CLIMATE CHANGE

SEASONALITY

In Canadian Outdoor Recreation and Tourism

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BACKGROUND

Tourism is one of Canada's largest industries. In 2003, tourism generated $52 billion in revenues (~2% of Canada's gross domestic product[1]) and was the sixth largest employer of Canadians[2]. Outdoor recreation is a critical component of Canada's tourism industry. Depending on the season, Canadians and visitors to Canada can pursue a wide range of winter and warm-weather outdoor recreation opportunities including alpine and cross-country skiing, snowmobiling, ice fishing, camping, golf, hiking and recreational boating.

A principal determinant in the diversity of outdoor recreation available in Canada is the climate. Climate plays a direct role in defining the length and quality (i.e., overall comfort and enjoyment of outdoor experience) of recreation and tourism seasons and in influencing the level of participation. This direct influence of climate on recreation and tourism is referred to as natural seasonality[3].

The seasonality and associated economic success of various winter and warm-weather outdoor recreation activities are impacted by inter-annual climate variability, both positively and negatively. Table 1 provides selected examples of how climate variability has impacted the tourism and recreation sector in Canada over the past five years. Given the sensitivity of outdoor recreation in Canada to climate, changes in the natural seasonality of individual recreation activities brought about by climate change could have implications for businesses and communities that depend on these activities for their economic livelihood.

Outdoor Recreation and Climate Change

Although climate variability has yielded some positive impacts for winter recreation over the last five years (Table 1), winter tourism in Canada is repeatedly identified as being highly vulnerable to climate change[4–7]. Climate change impact assessments of the ski industry in various parts of the country (Great Lakes, Québec, western Canada) project negative consequences of varying magnitude for the industry. A recent climate change impact assessment of winter recreation in Ontario found that snowmobiling was more vulnerable to climate change than alpine skiing because of its greater reliance on natural snowfall[4]. Technical and economic barriers also limit the use of snowmaking as a climatic adaptation in the snowmobiling industry[4].

Winter outdoor recreation is important to Canada's economy, but participation in outdoor recreation and related tourism typically peaks in Canada during the warm-weather season. For example, 43% of Canada's domestic and 62% of its international tourism expenditures occurs during the third quarter (July, August and September)[8]; approximately 70% of all national park visits (and the associated recreation activities people undertake in these parks) occur between May 1 and September 30[9]; and, much of the camping demand in Canada (~70% to 80%) occurs between June and the Labour Day weekend in September[10,11]. Research examining the important changes in warm-weather outdoor recreation seasons in Canada (and internationally) under a changed climate remains very limited.

Since the warm-weather outdoor recreation season is important to Canada's tourism industry, a changed climate could create new opportunities, as well as some important challenges. Assessing both the risks and opportunities to winter and warm-weather recreation is essential for understanding the net impact of climate change on Canada's outdoor recreation and tourism industry.

Table 1. Examples of the impact of climate variability on outdoor recreation and tourism in Canada

Winter recreation	Warm-weather recreation
2000/01 • Late spring snowfalls in western Canada allowed some ski resorts in the Rocky Mountains to extend their 2000/01 ski seasons by at least three weeks[12] • Blue Mountain Resort (Collingwood, Ontario) experienced its longest ski season in 60 years in 2000/01, which helped increase ski revenues 18% over the previous season[12] **2001/02** • Above normal temperatures between November 2001 and February 2002 delayed the opening of the Rideau Canal Skateway in Ottawa (Ontario) by almost six weeks and contributed to the shortest skating season in 30 years (only 34 days)[13] • Because of the mild winter and poor snow conditions in 2001/02, four of the Ontario Snow Resorts Association's 14 cross-country ski clubs in southern Ontario were unable to open for the season[14]; many ski resorts in southcentral Ontario did not open until Christmas in 2001, three to four weeks later than normal[15] **2004/05** A mild, wet winter had a negative impact on winter recreation: • Ski resorