to be operational. An additional track setter that requires only eight centimetres of snow is also used earlier in the season. To determine how climate change may influence the Nordic ski season in Gatineau Park, the number of days between November 1 and March 31 with at least a 15-centimetre snow depth (accommodates 5 cm track setter) and at least an eight-centimetre snow depth (accommodates 2.5 cm track setter) were examined.

Warm-Weather Recreation

Gatineau Park contains six staffed (*i.e.,* with lifeguards) public beaches — O'Brien, Blanchet, Breton, Parent, Smith and La Pêche. These beaches are popular destinations in the National Capital Region, attracting over 70,000 people each year (Riopel, 2003). Without reliable records of daily use of beach areas in Gatineau Park, temperature was used as the primary climate indicator influencing the season length of swimming and beach recreation.

Specific temperature thresholds for swimming and general beach use were derived from Paul's (1971) study of the relationship between climate and summer recreation in the Ottawa region. A daily maximum temperature of at least 23^{o}C was used to define a suitable day for swimming in

Gatineau Park. This threshold for swimming was derived from statistical analysis (*i.e.*, regression) of daily visitors to two outdoor unheated pools in the Ottawa area and five public beaches along the Ottawa and Rideau Rivers during the 1969 operating season. Similarly, climatic thresholds for public beach use were derived from daily vehicle counts (one-way traffic) at two beaches in Gatineau Park (Philippe Lake and Pêche Lake) and eight other beaches in the Ottawa region administered by the St. Lawrence Park Commission during the same operating season. A daily maximum temperature of at least 15^{o}C was used to define the season length of public beach recreation throughout the year. The lower temperature threshold for beach recreation likely reflects the range of activities that can occur on the beach without venturing into the water (*e.g.,* sunbathing, sports, leisure walks and picnicking). In both cases, the thresholds employed in this study for swimming and beach recreation represent limiting criteria, which reflect when participation levels in Paul's (1971) study fell below 10% of that experienced during peak use.

2.6 SUMMARY

This chapter set out the methods used in this study to conduct the climate change impact assessment of recreation and tourism in the National Capital Region. The research design was outlined. Key stages in the methods were discussed in detail including the nature and source of recreation and climate data, statistical approaches, climate thresholds, and the rationale for a number of analytical decisions. The next chapter presents the results of the climate change impact assessment.

CHAPTER THREE

Climate Impact Assessment

The National Capital Region's extensive mix of cultural and natural attractions provide a wealth of recreation and tourism opportunities for locals and visitors, and in doing help make the region one the largest tourism destinations in the Province in terms of tourism-related expenditures. Many of the region's most popular attractions are vulnerable to climate variability, and in the last two decades, associated reductions in recreation seasons and financial losses have been experienced. The purpose of this study was to understand the vulnerability of recreation and tourism in the National Capital Region to climate variability in order to determine the potential impacts of climate change on recreational operating seasons and tourism planning in the future. This chapter addresses these issues and is divided into two parts. First, the results of the regression analyses that were undertaken to explore the explanatory power of climate in recreation demand for a number of activities are presented. The second part of the chapter presents the climate change impact assessment results. The results of each section are divided into two sections – tourism events and Gatineau Park and other NCC lands.

3.1 CURRENT CLIMATE-RECREATION RELATIONSHIPS

Regression analysis was employed in this study to establish the nature and strength of the relationship between climate and recreation. It was used to define the influence of climate in the season length and opening day of the Rideau Canal Skateway, monthly campground occupancy rates in Gatineau Park, weekly rounds of golf played in the Ottawa area, and monthly visitor levels in Gatineau Park. The results of the analyses, including the statistical models, are discussed in this section.

3.1.1 Tourism Events

Rideau Canal Skateway

Regression analysis was performed on season length data obtained from the National Capital Commission for the period 1994/95 to 2003/04 and 12 climate variables to determine the role of climate in the winter operation of the Rideau Canal Skateway. Stepwise linear multiple regression analysis resulted in a best-fit, one-variable model ($r^2 = 0.53$; $p<0.005$). It was revealed that Ottawa's winter (DJFM - December, January, February and March) mean temperature (t-statistic = -3.02) was the strongest predictor of how many days the Rideau Canal Skateway would be open for public skating. Figure 3.1 illustrates the regression relationship between winter mean temperature and season length during the Skateway's 1994/95 to 2003/04 winter seasons. Mean winter temperatures colder than -8^{o}C tended to result in seasons of at least 50 days, while mean temperatures warmer than -5^{o}C contributed to shorter seasons. The expression derived from the analysis and subsequently used to model season length in this study was:

Skateway season length (days) = -5.127(Mean temperature, DJFM) + 19.917

Figure 3.2 provides a comparison of observed and modelled Skateway season lengths between 1994/95 and 2003/04.

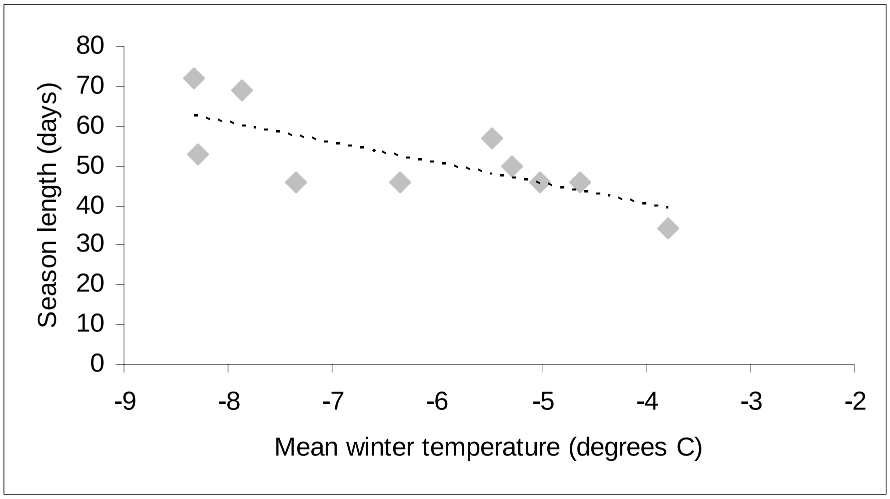

Figure 3.1 Linear regression model of the Rideau Canal Skateway's season length

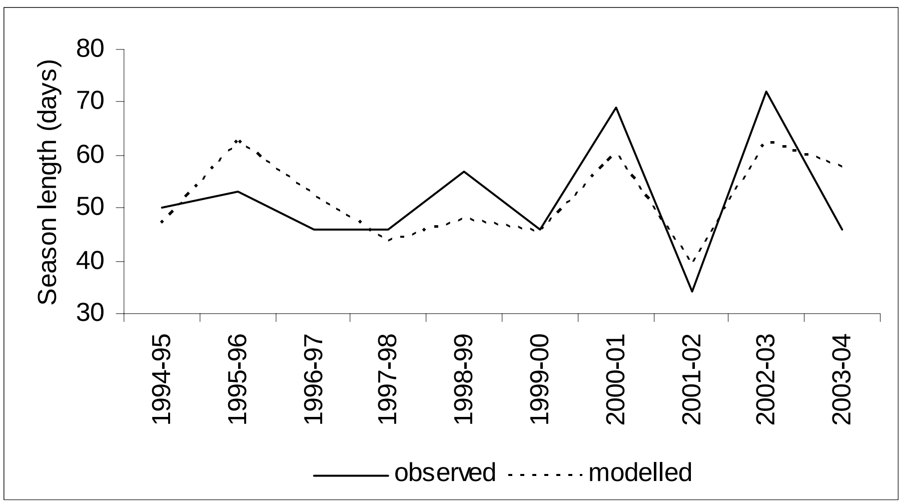

Figure 3.2 Comparison of observed and modelled season length of the Rideau Canal Skateway (1994/95 to 2003/04)

A number of attempts were made to model the relationship between climate and the Rideau Canal Skateway's opening day using the entire 30-year record obtained from the National Capital Commission, but a robust model could not be achieved[3]. It was assumed that factors such as changes in safety standards and operating experience over the 30 years likely played a part in influencing the decision to open the Skateway to the public. Attempts were made to model opening day using a shorter, more recent, period in which decision-making were more consistent. The 1989/90 to 2003/04 period of record was examined to determine if a stronger regression model could be developed. Linear multiple regression analysis of opening day and the 12 climate variables resulted in a three-variable model (r^2 = 0.74; $p<0.005$). The strongest predictors of when the Rideau Canal Skateway would be open for public skating were average minimum December temperature (t-statistic = 4.17), total January precipitation (t-statistic = -3.84), and

[3] r^2 values less than 0.2

average minimum January temperature (t-statistic = 2.26). The mathematical expression for the opening day model used in this study was:

*Skateway's opening day = 66.213+ (1.787 * average minimum temperature, Dec) - (0.171 * total precipitation, Jan) + (1.022 * average minimum temperature, Jan)*

Figure 3.3 provides a comparison of observed and modelled opening days for the Skateway between 1989/90 and 2003/04.

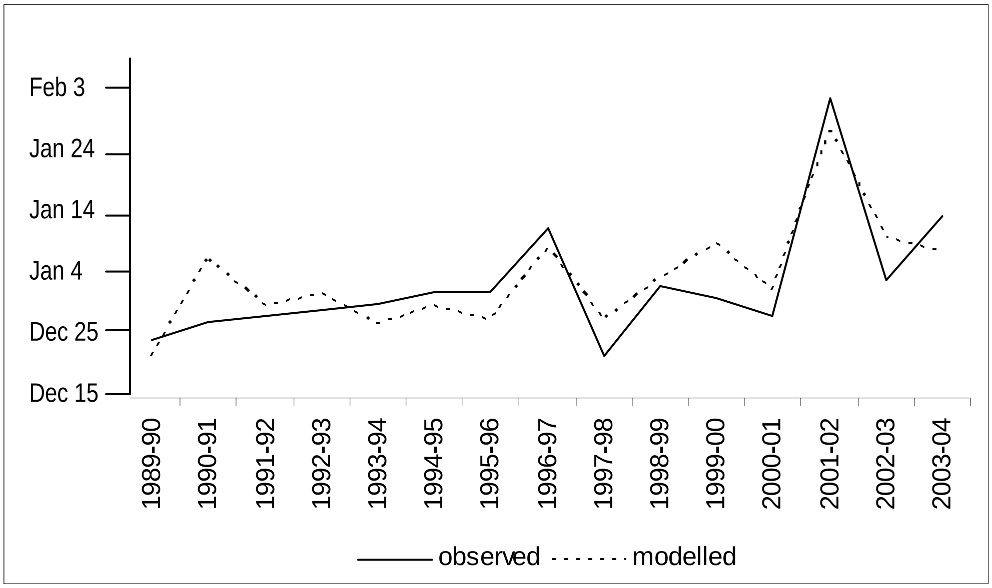

Figure 3.3 Comparison of observed and modelled opening day of the Rideau Canal Skateway (1989/90 to 2003/04)

3.1.2 Gatineau Park and Other NCC Lands

The statistical relationships between climate and other recreational activities examined in this study were generally much stronger than that for the winter operation of the Rideau Canal and the nature of the relationships were not necessarily linear. Discussed in this section are the climate-recreation relationships for golf demand in the National Capital Region, and camping in and visitation to Gatineau Park.

Golf

With no reliable golf demand data available from Ottawa-area golf courses, regression analysis of golf demand was performed on a proxy golf course in the Greater Toronto Area (GTA). The model developed was then used to project future demand in the National Capital Region. Stepwise linear multiple regression analysis of weekly rounds played and four climate variables indicated that maximum temperature (t-statistic = 14.78) was the single most important predictor of rounds played at the selected course ($r^2 = 0.77$; $p<0.005$). Although precipitation is routinely recognized as having an important influence on golf demand, particularly at hourly and daily levels, its influence was not significant at the weekly level in this analysis. Figure 3.4 illustrates the regression relationship between average weekly maximum temperature and weekly rounds played during the 2002 and 2003 seasons.

An important limitation of the linear regression model was that it continued to project an increase in rounds played as maximum temperature increased. Conceptually, this relationship is unrealistic because at some critical maximum temperature the number of weekly rounds played would begin to stabilize and then decline due to heat-related discomfort and eventually physiological heat stress. To address the issue of an upper temperature threshold affecting rounds played, a cubic regression analysis was subsequently performed on maximum temperature. The resultant model was stronger (r^2=0.82, p<0.005) (Figure 3.4), and 28^{o}C was revealed to be the upper critical temperature. This suggests that the number of rounds played will tend to stabilize and decline beyond this threshold.

The resultant expression of the cubic regression model for weekly rounds played and maximum temperature developed for Toronto and used as a proxy in this study was:

$$\textit{Weekly rounds played} = -0.133x^3 + 5.955x^2 - 16.192x - 34.448$$

The golf model was truncated at 4^{o}C because demand declined to zero in the GTA during weeks with average maximum temperatures less than this threshold. Therefore, if a week had a mean maximum temperature of 0^{o}C, it was assigned a value of zero rounds played. A comparison of the observed and simulated weekly rounds played in the GTA indicated that cubic model performed well over the two golf seasons for which data were available (Figure 3.5). Overall, the modelled annual rounds differed from the observed rounds by less than 2% in each of the two years with data.

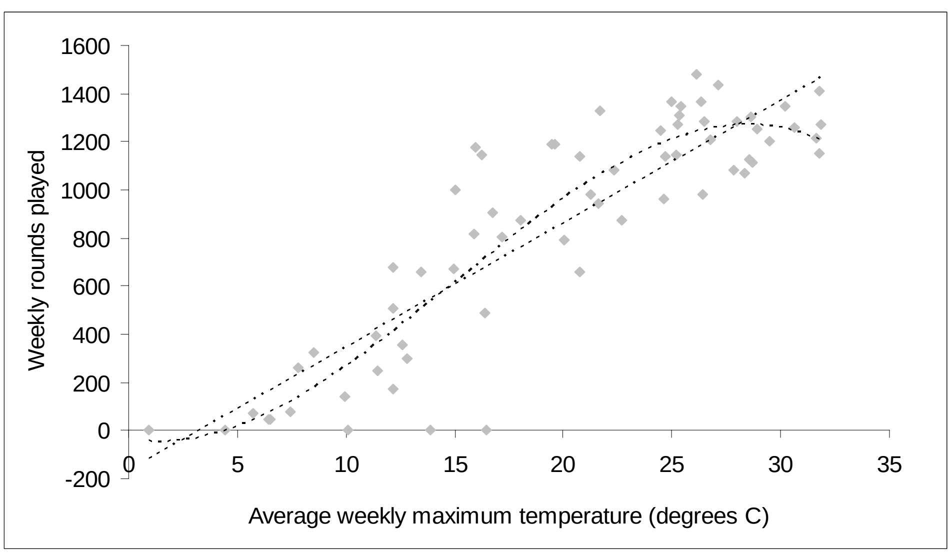

Figure 3.4 Linear and cubic regression models of weekly golf rounds played at the proxy GTA course

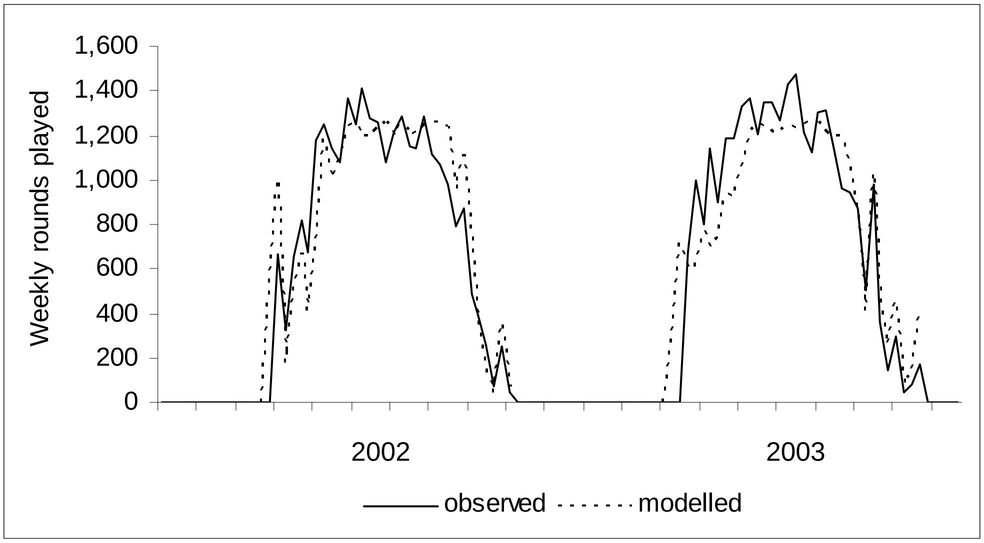

Figure 3.5 Observed and modelled weekly golf rounds played at the proxy GTA course

Camping

Preliminary examination of the camping data (2002–2004) for Gatineau Park's largest campground (Philippe Lake) revealed two distinct climate-recreation relationships during its year-round camping season. Figure 3.6 illustrates these relationships with respect to one climate variable. The first relationship was defined by occupancy rates less than 30%, which encompass the bottom portion of Figure 3.6. The cluster identified in Figure 3.6 defines the second relationship. During the three years of available data, occupancy rates greater than 60% corresponded with the months of July and August. Conceptually, this occupancy pattern is to be expected given that this period coincides with school and summer vacations; campgrounds are likely to be near full capacity at this time regardless of the prevailing climatic conditions, which are almost always suitable for camping. A year-round camping demand model incorporating the clustering effect would skew the simulation of monthly occupancy rates at Philippe Lake campground. Subsequently, to address this issue, separate demand models were established for the shoulder season (September to June; <=30% occupancy) and the summer peak season (July and August; >=60% occupancy).

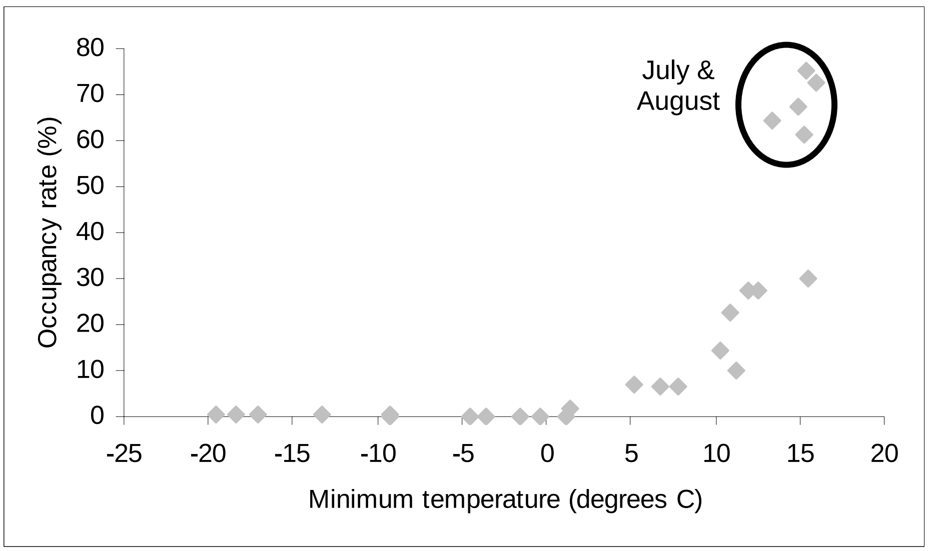

Figure 3.6 Monthly climate-camping relationship at Philippe Lake campground (2002-04)

An initial linear stepwise multiple regression analysis for the shoulder season returned a one-variable model ($r^2 = 0.53$; $p<0.005$), revealing that minimum temperature (t-statistic = 4.86) was the strongest predictor of how many campsites would be occupied each month at Philippe Lake (Figure 3.7). It is evident from Figure 3.7, however, that like golf, camping demand increases exponentially as minimum temperatures increase. To accommodate the less than linear pattern to camping demand, a cubic regression analysis was performed on minimum temperature, yielding a stronger model ($r^2 =0.89$, $p<0.005$) (Figure 3.7).

A separate analysis of the number of campsites occupied at Philippe Lake during July and August was undertaken in order to establish a camping demand model for Gatineau Park's peak camping season. Stepwise linear regression returned a one-variable model ($r^2 = 0.25$; $p<0.005$). Minimum temperature (t-statistic = 1.01) was also revealed to be the strongest predictor of how many campsites would be occupied during the months of July and August. Figure 3.8 illustrates the linear relationship between mean monthly minimum temperature and mean summer occupancy rate at Philippe Lake's campground.

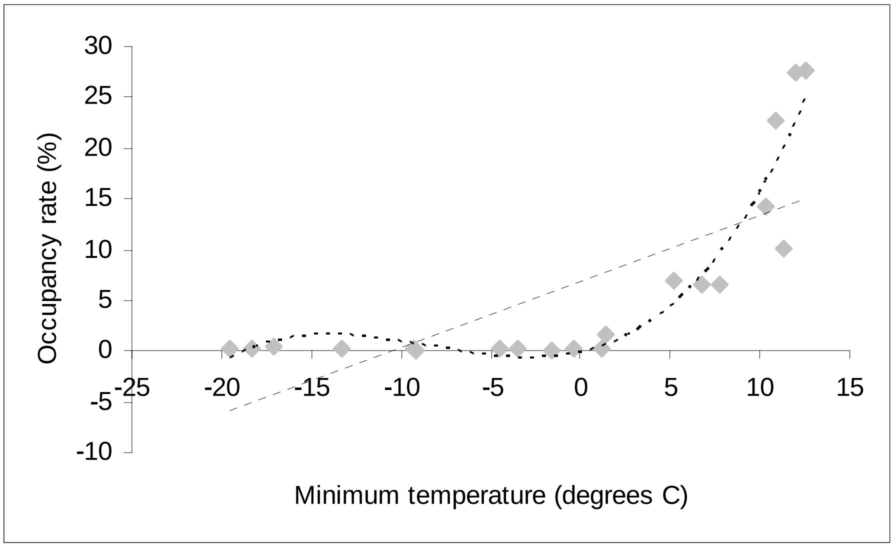

Figure 3.7 Regression models of campground occupancy at Philippe Lake (shoulder season)

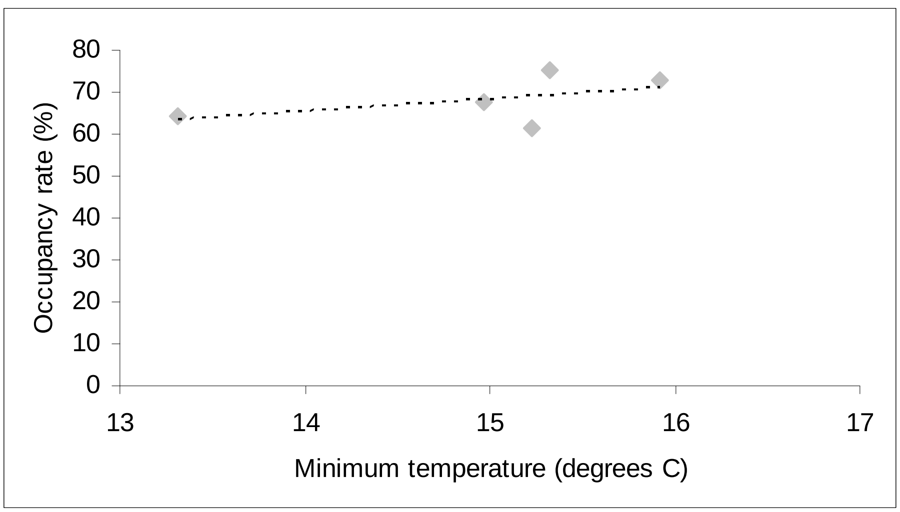

Figure 3.8 Linear regression model of campground occupancy at Philippe Lake (July and August)

The camping models developed and used in this study to project mean monthly occupancy rates (based on minimum temperature) at Gatineau Park's Philippe Lake campground were expressed as follows:

Mean monthly occupancy rate (%), shoulder = $0.003x^3 + 0.084x^2 + 0.398x - 0.135$
Mean monthly occupancy rate (%), July and August = $2.954x + 24.034$

The camping demand model was run at a daily level and values were then averaged to the monthly level. The shoulder model was truncated at 0^oC because observed demand declined to less than 1% during days and months with average minimum temperatures less than this threshold. Similar to the golf analysis, if the minimum temperature on March 3 was -5°C, it was assigned an occupancy rate of 0%. A comparison of the observed and modelled mean monthly occupancy rates at Philippe Lake revealed that the cubic and linear models performed well over the three camping seasons for which data were available (Figure 3.9). Modelled occupancy rates varied by less than 5% of observed rates in 21 of the 25 months for which data were available; 15 months were within 2% of observed monthly occupancy rates.

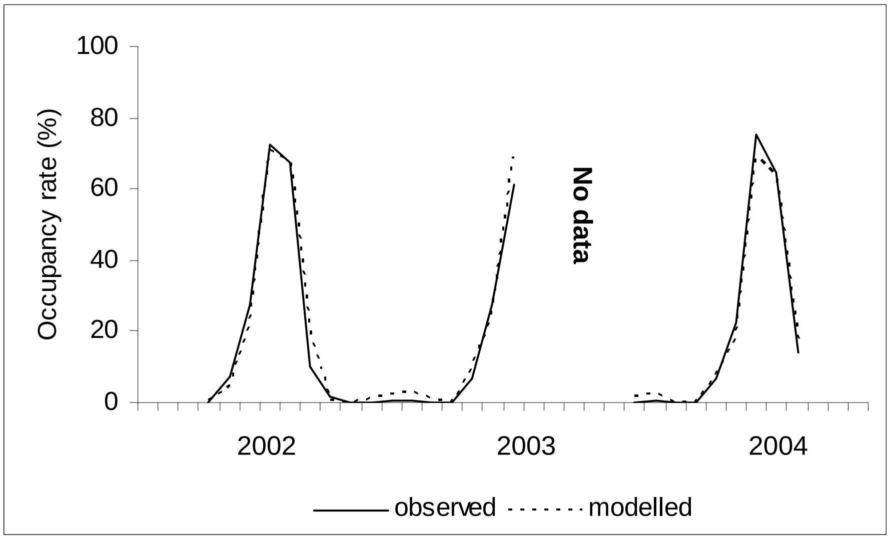

Figure 3.9 Observed and modelled monthly campground occupancy rates at Philippe Lake

Park Visitation Levels

As described earlier, no source of reliable daily or monthly visitation data for Gatineau Park were available. This prompted the use of Fitzroy Provincial Park as a proxy for the relationship between climate and Gatineau Park visitation. Initial stepwise regression analysis of monthly visitation data received from the Ontario Ministry of Natural Resources resulted in a one-variable model ($r^2 = 0.70$; $p<0.005$). Minimum temperature (t-statistic = 13.47) was the strongest predictor of monthly visitors to Fitzroy Provincial Park. Figure 3.10 illustrates the linear regression relationship between mean monthly minimum temperature and monthly visitors during the 1989 to 2003 operating seasons. Although the linear relationship between minimum temperature and visitor demand is relatively strong, it is evident from Figure 3.10 that the relationship is not completely linear. Similar to the golf analysis, an important limitation of the initial linear model was that it continued to project an increase in visitors as minimum temperatures increased. To address these issues, a cubic regression analysis was performed on minimum temperature ($r^2 = 0.82$, $p<0.005$) (Figure 3.10).

The cubic regression model of visitor demand developed for Fitzroy Provincial Park and used as a proxy for Gatineau Park in this study was as follows:

$$\textit{Monthly park visitors} = 14.572x^3 - 222.208x^2 + 1505.460x - 249.170$$

Similar to the golf and camping models, the visitor model for Fitzroy Provincial Park was truncated at 0^{o}C because demand during the observed months of May to October declined to zero when minimum temperatures were less than this threshold. A comparison of the observed and modelled monthly visitors at the provincial park revealed that the cubic regression model performed well over the 13 seasons for which data were available. Figure 3.11 illustrates observed and modelled values for the last four years.

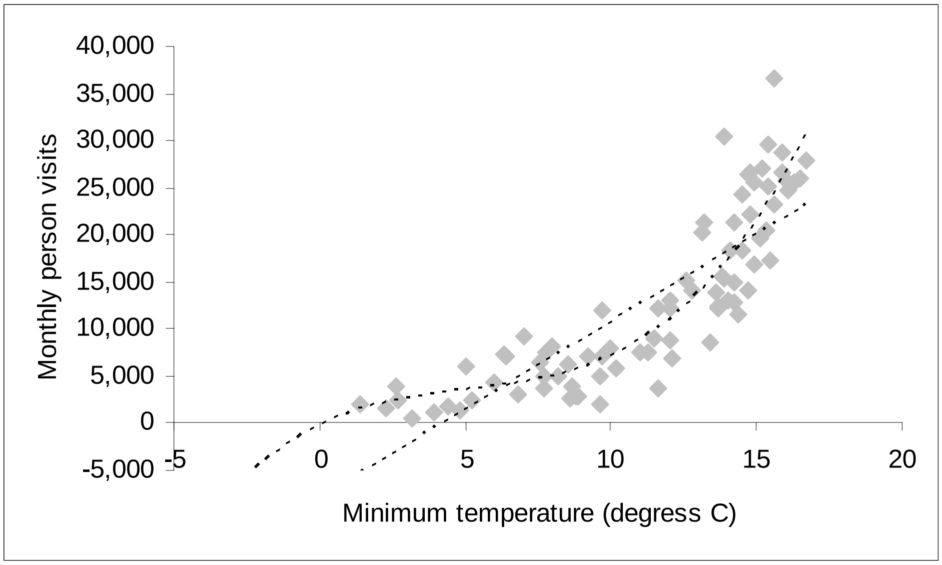

Figure 3.10 Linear and cubic regression models for Fitzroy Provincial Park

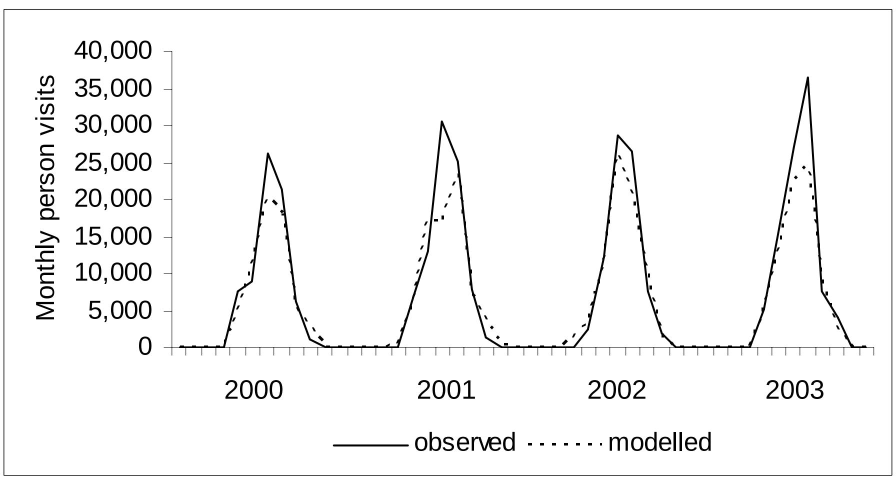

Figure 3.11 Observed and modelled monthly visitors to Fitzroy Provincial Park (2000–2003)

3.2 CLIMATE CHANGE IMPACT ASSESSMENT

In Chapter One, the vulnerability of recreation and tourism in the National Capital Region to climate variability was explored along with some of the adaptive strategies that officials with the National Capital Commission have used to reduce the impacts of adverse climatic conditions. This section examines how the vulnerability of various recreation and tourism activities in the National Capital Region may change under a range of climate change scenarios. A detailed analysis of the projected impacts of climate change on the three main tourism events that the National Capital Commission is responsible for planning (Winterlude, Canadian Tulip Festival and Canada Day) is presented first. The results of the climate change impact assessment for winter and warm-season recreation in Gatineau Park and on other NCC lands concludes the section.

3.2.1 Tourism Event Planning

Winterlude

Rideau Canal Skateway — Skating Season

Post-event evaluation surveys over the last 15 years indicate that Winterlude is critical to the National Capital Region's tourism economy. More than 50% of respondents in each survey indicated that Winterlude was their main reason for coming to the Ottawa area during the month of February (Coopers & Lybrand Consulting, 1988b; Gallup Canada, 1991; Ekos Research Associates, 1994, 2000). The results of the climate change impact assessment suggest that it will become increasingly challenging to provide many of the most popular Winterlude attractions under a warmer climate.

The Rideau Canal Skateway is the quintessential symbol of winter in the National Capital Region, and is considered the primary attraction at Winterlude (Coopers & Lybrand Consulting, 1988b; Gallup Canada, 1991; Ekos Research Associates, 1994, 2000). The climate change scenarios, however, consistently indicated a trend toward shorter operating seasons. Table 3.1 illustrates that the number of days the Skateway is open to the public is projected to decline substantially under the three climate change scenarios. The average operating season is projected to decrease between 14.7% (NCARPCM B21) and 29.4% (CCSRNIES A11) by the 2020s. In the 2050s, the projected decrease in season length ranges from 19.4% in the least-change scenario (NCARPCM B21) to 67.3% in the warmest scenario (CCSRNIES A11). Two of the 2050s scenarios projected that the Skateway would be operational for only three to four weeks at most. The winter season of 2001/02 in which the Skateway operated for only 34 days serves as an important analogue for what the National Capital Commission could expect to become normal winter canal operations in the 2050s. In the 2080s, the warmest scenario (CCSRNIES A11) projected that the Skateway's average operating season will be reduced to just one week, while the least-change scenario still projected an average 42-day operating period.

Season length of the Rideau Canal Skateway is primarily determined by when it opens. If the Skateway is opened to the public earlier than the traditional period between Christmas Eve Day and New Year's Day, it could have a longer season than if it opens sometime in January. All three climate change scenarios projected a trend toward later opening dates (Table 3.1). The average opening day for the Skateway is projected to occur between January 7 (NCARPCM B21) and January 12 (CCSRNIES A11) in the 2020s, six to nine days later than the current average. In the 2050s, little change in the opening day occurs under the least-warming scenario

(NCARPCM B21), but the projected change is much more pronounced in the warmest scenario (CCSRNIES A11) where the canal is projected to remain closed, on average, until January 23. The additional projected warming by the 2080s does not affect the opening date under the least-change scenario. Under the warmest scenario (CCSRNIES A11), however, it is projected that on average the Skateway will likely not open until the start of Winterlude.

Table 3.1 Projected changes in operation of the Rideau Canal Skateway

	1961–90	2020s		2050s		2080s	
	(Days)	Days	%Δ	Days	%Δ	Days	%Δ
		Climate change scenarios for season length					
Current average	**61**						
NCARPCM B21		52	-14.7%	49	-19.4%	42	-30.3%
ECHAM4 A21		46	-24.8%	34	-44.3%	25	-59.5%
CCSRNIES A11		43	-29.4%	20	-67.3%	8	-87.0%
		Climate change scenarios for opening day					
	(Opening day)	Opening Day	Days later	Opening Day	Days later	Opening Day	Days later
Current average	**Jan 1**						
NCARPCM B21		Jan 7	+6	Jan 7	+6	Jan 12	+11
ECHAM4 A21		Jan 9	+8	Jan 18	+17	Jan 20	+19
CCSRNIES A11		Jan 10	+9	Jan 23	+22	Jan 29	+28

Other Winterlude Attractions

Although the Rideau Canal Skateway is considered the most popular attraction at Winterlude, there are numerous other activities for locals and visitors including ice sculptures and the Snowflake Kingdom. The success of many of these activities is partially dependent on temperature. For example, people tend to spend more time outdoors at Winterlude's attractions when it is mild rather than when temperatures are in the -30s. However, the same mild temperatures that can bring more people out to Winterlude can also negatively affect the attractions they come to see (*e.g.,* melt ice sculptures and snow slides).

The suitability of climatic conditions for these other Winterlude attractions was also examined. Table 3.2 summarizes the projected mean daily maximum and minimum temperatures during the 21 days of Winterlude under the three climate change scenarios. The current (1961-90) normal maximum temperatures during Winterlude is -5.4^{o}C and the mean minimum temperature is -15.3^{o}C. By the 2020s, it was projected that maximum temperatures would increase 1.7^{o}C (NCARPCM B21) to 2.3^{o}C (CCSRNIES A11) above the 1961-90 baseline. By the 2050s, the increase ranged between 5.4^{o}C (NCARPCM B21) and 6.9^{o}C (CCSRNIES A11). Under the warmest (CCSRNIES A11) and middle of the road (ECHAM4 A21) scenarios, average maximum temperatures during Winterlude would be above 0^{o}C in the 2080s. Since most Winterlude activities occur during the day, these changes will likely negatively affect the quality of many Winterlude attractions and visitor satisfaction in the future.

Table 3.2 Projected mean maximum and minimum temperatures during Winterlude

	1961–90	2020s	2050s	2080s
		Climate change scenarios for mean maximum temperature		
Current average	**-5.4 °C**			
NCARPCM B21		-3.7 °C	-2.8 °C	-2.1 °C
ECHAM4 A21		-3.4 °C	-1.3 °C	0.7 °C
CCSRNIES A11		-3.1 °C	-1.5 °C	4.1 °C
		Climate change scenarios for mean minimum temperature		
Current average	**-15.3 °C**			
NCARPCM B21		-12.9 °C	-12.0 °C	-11.4 °C
ECHAM4 A21		-12.6 °C	-10.5 °C	-8.5 °C
CCSRNIES A11		-12.3 °C	-7.8 °C	-5.1 °C

Temperature plays an important role in human comfort, and as a result, it can have a significant impact on the level of participation in outdoor recreation activities. Officials with the National Capital Commission cited a number of temperature-related 'comfort' conditions that influence people's participation at Winterlude. For example, people tend not to take in attractions at temperatures in the -30s, while values in the -20s are often still considered too cold for many visitors. Temperatures between -10°C and -20°C are considered ideal for maintaining attractions and getting people to come out to visit them. Temperatures above 0°C are even better for attendance, but at this threshold, the negative effect on the quality of experience is strong as attractions begin to deteriorate.

Table 3.3 summarizes the projected number of days during Winterlude with three maximum temperature thresholds[4]. Comparison of the three temperature thresholds suggested that thermal comfort conditions would likely become more favourable under climate change as the occurrence of days with maximum temperatures between -20°C and -10°C were projected to substantially decline. The average number of days between -20°C and -10°C was projected to be three in the 2020s under all three climate change scenarios, and be reduced by at least half in the in the 2050s. In the 2080s, it was projected that, on average, only two of the 21 days would fall in this range. By comparison, the number of days during Winterlude that are above 0°C was projected to substantially increase. The improvement in thermal conditions during the day may entice more people to participate in Winterlude, but it would also likely negatively affect the attractions people come out to see. The warmer conditions were projected to become more prominent in the 2050s, with one (NCARPCM B21) to seven (NCARPCM B21) additional days projected to be above 0°C. Under the two warmest scenarios, the average number of days above 0°C in the 2080s was projected to be 11 and 15, respectively, which represents a 120% to 200% increase over the 1961–90 baseline.

[4] Analysis of baseline conditions found that, on average, there was less than one day with temperatures colder than -20°C. Further discussion was therefore excluded.

Table 3.3 Projected changes in maximum temperatures during Winterlude

	1961–90	**2020s**	**2050s**	**2080s**
	(Days)	(Days)	(Days)	(Days)
		Climate change scenarios for maximum temperature (-20°C to -10°C)		
Current average	**5**			
NCARPCM B21		3	2	2
ECHAM4 A21		3	1	1
CCSRNIES A11		3	1	0
		Climate change scenarios for maximum temperature (-10°C to 0°C)		
Current average	**11**			
NCARPCM B21		12	12	12
ECHAM4 A21		12	11	9
CCSRNIES A11		12	8	5
		Climate change scenarios for maximum temperature (>0°C)		
Current average	**5**			
NCARPCM B21		5	6	7
ECHAM4 A21		5	8	11
CCSRNIES A11		6	12	15

Popular attractions during Winterlude are the ice sculptures, which are designed and carved by master ice-carvers from around the world. A number of post-Winterlude evaluation surveys conducted for the National Capital Commission revealed that participants tended to be very satisfied with the ice sculpture displays and would like to see the attraction continue (Coopers & Lybrand Consulting, 1988b; Gallup Canada, 1991; Ekos Reseach Associates, 2000). Officials with the National Capital Commission suggested that temperatures colder than -5°C are a minimum threshold for maintaining the ice sculptures. Table 3.4 summarizes the projected number of days during the 21 days of Winterlude with daily maximum temperatures colder than -5°C, between -5°C and +5°C, and warmer than +5°C. When the three temperature thresholds were compared, it was apparent that the ice sculptures might become increasingly vulnerable to climate change as the occurrence of days with maximum temperatures colder than -5°C are projected to decline considerably. In the 2020s, it was projected that between one (NCARPCM B21) and two (CCSRNIES A11) fewer days would be colder than -5°C, while two (NCARPCM B21) to seven (CCSRNIES A11) fewer days would occur in the 2050s. In the 2080s, two of the three climate change scenarios projected that days suitable for maintaining ice sculptures would be reduced by one-half.

The number of days above +5°C during the 21 days of Winterlude was projected to increase significantly, which would create additional challenges for preventing the ice sculptures from melting. Two of the climate change scenarios (ECHAM4 A21 and CCSRNIES A11) projected a doubling in the number of days warmer than +5°C during Winterlude as early as the 2020s. By the 2050s, the projected increase ranged from twice as many days (NCARPCM B21) to five times as many days (CCSRNIES A11). Under the two warmest climate change scenarios, the average number of days warmer than +5°C was projected to be five and nine by the 2080s, respectively, which is a 400% to 800% increase over the 1961–90 baseline.

Table 3.4 Projected daily maximum temperatures during Winterlude

	1961–90	**2020s**	**2050s**	**2080s**
	(Days)	(Days)	(Days)	(Days)
		Daily maximum temperatures (<-5°C)		
Current average	**10**			
NCARPCM B21		9	8	7
ECHAM4 A21		8	5	4
CCSRNIES A11		8	3	1
		Daily maximum temperatures (-5°C to +5°C)		
Current average	**10**			
NCARPCM B21		11	11	12
ECHAM4 A21		11	12	13
CCSRNIES A11		11	12	10
		Daily maximum temperatures (> +5°C)		
Current average	**1**			
NCARPCM B21		1	2	3
ECHAM4 A21		2	3	5
CCSRNIES A11		2	5	9

Many of Winterlude's attractions require snow. The snow slides at Snowflake Kingdom in Jacques Cartier Park, for example, require a large volume of snow. Table 3.5 summarizes the average daily natural snow depth during the 21 days of Winterlude, which demonstrates a trend toward less natural snow in the Ottawa region under climate change. In the 2020s, average snow depths were projected to decline between 13.3% (NCARPCM B21) and 36.7% (CCSRNIES A11) from a baseline of 30 centimetres. In the 2050s and 2080s, the two warmest climate change scenarios projected daily snow depths, on average, would be less than 10 centimetres. As a result, it is likely that without adaptations such as snowmaking there will be insufficient natural snow to sustain some of Winterlude's attractions.

Table 3.5 Projected natural daily snow depths during Winterlude

	1961–90	**2020s**		**2050s**		**2080s**	
	(cm)	(cm)	%Δ	(cm)	%Δ	(cm)	%Δ
Current average	**30**						
NCARPCM B21		26	-13.3%	24	-20.0%	17	-43.3%
ECHAM4 A21		18	-40.0%	9	-70.0%	5	-83.3%
CCSRNIES A11		19	-36.7%	4	-86.7%	2	-93.3%

In the past, snowmaking has been employed by the National Capital Commission to sustain Snowflake Kingdom during Winterlude's unseasonably warm periods. Table 3.6 summarizes the impact of climate change on the number of days suitable for snowmaking before and during Winterlude. With current technology, snowmaking is feasible at temperatures colder than -5°C, but is generally considered most efficient at temperatures colder than -10°C. Analysis of daily minimum temperatures suggested that snowmaking would still be possible in the future, but the number of days defined as being most efficient (*i.e.*, colder than -10°C) was reduced under climate change. In the period before Winterlude, the least-change scenario (NCARPCM B21) projected little change (<20%) in the number of days with minimum temperatures colder than -10^{o}C in either the 2020s or 2050s. This means that snow could still be made and stockpiled during these periods as required. The two warmer climate change scenarios projected a reduction of 32% in the 2020s, and at least 50% in the 2050s.

Table 3.6 Projected snowmaking days before and during Winterlude

	One month before Winterlude (Days)				**During Winterlude** (Days)			
	1961–90	**2020s**	**2050s**	**2080s**	**1961–90**	**2020s**	**2050s**	**2080s**
		Daily minimum temperatures (<= -5^{o}C)				**Daily minimum temperatures (<= -5^{o}C)**		
Current average	**29**				**19**			
NCARPCM B21		28	27	25		19	18	17
ECHAM4 A21		24	20	17		18	16	15
CCSRNIES A11		25	21	17		18	14	10
		Daily minimum temperatures (<= -10^{o}C)				**Daily minimum temperatures (<= -10^{o}C)**		
Current average	**25**				**5**			
NCARPCM B21		22	21	17		3	2	2
ECHAM4 A21		17	13	9		3	2	1
CCSRNIES A11		17	9	6		3	1	0

The results of the climate change impact assessment suggested that more snow will be needed to sustain some of Winterlude's attractions in the future, but it would become increasingly difficult for event organizers to utilize snowmaking. All three climate change scenarios projected a reduction of 40% (compared to the 1961–90 average) in days with temperatures colder than -10^{o}C during the event as early as the 2020s, and a reduction of 60% by the 2050s. In the 2080s, optimal conditions for efficient snowmaking were reduced even further, and were eliminated in the warmest scenario (CCSRNIES A11). The reduced number of days available for snowmaking, especially in the warmer climate change scenarios, can be compensated for by increasing snowmaking capacity when climatic conditions are more suitable (*e.g.*, increase the number of operating snow guns).

One final Winterlude attraction examined in this study was the Keskinada Loppet Nordic ski race. Each year, approximately 2,000 Nordic skiers race through a 25, 35 or 55-kilometre course, usually on the last weekend of Winterlude. Since it is impossible to project what climatic conditions will be like on a specific weekend, this study examined snow conditions for the three-week period (February 1 to 21) during Winterlude. Two snow depth thresholds were examined: 15 centimetres, representing the depth required for setting a regulation ski track, and eight centimetres that would allow the event to take place with a modified non-regulation track.

Table 3.7 summarizes the number of days during Winterlude projected to have at least a 15 and an eight-centimetre base of snow for the three future time periods. If the Loppet race required at least 15 centimetres of snow to be operational, all three climate change scenarios projected that this condition would continue to be met in the 2020s. The least-change scenario (NCARPCM B21) projected four fewer days during Winterlude with a 15-centimetre snow base in the 2050s and 2080s. By comparison, the two warmer climate change scenarios (ECHAM4 A21 and CCSRNIES A11) projected that there would be less than 15 centimetres of snow on the ground throughout Winterlude during the same time periods. If either of the warmer climate change scenarios is realized, the Keskinada Loppet Nordic ski race would be jeopardy as early as the 2050s.

Table 3.7 Projected number of days with 8 and 15-centimetre snow depths during Winterlude

	1961–90	**2020s**	**2050s**	**2080s**
	(Days)	(Days)	(Days)	(Days)
		Climate change scenarios for 15 centimetres (regulation track)		
Current average	**21**			
NCARPCM B21		21	17	17
ECHAM4 A21		16	0	0
CCSRNIES A11		20	0	0
		Climate change scenarios for 8 centimetres (non-regulation track)		
Current average	**21**			
NCARPCM B21		21	21	21
ECHAM4 A21		21	14	0
CCSRNIES A11		21	0	0

If organizers and participants in the Keskinada Loppet Nordic ski race are willing to conduct the event with a non-regulation classic Nordic ski track, then the race will be less affected by climate change. Each of the three climate change scenarios projected that the 21 days of Winterlude will continue to have eight centimetres of snow in the 2020s. The least-change scenario (NCARPCM B21) projected 21 days with an eight-centimetre snow base in the 2050s and 2080s as well. The two warmer climate change scenarios projected substantial reductions in the number of days with at least eight centimetres of snow on the ground. As early as the 2050s, the warmest scenario (CCSRNIES A11) projected that snow conditions would be unsuitable to hold the race. Both scenarios projected zero days with suitable snow conditions in the 2080s.

Canadian Tulip Festival

Tulips are among the first spring flowers to emerge from the ground and bloom, thus providing an early indication of changing seasons and climate conditions. Staff with the Environment, Capital Lands and Parks Branch of the National Capital Commission plant hundreds of thousands of tulip bulbs each fall across the region for bloom the following May as part of the National Capital Region’s annual Canadian Tulip Festival. The Canadian Tulip Festival is the largest festival of spring flowers in the world with more than one million blossoms gracing the National Capital Region each May. It is also the second largest tourism event in the National Capital Region after Winterlude in terms of visitors and tourism-related benefits to the local economy (Coopers & Lybrand Consulting, 1988a).

Tulips are very climate sensitive, and staff with the National Capital Commission has undertaken strategies to delay their growth when spring conditions are unseasonably warm so that peak bloom occurs during May. This section explores how the vulnerability of the National Capital Region’s Canadian Tulip Festival may change under climate change. Using a range of temperature and phenology thresholds, changes in the suitable conditions for the growth and development of tulips in the Ottawa region were projected with specific attention being given to the timing of the tulips' first emergence from the ground and peak bloom. The results associated with each threshold type are discussed below.

Air Temperatures

As mentioned earlier, three air-temperature thresholds were considered in this study with respect to tulips. These included the mean maximum and mean minimum daily temperature during the two-week period before the start of the Festival (April 16 to 30), the mean daily maximum temperature during the three-week festival (May 1 to 21), and the number of days in the two-week period before the Festival and during the Festival with frost.

Analysis of air temperatures revealed important changes in climatic conditions suitable for the growth and development of tulips under climate change. Table 3.8 demonstrates the projected maximum and minimum temperatures in Ottawa during the two weeks leading up to the Festival. The current average maximum temperature in the two weeks before the Festival is 13.7^{o}C. The mean maximum temperature was projected to increase between 1.0^{o}C (NCARPCM B21) and 4.0^{o}C (CCSRNIES A11) over the 1961–90 baseline by the 2020s. In the 2050s, mean maximum temperature in the two weeks before the Festival increased 1.5^{o}C (NCARPCM B21) and 4.7^{o}C (CCSRNIES A11). Under the warmest climate change scenario, the average maximum temperature in the two weeks before the Festival was projected to be 23.2^{o}C, almost 10^{o}C warmer than current baseline conditions.

The projected magnitude of change in minimum temperatures was similar to the change in maximum temperatures. However, minimum temperatures may have a greater impact on the development of tulips as it regulates initial growth. By the 2020s, the mean minimum temperature in the two weeks before the Festival was projected to range from 3.3^{o}C (NCARPCM B21) to 6.2^{o}C (CCSRNIES A11), a 0.9^{o}C and 3.8^{o}C increase over the 1961-90 baseline, respectively. Projected minimum temperatures, on average, increased between 1.4^{o}C (NCARPCM B21) and 7.4^{o}C (CCSRNIES A11) in the 2050s. Under further warming, it was projected that the mean minimum temperature would be 9.3^{o}C above the 1961–90 baseline in the 2080s under the warmest climate change scenario (CCSRNIES A11).

Table 3.9 summarizes the projected changes in daily maximum temperature under climate change between May 1 and 21. There was little or no projected change in the number of days with maximum temperatures cooler than 10^{o}C or below 15^{o}C under the least-change scenario (NCARPCM B21) in the 2020s. Under the warmest climate change scenario (CCSRNIES A11), there was a 50% reduction in the number of days with maximum temperatures below 10^{o}C and a 60% reduction in the number of days below 15^{o}C. In the 2050s and 2080s, the two warmest climate change scenarios projected a further reduction in the number of days during the Festival with maximum temperatures below 10^{o}C and 15^{o}C.

Table 3.8 Projected temperatures two weeks before the Canadian Tulip Festival

	1961–90	2020s	2050s	2080s
		Climate change scenarios for maximum temperature		
Current average	**13.7 ^{o}C**			
NCARPCM B21		14.7 ^{o}C	15.2 ^{o}C	16.2 ^{o}C
ECHAM4 A21		15.3 ^{o}C	17.4 ^{o}C	18.8 ^{o}C
CCSRNIES A11		17.7 ^{o}C	21.4 ^{o}C	23.2 ^{o}C
		Climate change scenarios for minimum temperature		
Current average	**2.4 ^{o}C**			
NCARPCM B21		3.3 ^{o}C	3.8 ^{o}C	4.8 ^{o}C
ECHAM4 A21		3.9 ^{o}C	6.0 ^{o}C	7.4 ^{o}C
CCSRNIES A11		6.2 ^{o}C	9.8 ^{o}C	11.7 ^{o}C

Daytime highs in the low to mid-20s tend to shorten tulip blooming periods. Analysis of daytime temperatures during the Festival revealed that days with maximum temperatures warmer than 20^{o}C would become more common in the National Capital Region under climate change. The NCARPCM B21 scenario projected one additional day during the Festival with maximum temperatures warmer than 20^{o}C (with respect to the 1961–90 average) in the 2020s, while the CCSRNIES A21 scenario projected an additional seven. In the 2050s, the projected increase in the number of days with maximum temperatures warmer than 20^{o}C ranged between two (NCARNIES B21) and ten (CCSRNIES A21). In the 2080s, the warmest climate change scenario projected that most of the 21 Festival days would be warmer than 20^{o}C.

Table 3.9 Projected mean maximum temperatures during the Canadian Tulip Festival

	1961–90	2020s	2050s	2080s
	(Days)	(Days)	(Days)	(Days)
		Daily maximum temperature (<10^{o}C; above 0^{o}C)		
Current average	**2**			
NCARPCM B21		2	2	1
ECHAM4 A21		1	1	1
CCSRNIES A11		1	0	0
		Daily maximum temperature (10.1^{o}C to 15^{o}C)		
Current average	**5**			
NCARPCM B21		5	4	3
ECHAM4 A21		4	3	2
CCSRNIES A11		2	1	0
		Daily maximum temperature (15.1^{o}C to 20^{o}C)		
Current average	**7**			
NCARPCM B21		7	7	7
ECHAM4 A21		7	7	6
CCSRNIES A11		5	4	2
		Daily maximum temperature (>20^{o}C)		
Current average	**6**			
NCARPCM B21		7	8	10
ECHAM4 A21		8	10	12
CCSRNIES A11		13	16	18

Frost also has a detrimental effect on tulips as it can cause blossoms to shrivel prematurely. Table 3.10 illustrates the projected change in days with frost (minimum temperature at least or colder than $0^{o}C$) during the two weeks before the Festival. The occurrence of frost during the Tulip Festival was also examined, but on average only one day per year in the 1961-90 baseline experienced frost, so no further discussion is provided here. Currently, in the 14 days before the official start of the Tulip Festival, frost occurs on an average of four days. In the 2020s, only two (CCSRNIES A21) to three (NCARPCM B21) days are projected to experience frost. Under further warming, only two days during the two weeks before the Festival on average are projected to experience frost under the least-change scenario in the 2050s and 2080s. Under the warmest climate change scenario, the average number of days with frost was projected to be eliminated as early as the 2050s.

Table 3.10 Projected number of frost days in the two weeks before the Canadian Tulip Festival

	1961–90	**2020s**	**2050s**	**2080s**
	(Days)	(Days)	(Days)	(Days)
Current average	**4**			
NCARPCM B21		3	3	2
ECHAM4 A21		3	1	1
CCSRNIES A11		1	0	0

Growing Degree Days

Growing degree days were the second type of threshold employed in this study to examine the vulnerability of the Canadian Tulip Festival to climate change. A minimum of 20 growing degree days was used to define when tulips would first emerge from the ground, while the timing of full bloom was defined as more than 120 growing degree days. The results of the climate change impact assessment on growing degree days suggest that tulips would likely be sprouting and blooming much earlier under a warmer climate. This pattern corresponds with those projected with respect to air temperatures (Table 3.11).

The current average date of the spring emergence of tulips (GDD>20) in Ottawa is Julian day 107 (or approximately April 17). Under a warmer climate, tulips were projected to emerge from the ground, on average, 10 (NCARPCM B21) to 24 (CCSRNIES A11) days earlier in the 2020s. The first appearance of tulips was projected to be even earlier in the 2050s. Under the least-change scenario (NCARPCM B21), tulips were projected to appear, on average, 12 days earlier than current conditions. Under the warmest climate change scenario (CCSRNIES A11), tulips were projected to emerge 54 days earlier, placing the date for this event close to the end of February (Julian day 53). By the 2080s, the two warmer climate change scenarios projected that tulips would emerge before the end of March (ECAHM4 A21 and CCSRNIES A11); the warmest scenario projects that emergence would occur around the beginning of February, 75 days earlier than 1961-90 baseline conditions.

The current average date of peak bloom (GDD>120) in the Ottawa is around Julian day 129 (approximately May 9), although adaptation strategies by National Capital Commission officials have been used to shift the peak bloom closer mid-May. The results of the climate change impact assessment suggest that peak bloom would also occur much earlier. The average date of peak bloom was projected to be five (NCARPCM B21) to 16 (CCSRNIES A11) days earlier in the

2020s, placing peak bloom closer to mid-April. In the 2050s, the occurrence of peak bloom was projected to be seven days earlier under the least-change scenario (NCARPCM B21) and, on average, 31 days earlier under the warmest climate change scenario (CCSRNIES A11). It was projected that additional warming by the 2080s would contribute to even earlier peak bloom periods, with all climate change scenarios suggesting that this event would occur before April 1. Under the warmest climate change scenario (CCSRNIES A11), it was projected that peak bloom in the 2080s would occur near the end of March.

Table 3.11 Projected dates of tulip emergence and full bloom[a] in the Ottawa region

	1961–90 Julian Day	**2020s**		**2050s**		**2080s**	
		Julian Day	Days earlier	Julian Day	Days earlier	Julian Day	Days earlier
		Climate change scenarios for the date of first emergence (GDD>20)					
Current average	**107 (Apr 17)**						
NCARPCM B21		97 (Apr 7)	-10	95 (Apr 5)	-12	86 (Mar 27)	-21
ECHAM4 A21		87 (Mar 28)	-20	74 (Mar 15)	-33	57 (Feb 26)	-50
CCSRNIES A11		83 (Mar 24)	-24	53 (Feb 22)	-54	32 (Feb 1)	-75
		Climate change scenarios for the date of peak bloom (GDD>120)					
Current average	**129 (May 9)**						
NCARPCM B21		124 (May 4)	-5	122 (May 2)	-7	118 (Apr 28)	-11
ECHAM4 A21		120 (Apr 30)	-9	112 (Apr 22)	-17	104 (Apr 14)	-25
CCSRNIES A11		113 (Apr 23)	-16	98 (Apr 18)	-31	85 (Mar 26)	-44

[a] GDD, base 5^{o}C

Canada Day

Event planners with the National Capital Commission routinely prepare for a range of emergency scenarios during Ottawa's Canada Day celebrations, including heat emergencies. Contingency plans for heat-emergencies typically involve public education prior to the event, and having cooling systems and medical staff available on Canada Day to treat individuals who experience heat-related stress. Due to the difficulties in projecting future climatic conditions on a single day, two heat stress indicators were assessed (mean temperature and days with maximum temperatures greater than or equal to 30^{o}C) for the two weeks surrounding July 1.

Climate change scenarios projected climatic conditions around July 1 would become warmer, potentially leading to higher occurrences of heat-related discomfort among participants at Canada Day celebrations. Table 3.12 presents the average mean temperature and the number of days warmer than 30^{o}C during the two weeks surrounding Canada Day. Mean temperature was projected to increase 1.5^{o}C (NCARPCM B21) to 2.6^{o}C (CCSRNIES A11) in the 2020s over the current mean temperature of 19.7°C. In the 2050s, mean temperatures were projected to range between 21.7°C (NCARPCM B21) and 24.6°C (CCSRNIES A11). Under the warmest climate change scenario (CCSRNIES A11), the average mean temperature in the two weeks surrounding July 1 was projected to be 26.3°C in the 2080s, 6.6°C warmer than current baseline conditions.

Table 3.12 Projected temperature change in the two weeks surrounding July 1 in the Ottawa region

	1961–90	**2020s**	**2050s**	**2080s**
		Climate change scenarios for mean temperature		
Current average	**19.7 °C**			
NCARPCM B21		21.2 °C	21.7 °C	22.1 °C
ECHAM4 A21		21.4 °C	23.2 °C	24.9 °C
CCSRNIES A11		22.3 °C	24.6 °C	26.3 °C
		Climate change scenarios for maximum temperature (>=30°C)		
	(Days)	(Days)	(Days)	(Days)
Current average	**2**			
NCARPCM B21		3	3	4
ECHAM4 A21		4	5	8
CCSRNIES A11		4	8	10

A dry bulb temperature of 30°C was used as heat-related comfort threshold in this study to assess changes in the need for emergency support at Canada Day celebrations. Comparison of the projected changes in the number of days with maximum daily temperatures equal to or greater than 30°C suggests that this thermal condition will become more common in the period surrounding Canada Day (Table 3.12). One to two additional days in the 14 days around July 1 were projected to have maximum temperatures equal to or greater than 30°C in the 2020s. In the 2050s, on average, at least one-half of the 14 days were projected meet this threshold under warmest climate change scenario (CCSRNIES A11). With additional warming, it was projected that the number of days in the two weeks surrounding July 1 would double under the least-change climate change scenario (NCARPCM B21) in the 2080s; under the two warmest scenarios (ECHAM A21 and CCSRNIES A11) most of the 14 days will experience temperatures of at least 30°C in the 2080s.

3.2.2 Gatineau Park and Other NCC Lands

The National Capital Commission maintains an extensive network of parkland and urban green spaces in the National Capital Region, including some 36,000 hectares in Gatineau Park. These properties provide a wealth of recreation resources such as Nordic skiing trails, hiking trails, public beaches and campgrounds. The vulnerability of winter and warm-season recreation in Gatineau Park and on other lands operated by the National Capital Commission under climate change was examined in this study to determine where risks and opportunities may exist. The impact of climate change on the physical resources and seasons for skiing, golf, camping and beach use are examined in this section. Also examined are the projected changes in visitor demand in Gatineau Park, a popular year-round destination in the National Capital Region.

Skiing
Alpine Skiing

Camp Fortune is the primary alpine skiing destination in the National Capital Region. Located in the heart of Gatineau Park, Camp Fortune has 20 trails and typically operates between December and March. Analysis of the snow regime in the National Capital Region revealed important changes under the three climate change scenarios. The assessment suggested that the business environment for alpine skiing will become increasingly challenging under climate change, with the overall trend being towards shorter ski seasons and increased snowmaking costs resulting from reductions in natural snow.

Like many ski areas in Ontario, Camp Fortune has adapted to climate variability by investing in snowmaking technology. The ski area has the capacity to cover all its skiable terrain with machine-made snow, allowing it to open earlier in the season and extend the season into late March. Using the ski season model developed by Scott *et al.* (2002, 2005), which incorporates current snowmaking technology, the average ski season at Camp Fortune during the 1961–90 baseline period was approximately 146 days (~21 weeks) (Table 3.13). Snowmaking is also important for reducing the vulnerability of the alpine ski industry in the National Capital Region to climate change. With current snowmaking technology, projected reductions in the average ski season ranged between 4.0% (NCARPCM B21) and 16.2% (CCSRNIES A11) in the 2020s and between 7.7% (NCARPCM B21) and 41.4% (CCSRNIES A11) in the 2050s. By the 2080s, it was projected that the average ski season would be between 63 days (CCSRNIES A11; a 56.5% reduction) and 111 days (NCARPCM B21; a 10.5% reduction).

Table 3.13 Projected season length of alpine skiing in the Ottawa region

	1961–90 (days)	**2020s**		**2050s**		**2080s**	
		Days	%∆	Days	%∆	Days	%∆
Current average	**146**						
NCARPCM B21		140	-4.0%	135	-7.7%	111	-10.5%
ECHAM4 A21		133	-9.2%	114	-19.9%	103	-29.5%
CCSRNIES A11		122	-16.2%	86	-41.4%	63	-56.5%

Maintaining the ski seasons at Camp Fortune under increasing climate change will come at a cost, in the form of increased snowmaking. Table 3.14 illustrates the amount of snowmaking (cm) required to maintain the season lengths in Table 3.13 increases substantially as the magnitude of climate change increases. Assuming no change in current snowmaking technology, the amount of snow required to maintain ski seasons increased approximately 15% (NCARPCM B21) to 35% (CCSRNIES A11) in the 2020s. By the 2050s, the amount of machine-made snow was projected to increase 20% (NCARPCM B21) to 103% (CCSRNIES A11) of baseline requirements. With additional warming by the 2080s, the warmest scenario (CCSRNIES A11) projected a 128% increase in snowmaking requirements over the 1961-90 baseline. Snowmaking represents a significant proportion of the annual operating expenses at Camp Fortune, and it remains uncertain as to how these increases will affect the profitability of the ski area.

Table 3.14 Projected snowmaking requirements in the Ottawa region

	1961–90	2020s		2050s		2080s	
	(cm)	cm	%△	cm	%△	cm	%△
Current average	98						
NCARPCM B21		113	+15%	118	+20%	133	+36%
ECHAM4 A21		130	+32%	164	+67%	198	+102%
CCSRNIES A11		132	+35%	199	+103%	223	+128%

Nordic Skiing

In contrast to alpine skiing, Nordic skiing generally requires less snow to be operational. However, unlike alpine skiing where snowmaking can be efficiently concentrated to provide an adaptation to climate variability, the linear nature and large distances of Nordic ski trails in the National Capital Region pose a significant barrier to the widespread implementation of snowmaking systems. As a result, the Nordic ski sector in the National Capital Region remains reliant on natural snowfall, making it more vulnerable to climate change.

With the natural snow pack being reduced by projected climatic changes, Nordic skiing was found to be more vulnerable to climate change than alpine skiing. Table 3.16 summarizes the season length of Nordic skiing in Gatineau Park. Season length was calculated from November 1 to March 31 based on a 15-centimetre snow depth, which accommodates a regulation five-centimetre track setter used to groom trails. The current Nordic ski season in Gatineau Park averages about 94 days. The average Nordic ski season was projected to be reduced between 13.8% (NCARPCM B21) and 48.9% (CCSRNIES A21) by the 2020s. Season length was projected to be reduced by half under the least-change scenario (NCARPCM B21) in the 2050s; under the warmest scenario (CCSRNIES A11) a Nordic skiing season was no longer feasible. Two of the three scenarios projected a complete loss of the Nordic ski season (ECHAM4 A21 and CCSRNIES A11) from Gatineau Park by the 2080s.

A regulation (5 centimetres) Nordic track setter requires a 15-centimetre snow base to be operational. Officials with the National Capital Commission have developed an additional non-regulation (2.5 centimetres) track setter than requires only eight centimetres of snow, thus allowing the agency to groom trails earlier in the winter season when snow cover is less. Analysis of the snow regime in the National Capital Region suggests that use of the modified track setter may become more common under climate change.

Using a snow depth of eight centimetres, the current Nordic ski season in Gatineau Park averages about 115 days (~16 weeks), approximately one month longer than the season defined by 15 centimetres (Table 3.15). Comparing the season lengths with two different snow depths, it is evident that the magnitude of change is substantially smaller in the 2020s under an eight-centimetre base, but season losses were projected to occur as early as the 2050s. Losses to the Nordic ski season were projected to range between 5.2% (NCARPCM B21) and 21.7% (CCSRNIES A11) in the 2020s and between 20.0% (NCARPCM B21) and 100% (CCSRNIES A11) in the 2050s. Again, by the 2080s, two of the three climate change scenarios projected a complete loss of Nordic skiing opportunities in Gatineau Park and other NCC lands.

Table 3.15 Projected season length of Nordic skiing in Gatineau Park

	1961–90 (days)	**2020s**		**2050s**		**2080s**	
		Days	%∆	Days	%∆	Days	%∆
		Climate change scenarios for a 15 centimetre snow base					
Current average	**94**						
NCARPCM B21		81	-13.8%	46	-51.1%	46	-51.1%
ECHAM4 A21		45	-52.1%	0	-100.0%	0	-100.0%
CCSRNIES A11		48	-48.9%	0	-100.0%	0	-100.0%
		Climate change scenarios for an 8 centimetre snow base					
Current average	**115**						
NCARPCM B21		109	-5.2%	92	-20.0%	92	-20.0%
ECHAM4 A21		95	-17.4%	40	-65.2%	0	-100.0%
CCSRNIES A11		90	-21.7%	0	-100.0%	0	-100.0%

Golf

More than 20 golf courses are operational in the National Capital Region, including Mont Saint Marie, an 18-hole, par-72 golf course located outside Gatineau Park's eastern border. It was assumed that Ottawa-area golf courses would adapt to the new opportunities provided by a changed climate in the region and extend the golf season when suitable conditions existed. It was assumed that golf courses would open and close when demand was similar to levels typical of current opening and closing weeks. The climate change-adapted average season length for each scenario is shown in Figure 3.12. There was little noticeable extension in the golf season under the NCARPCM B21 scenario. Under the much warmer CCSRNIES A11 scenario, however, the golf season was projected to be three weeks longer in the 2020s and six weeks longer in the 2050s; by the 2080s, golf was projected to extend through December in the Ottawa region.

A comparison of the projected changes in rounds played under the three climate change scenarios consistently indicated a trend toward higher golf demand in the Ottawa area (Table 3.16). The increase in average number of rounds played per season at a typical 18-hole golf course in the Ottawa area was projected to range from 7.0% (NCARPCM B21) to 18.4% (CCSRNIES A11) in the 2020s, and between 10.3% (NCARPCM B21) to 34.5% (CCSRNIES A11) in the 2050s. In the 2080s, 18-hole golf courses in Ottawa could experience an additional 13.6% (~3,659 rounds) to 43.4% (~11,723 rounds) more rounds per year.

Table 3.16 Projected changes in seasonal rounds (per 18-hole course)

	1961–90 Rounds	**2020s**		**2050s**		**2080s**	
		Rounds	%∆	Rounds	%∆	Rounds	%∆
Current average	**26,983**						
NCARPCM B21		28,860	+7.0%	29,771	+10.3%	30,642	+13.6%
ECHAM4 A21		29,725	+10.2%	32,351	+19.9%	34,334	+27.2%
CCSRNIES A11		31,941	+18.4%	36,303	+34.5%	38,706	+43.4%

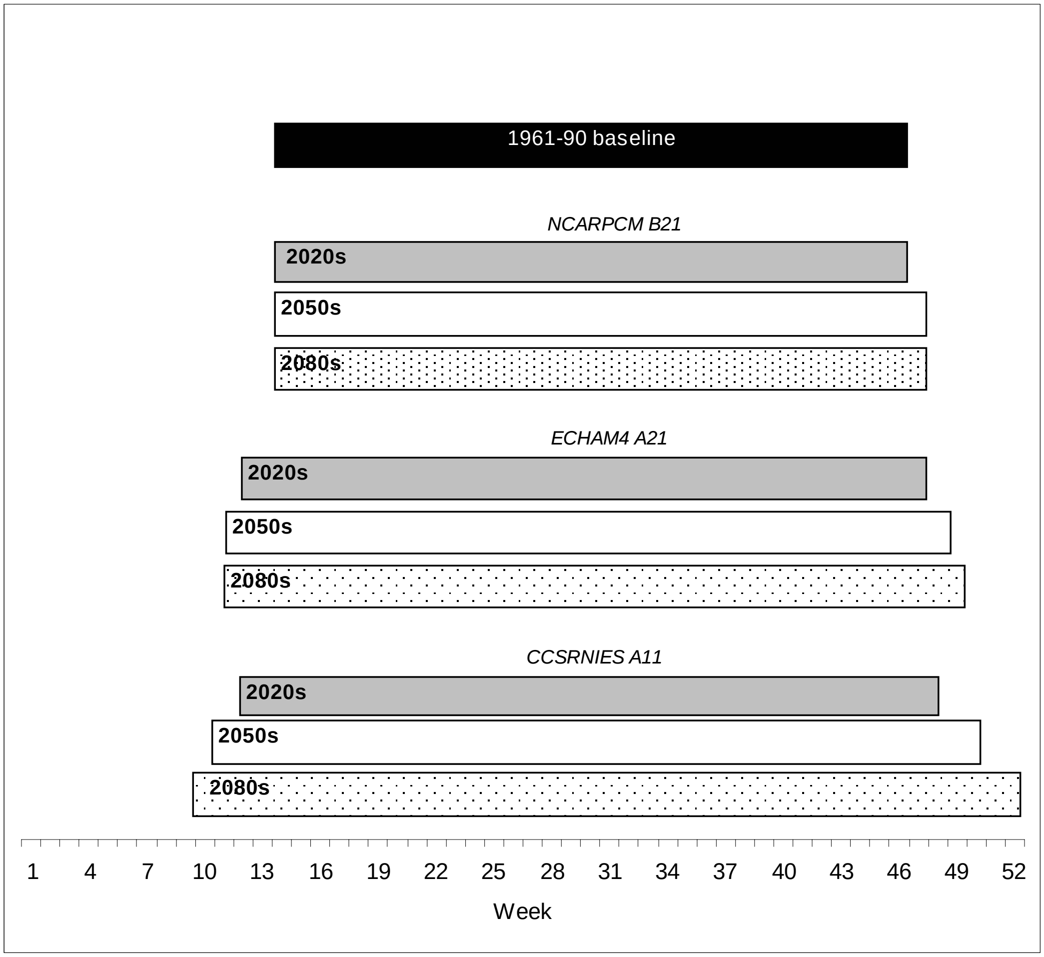

Figure 3.12 Projected golf seasons in the Ottawa region

Camping

Philippe Lake is Gatineau Park's largest campground. With 262 campsites, Philippe Lake is a popular summer recreation destination in the National Capital Region. The results of the climate change impact assessment suggested that Philippe Lake campground would benefit from a warmer climate (Table 3.17). During the peak summer season (July and August), Philippe Lake campground rarely operates at full capacity (average of 64.6% or approximately 170 campsites), but under climate change, summer occupancy rates are projected to approach this level. In the 2020s, occupancy was projected to increase to between 67.4% (NCARPCM B21) and 70.4% (CCSRNIES A11). In the 2050s, the projected increase was even more pronounced, particularly under the warmest scenario. Campground occupancy was projected to range from 69.4% under the least-change climate change scenario (NCARPCM B21) to 76.7% under the warmest scenario (CCSRNIES A11). Under the warmest scenario (CCSRNIES A11), summer occupancy levels are projected to be 82.7% in the 2080s, which represents, on average, an additional 47 campsites being occupied each day during the two summer months. If population growth were also factored in, demand for campsites would likely still meet supply.

During the shoulder season (September to June), camping demand in Gatineau Park is quite low, averaging only 4.6% (~12 campsites per day). The average occupancy rate at Philippe Lake during the shoulder season was projected to increase to between 6.3% (NCARPCM B21) and 8.6% (CCSRNIES A11) by the 2020s. By the 2050s, the occupancy rate was projected to range from 6.9% (NCARPCM B21) to 13.2% (CCSRNIES A11). With additional warming, there was little change in the least-change scenario (NCARPCM B21) in the 2080s, but under the warmest scenario (CCSRNIES A11), it was projected that Philippe Lake campground would have a mean occupancy rate of 18.0% (~47 campsites per day).

Table 3.17 Projected changes in seasonal occupancy rates at Philippe Lake campground

	1961–90 Occupancy rate (%)	**2020s**		**2050s**		**2080s**	
		Occupancy rate (%)	△ in number of sites	Occupancy rate (%)	△ in number of sites	Occupancy rate (%)	△ in number of sites
		Climate change scenarios for the shoulder season					
Current average	**4.6%**						
NCARPCM B21		6.3%	+4	6.9%	+6	7.7%	+8
ECHAM4 A21		6.4%	+5	8.8%	+11	11.6%	+18
CCSRNIES A11		8.6%	+11	13.2%	+23	18.0%	+35
		Climate change scenarios for the peak season (July and August)					
Current average	**64.6%**						
NCARPCM B21		67.4%	+7	68.9%	+11	69.4%	+13
ECHAM4 A21		68.4%	+10	73.7%	+24	78.7%	+37
CCSRNIES A11		70.4%	+15	76.7%	+32	82.7%	+47

The timing of camping demand changes would likely be an important issue, as it would influence the financial and environmental operation of Gatineau Park's campgrounds. Figures 3.13 and 3.14 illustrate the occupancy rates at Philippe Lake campground for each month under the least-change (NCARPCM A11) and warmest (CCSRNIES A11) climate change scenarios. It is apparent from these Figures that the largest gains in camping demand were projected to occur during the shoulder months, particularly in the spring. In the least-change scenario (NCARPCM B21), the average number of campsites occupied in the 2050s increases 1.5 times in May, June and September, with little additional gain by the 2080s. In the warmest climate change scenario (CCSRNIES A21), it was projected that the average number of campsites occupied in May and September would triple in the 2050s, and increase respectively five and four times in the 2080s.

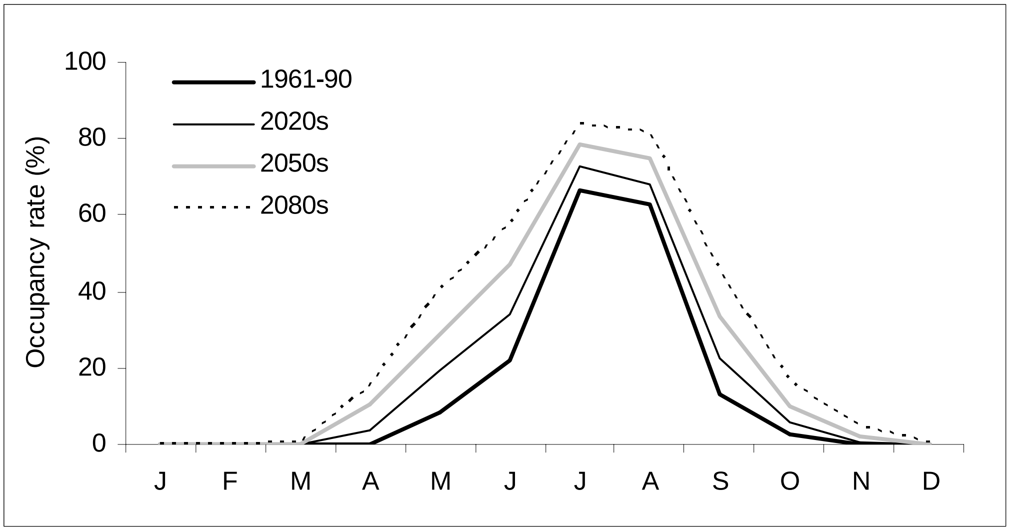

Figure 3.13 Projected monthly occupancy rates under the NCARPCM B21 scenario at Philippe Lake campground

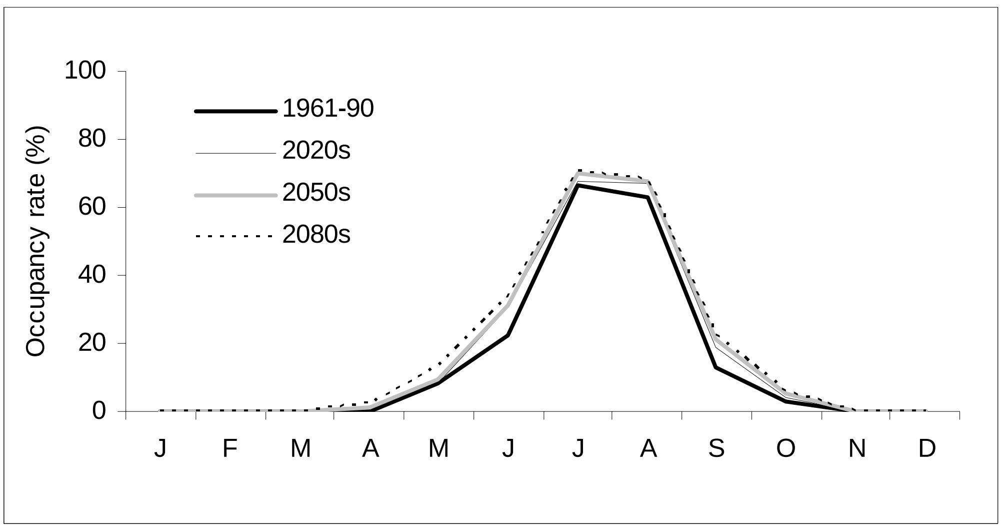

Figure 3.14 Projected monthly occupancy rates under the CCSRNIES A11 scenario at Philippe Lake campground

Public Use of Lakes and Beaches

Gatineau Park has over 50 lakes that provide abundant opportunities for recreation. The National Capital Commission operates six public beaches in Gatineau Park — O'Brien, Blanchet, Breton, Parent, Smith and La Pêche — all of which are staffed with lifeguards in the summer. These beaches collectively attracted more than 70,000 people to Gatineau Park during the summer of 2003 (Riopel, 2003).

A warmer climate would increase swimming and beach use opportunities in Gatineau Park by extending their recreation seasons. Using a threshold temperature of 23^{o}C (based on Paul 1971), the current average swimming season in Gatineau Park is approximately 80 days, usually stretching from mid-June to mid-September (Table 3.18). Under climate change, the average swimming season was projected to increase between 21.3% (17 days) (NCARPCM B21) and 41.3% (26 days) (CCSRNIES A11) as early as the 2020s. In the 2050s, the projected increase in season length ranged from 27.5% (22 days) in the least-change scenario (NCARPCM B21) to 75.0% (60 days) in the warmest scenario (CCSRNIES A11). Swimming seasons were projected to be at least 100 days under all climate change scenarios by the 2080s. Under the warmest scenario (CCSRNIES A11), the swimming season doubled from an average of 80 days to 159 days in the 2080s.

While warmer temperatures are a benefit for swimming opportunities, they also tend to affect dissolved oxygen levels in water, and research has suggested that water quality in the Great Lakes Basin will decline under a warmer climate (International Joint Commission, 2003). It is currently uncertain as to what degree water quality at Gatineau Park's public beaches will diminish. It is possible that beach closures could become more common as the magnitude of climate change increases.

Table 3.18 Projected season length for swimming in Gatineau Park (days)

	1961–90 (days)	**2020s**		**2050s**		**2080s**	
		Days	%∆	Days	%∆	Days	%∆
		Climate change scenarios for swimming (>=23°C)					
Current average	**80**						
NCARPCM B21		97	+21.3%	102	+27.5%	107	+33.8%
ECHAM4 A21		98	+22.5%	115	+43.8%	133	+66.3%
CCSRNIES A11		113	+41.3%	140	+75.0%	159	+98.8%
		Climate change scenarios for beach use (>=15°C)					
Current average	**158**						
NCARPCM B21		168	+6.3%	172	+8.9%	177	+12.0%
ECHAM4 A21		173	+9.5%	187	+18.4%	200	+26.6%
CCSRNIES A11		185	+17.1%	210	+32.9%	227	+43.7%

Paul (1971) concluded that the limiting climatic threshold for beach use (~+15°C) was 8°C lower than that for outdoor swimming. This finding is conceptually intuitive as it likely reflects the range of activities that can occur at public beaches without venturing into the water (*e.g.*, sunbathing, sports, leisure walks and picnicking). The results of the impact assessment suggested that beach use would also increase under a warmer climate (Table 3.19). The current season for beach activities in Gatineau Park is 158 days (mid-May to mid-October); this is almost twice as long as the current swimming season. Beach use was projected to increase between 6.3% (10 days) (NCARPCM B21) and 17.1% (27 days) (CCSRNIES A11) in the 2020s and between 8.9% (14 days) (NCARPCM B21) and 32.9% (52 days) (CCSRNIES A11) in the 2050s. In the 2080s, two of the climate change scenarios projected that the season length for beach use in Gatineau Park would be extended by at least six additional weeks (to ~200 days).

Park Visitation Levels

The final issue examined in this chapter is the potential impact of climate change on overall park visitation. The National Capital Commission estimates that almost two million people visit Gatineau Park annually (Del Degan, Massé et Associés, 2002), participating in a range of recreation activities from hiking and skiing to bird watching and fall colour tours. Without a reliable source of daily or monthly visitor data for Gatineau Park, Fitzroy Provincial Park was used as a proxy for the relationship between climate and park visitation. It is important to note here that although Fitzroy Provincial Park receives significantly fewer visitors (~70,000), it is relatively close to Ottawa (~50 kilometres); thus, it was hypothesized that proportional changes in demand would be applicable to both parks under a similar changed future climate.

Under a warmer climate, Fitzroy Provincial Park would likely become a more popular recreation destination (Table 3.19). Annual visitors are projected to increase between 29.6% (NCARPCM B21) and 65.7% (CCSRNIES A11) in the 2020s. In the 2050s, the projected increase was even more pronounced, particularly under the warmest scenario. Seasonal visits were projected to increase between 42.3% (NCARPCM B21) and 171.4% (CCSRNIES A11). In the 2080s, seasonal visits were projected to increase 54.0% under the least-change scenario (NCARPCM B21) and 296.8% under the warmest scenario (CCSRNIES A11).

If visitation patterns at Gatineau Park are similar and comparable increases in visitation occur, Gatineau Park's current annual visitation of 1.7 million people could increase to between 2.2 million (NCARPCM B21) and 2.8 million (CCSRNIES A11) as early as the 2020s. In the 2050s, visitation would range between 2.4 million (NCARPCM B21) and 4.6 million (CCSRNIES A11). Under the two warmest scenarios, visitors were projected to increase between 172.0% (ECHAM4 A21) and 295.1% (CCSRNIES A11). Using comparable proportional changes to Fitzroy Provincial Park suggested that between 2.6 million (NCARPCM B21) and 6.7 million (CCSRNIES A11) people would visit Gatineau Park each year. Any increases in visitor use under climate change would certainly produce benefits for Gatineau Park, especially additional revenues from user fees. However, significant increases in visitor demand could also enhance existing visitor pressures, contribute to escalated user conflicts, and hinder the National Capital Commission's ability to preserve and protect Gatineau Park's ecosystem.

Table 3.19 Projected changes in annual visitors to Fitzroy Provincial Park

	1961–90	**2020s**		**2050s**		**2080s**	
	(Visits)	Visits	%∆	Visits	%∆	Visits	%∆
Current average	**65,162**						
NCARPCM B21		84,450	+29.6%	92,726	+42.3%	100,350	+54.0%
ECHAM4 A21		87,708	+34.6%	126,936	+94.8%	177,297	+172.0%
CCSRNIES A11		107,945	+65.7%	176,827	+171.4%	259,250	+295.1%

3.3 SUMMARY

This chapter examined the relationships between climate and various winter and warm-season recreation activities that support a considerable portion of the tourism base in the National Capital Region. The results of the climate change impact assessment clearly illustrated that some recreation and tourism events are more vulnerable to climate change than others are. Chapter Four explores the implications of the climate change impact assessment for tourism in the National Capital Region, and suggests a number of adaptation strategies to reduce the impact of a projected warmer climate on the area's multi-billion tourism industry.

Conclusions

In spite of the importance of tourism to Canada's economy, little research has actually examined the potential impact of climate change on the country's recreation and tourism sector. Scott *et al.'s* (2002) study of winter recreation in Ontario's Lakelands Tourism Region is the only known published study to examine differences in the vulnerability of different winter recreation industries in one location. The current study was undertaken to assess the potential impact of climate change on recreation and tourism in one of Canada's largest tourism destinations - the National Capital Region. Focusing on the National Capital Region's extensive mix of natural and cultural recreation attractions, this study endeavoured to address two important questions:

1) How will climate change influence the seasonality of major segments of the winter and warm-season recreation and tourism markets?
2) What are the implications of climate change for major tourism event planning and programming?

By addressing these questions, this study provided an opportunity to highlight disparities in the vulnerability of recreation segments to climate variability and climate change, and to identify risks and opportunities for recreation and tourism in the National Capital Region.

4.1 SUMMARY

A number of key findings emerged over the course of this study. The results suggested that it would become increasingly difficult for the National Capital Commission to provide at least two of the region’s most popular, and economically important, tourism events in their current form under climate change.

At Winterlude, the Rideau Canal Skateway is the most popular attraction. One in four visitors to Winterlude skates on the Skateway; the novelty of skating on the canal is considered a key factor in the event’s enduring success. It was projected that the skating season on the Rideau Canal Skateway would become shorter, with the eventual possibility that it may not open until just before Winterlude. The canal’s winter operating season was projected to be shorter by nine (NCARPCM B21) to 18 (CCSRNIES A11) days in the next 20 years, and be between 12 (NCARPCM B21) and 41 (CCSRNIES A11) days shorter by the middle of the century. The climatic conditions in the 2050s are expected to be similar to those experienced in the National Capital Region during the record warm winter of 2001/02 when the canal had one of its shortest seasons (~34 days). Other Winterlude activities were projected to suffer under a changed climate as well. Without adaptive measures like refrigeration, higher daytime temperatures will make it increasingly difficult to sustain the immensely popular ice sculptures. It was projected that by the 2050s, maximum temperatures during the winter event would be close to 0°C. The future of the Keskinada Loppet Nordic ski race (requiring a regulation 15-centimetre set track) becomes difficult to maintain after the 2020s due to insufficient snow. Other Nordic races requiring less snow (*i.e.*, a non-regulation 2.5 centimetre track) will be more sustainable, with no reduction in the ability to hold these races in the 2020s; only the warmest climate change scenarios project insufficient snow to hold the race in the 2050s during Winterlude. In addition, warmer minimum temperatures would likely decrease snowmaking opportunities, an adaptation currently used to sustain snow-based events when climatic conditions are unseasonably warm.

Under a warmer climate, tulips in the National Capital Region are expected to emerge and reach peak bloom much earlier than at present, thus placing the spring Canadian Tulip Festival in jeopardy unless the timing of this event is adjusted accordingly. Phenology analysis, defined in this study by growing degree days, suggested that in the 2020s tulips would emerge 10 (NCARPCM B21) to 24 (CCSRNIES A11) days earlier than at present, and be at peak bloom five to 16 days earlier. In the 2050s, tulips were projected to emerge 12 (NCARPCM B21) to 54 (CCSRNIES A11) days earlier, and subsequently bloom seven to 31 days earlier. Under the warmest scenario (CCSRNIES A11), peak bloom was projected to occur in mid April, well before of the current May dates of the Festival.

In Gatineau Park, some winter recreation segments were found to be more at risk to climate change than others, while most warm-season recreation segments benefited. Average alpine ski seasons in the 2020s were reduced between 4% (NCARPCM B21) and 16.2% (CCSRNIES A11) and between 7.7% (NCARPCM B21) and 41.4% (CCSRNIES A11) in the 2050s. However, the amount of additional snow required to maintain the shortened seasons was projected to range between 15% and 35% in the 2020s and 20% and 103% in the 2050s. Although machine-made snow is a critical climatic adaptation for ensuring the success of alpine skiing in Gatineau Park, it is possible that the additional snowmaking costs under a warming climate will outweigh the economic benefits. Nordic skiing was found to be even more vulnerable to climate change than alpine skiing in the 2020s. Nordic seasons could experience reductions of 50% (NCARPCM B21) to a complete loss of the season (CCSRNIES A11) by the 2050s.

By comparison, warm-weather recreation in the National Capital Region benefits from a warmer climate through greater demand and extended seasons. Seasonal rounds of golf were projected to increase 7.0% (NCARPCM B21) to 18.4% (CCSRNIES A11) as early as the 2020s, and 10.3% (NCARPCM B21) to 34.5% (CCSRNIES A11) in the 2050s. The latter translates into an additional 3,000 to 9,500 rounds being played at a typical 18-hole golf course, and between 60,000 and 190,000 additional rounds in the National Capital Region. The golf season was also projected to extend an additional three weeks in the 2020s and six weeks by the 2050s, with the largest gains in demand occurring in late fall. The Philippe Lake campground could come closer to reaching full capacity under a warmer climate. Occupancy rates during July and August were projected to be around 67.4% (NCARPCM B21) to 76.7% (CCSRNIES A11) in the 2020s and between 68.9% (NCARPCM B21) and 76.7% (CCSRNIES A11) in the 2050s. Increased maintenance of campground facilities may be required in the future, as the average number of occupied campsites was projected to increase 1.5 to three times during the months of May, June and September. The popularity of Gatineau Park’s beach areas will also increase under climate change. The swimming season at the park’s six staffed public beaches could be extended three to four weeks in the 2020s, and as much as six weeks in the 2050s. As climatic conditions facilitate an extension of the swimming season, additional lifeguard supervision costs will be incurred. Based on current operating contracts, 144 hours per day of paid supervision is contracted out by the National Capital Commission during the swimming season (Riopel, 2003); at least 2,500 and

3,200 additional hours of paid supervision will be required in the 2020s and 2050s, respectively. In general, seasonal declines in the National Capital Region's winter recreation segments (*i.e.*, skiing) could be offset by longer seasons in its warm-weather recreational segments (*i.e.*, golf, camping and beach use).

4.2 ADAPTING TO CLIMATE CHANGE IN THE FUTURE

Staff of the National Capital Commission has undertaken a range of adaptation strategies to deal with climate variability. With respect to Winterlude, public events being moved from ice to safer land locations, the engineering of an outdoor ice rink that remains operational to +15^{o}C, and the conversion of the event itself from a 10-day event to a three-weekend event are all examples of how the organization protects its Winterlude against climate variability. Similarly, heavily mulching flowerbeds in the fall or ensuring a deep layer of snow collects (using snow fences) and covers tulip bulbs later into spring are just two examples of strategies used by the National Capital Commission to slow the initial growth of tulips and to aid them in reaching peak bloom during the May dates of the Canadian Tulip Festival. The question that remains, however, is whether the current adaptation strategies will be sufficient to deal with the projected impacts of climate change on tourism and recreation segments in the National Capital Region.

4.2.1 Tourism Events

A number of adaptation strategies could be used to reduce the projected impacts of climate change on tourism events in the National Capital Region. With respect to Winterlude, snowmaking was identified as a strategy to limit loss of snow slides at Snowflake Kingdom, particularly if the current technology is improved and becomes more efficient at temperatures warmer than -5^{o}C. Refrigeration will likely become a common method of maintaining ice sculptures in the future. The integration of more indoor sporting and cultural events using local arenas and community centres could also help to reduce the vulnerability of Winterlude's weather-sensitive outdoor events and attractions.

The National Capital Commission will also likely need to consider other broader adaptation strategies. The National Capital Commission may need to shift the focus away from certain attractions during Winterlude. The Rideau Canal Skateway is the primary attraction at Winterlude, but the results of the climate change impact assessment suggested that the skating season could be reduced by one-half as early as the 2050s. The media also tend to focus on the conditions of the Skateway, which serves to highlight its importance for winter tourism and recreation in the National Capital Region. It may be necessary for the National Capital Commission to devise public marketing strategies to draw attention to events or experiences other than skating on the Rideau Canal Skateway. Such strategies would take substantial time to change public perception, and even financial sponsors' perception, about what makes Winterlude successful.

Our understanding of demand side adaptations is very limited as very little research has examined how climate variability and change may influence recreation users' choices regarding activities and destinations. It is possible that under climate change, demand for Winterlude may actually decline. As an outdoor event, Winterlude serves to draws Canadians outside, thus helping many to overcome the winter blahs that tend to set in by February. If winter temperatures continue to increase and the winter season shortens, as projected by a range of climate change scenarios, the need for a winter celebration as currently devised may diminish in the future.

Tulip growth and development is highly sensitive to climatic conditions, and the climate change impact assessment indicated that tulips will likely emerge and bloom earlier than at present in the Ottawa region. Change in the timing of tulip development and bloom will eventually put the May dates of the Canadian Tulip Festival in jeopardy. Even with current adaptation strategies (*e.g.*, mulching), it is uncertain how well staff will be able to delay the growth of tulips under climate change. One strategy that the National Capital Commission could undertake is to host the Festival earlier in the spring (~mid April) to accommodate projected changes in emergence and peak bloom dates. If institutional barriers pose challenges to changing the date of the Festival, other strategies would need to be considered. For example, organizers may need to return to the 'Festival of the Spring' theme used in the late 1980s (Coopers & Lybrand Consulting, 1998a) and promote other spring flowers that would be more likely to bloom during the current May Festival dates. Horticulturists may also need to adapt their tulip stock. The hundreds of thousands of tulip bulbs that staff plant across the Ottawa region each fall are adapted for current climatic conditions. New hybrid tulips that require a shorter and warmer dormant period, become active later, and are more tolerant of warmer climates may need to be planted.

As for Canada Day celebrations, the climate change impact assessment indicated that temperatures on July 1 would become warmer, likely requiring the National Capital Commission to implement its heat-emergency contingency plans more frequently. Yet, other measures could also be taken. The official Canada Day ceremony that is televised nationally occurs during mid-day. The timing of this ceremony and other Canada Day activities could be altered so as to avoid the warmest part of the day (i.e., 12 to 3 pm). In addition, the type and location of events (i.e., more shaded environments) could be shifted so as to reduce heat-related stresses.

In the short term, an important adaptation that the National Capital Commission should consider to reduce the weather-related risk of its two largest and economically important tourism events (Winterlude and the Canadian Tulip Festival) is weather insurance and derivatives. Weather insurance and weather derivatives are an underutilized means for reducing weather risk for tourism events. A weather derivative is a contract between two parties that stipulates what payment will occur because of certain climatological conditions occurring during the contract period (Conley, 1999; Zeng, 2000). Derivatives are highly flexible instruments that can be based on a wide range of climatological variables (e.g., temperature, precipitation, sunshine, snow and ice conditions) and temporal periods (e.g., a one-week festival, weekends during the summer months), and can be structured to the weather-related risk of a range of outdoor events (cultural festivals, concerts, sporting events) and other tourism businesses. For example, a wine-bar chain in London, England purchased a weather derivative because previous summers of poor weather kept customers away from its restaurant patios. Based on its agreement, the chain would be paid C$31,000 for every Thursday and Friday during the summer of 2001 that temperatures failed to reach 24^{o}C (Bloomberg, 2004). As the National Capital Commission enhances their understanding of the weather and climate sensitivities of their tourism events, they will be able to minimize weather-related risks.

4.2.2 Gatineau Park and Other NCC Lands

In Gatineau Park, winter recreation was found to be more at risk to climate change than most warm-season recreation segments, which tended to benefit through extended seasons. In this study, snowmaking technology was shown to limit season losses at Camp Fortune, with its benefits becoming more salient by the middle of the century. Snowmaking represents a significant proportion of the annual operating costs at alpine ski areas, so Camp Fortune would benefit from any improvements to current snowmaking technology. Camp Fortune officials could also undertake other supply-side adaptations to reduce their vulnerability to climate change. For instance, slope design could be altered by smoothing rough surfaces to reduce snow requirements. The ski area could also diversify the use of its ski terrain during the summer. In addition to hiking, a number of dry slope recreation equipment (*e.g.*, various wheeled mountain boards) have been developed and could be marketed to youth in the National Capital Region that enjoys snowboarding or skateboarding.

The Gatineau Park Master Plan Review encourages the expansion of winter recreation in the park, especially use of the winter trail system (Del Degan, Massé et Associés, 2002). Natural snow cover, rather than snowmaking, currently sustains this trail system. However, natural snow cover in the National Capital Region was expected to diminish, and Nordic skiing was projected to be reduced 50% to 100% by the 2050s. Potential adaptations exist (*e.g.,* implementation of snowmaking) to reduce the vulnerability of the winter trail system to climate change, but they would require substantial technological and financial investments.

The National Capital Commission will also have to consider adaptive strategies to cope with increased visitor demands in Gatineau Park. Approximately two million people visit Gatineau Park annually (Del Degan, Massé et Associés, 2002), but as early as the 2050s it was projected that annual visits could increase by one million people. Such an increase in demand could significantly stress natural resources in the park and potentially lead to conflicts among users. Officials may need to consider regulating the number of people who enter the park for certain recreation activities (e.g., paid passes, entrance gates). In addition, increased visitor demand could hinder the ecological integrity of Gatineau Park. Since the National Capital Commission is mandated to protect the ecological resources of the park, visitor and recreation restrictions may become a viable adaptation strategy in the future.

4.3 FINAL THOUGHTS

The National Capital Region’s mix of natural and cultural attractions, many of which are climate-sensitive, draws millions of tourists to the region every year. As a result, the National Capital Region has a great deal at stake from any changes in the climate. Some recreation and tourism segments will be negatively impacted, while others will benefit from a changing climate. Even though a number of adaptations have been used in the past to cope with climate variability, the National Capital Commission will now have to examine how it plans and promotes tourism and recreation in the National Capital Region in the context of climate change.

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Appendix A

Summarized here is the list of stakeholders who contributed to this project. At various stages in this project, those listed participated in consultation meetings, provided recreation and tourism data, or provided feedback on the research methods and analyses.

NATIONAL CAPITAL COMMISSION

Capital Planning and Real Asset Management Branch

Sherry Berg	Project Landscape Architect
Lucie Bureau	Principal Regional Planner
Gerry Lajeunesse	Chief, Landscape Architect
Richard Scott	Principal Regional Planner
Tommy Wingreen	Horticultural Technician

Communications, Marketing and External Relations Branch

Laurie Peters	Director, Strategic Communications

Environment, Capital Lands and Parks Branch

Mark Burleton	Manager, Greenhouse Operations
Marc Corriveau	Manager, Events and Program Support (Rideau Canal Skateway)
Michel Dallaire	Manager, Recreational Services, Visitors and Operations, Gatineau Park
Jean-René Doyon	Director, Environment and Natural Resources, Gatineau Park and Greenbelt
Mario Fournier	Urban Lands and Transportation
Marc Graveline	Coordinator Events and Facilities (Rideau Canal Skateway)
Ed Lawrence	Horticultural Specialist, Grounds Services, Official Residences
Bob Lewis	Director, Urban Lands and Transportation
Gershon Rother	Senior Manager, Greenbelt
Gabrielle Simonyi	Manager, Environmental Services, Environmental Management and Protection
Luc Turpin	Contract Management Officer, Urban Lands and Transportation
Michel Viens	Senior Manager, Natural Resources and Land Management, Gatineau Park

National Programming Branch

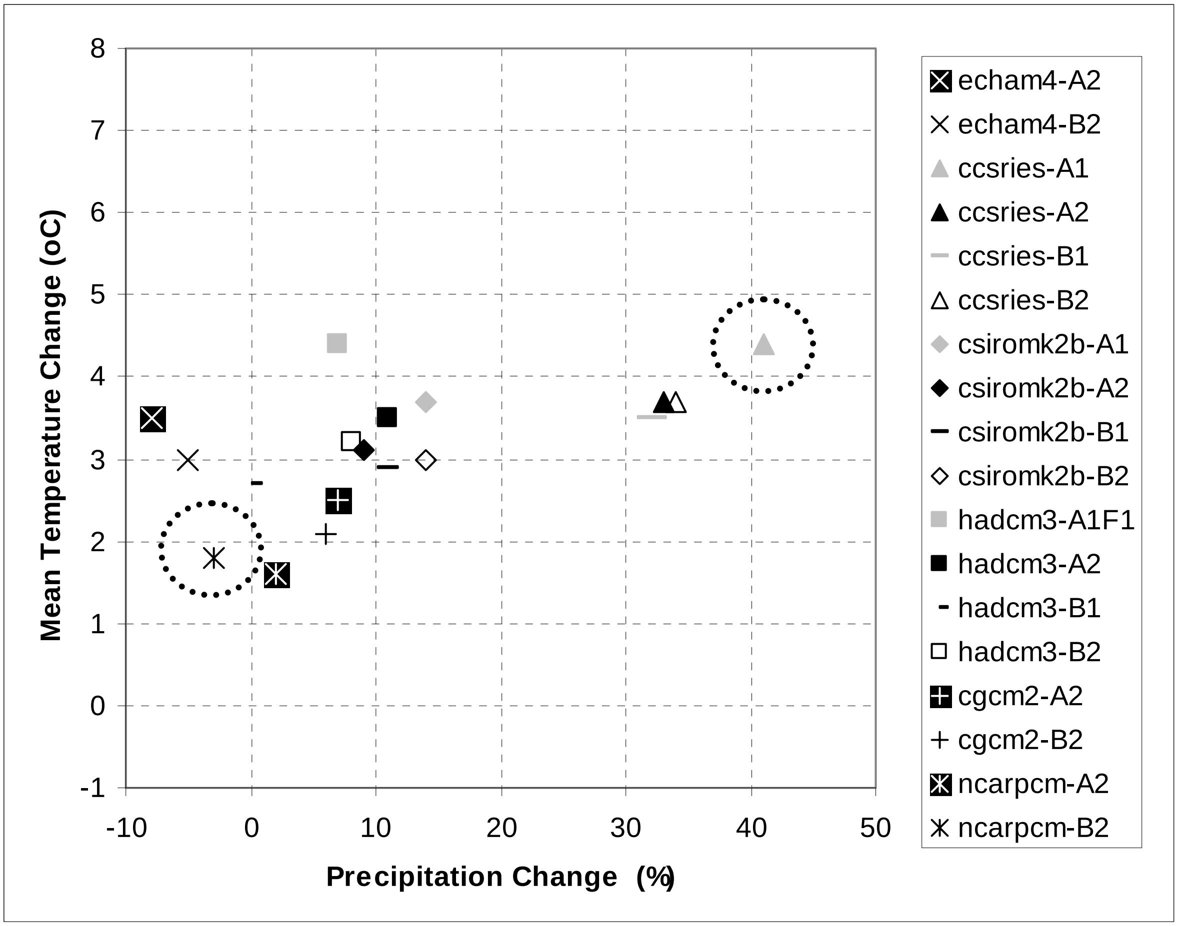
Jean-Marc Robillard	Manager, Production Services, Capital Events
Thérèse St-Onge	Manager, Events and Celebrations

OTHER ORGANIZATIONS

	Decima Research Inc
	Group Sodem
Jim Curran	La Fleur de la Capitale
Gary Fournier	La Fleur de la Capitale
Amy Shearer	Ontario Ministry of Natural Resources

Appendix B

Ottawa Region – Summer (2050s)



Ottawa Region – Winter (2050s)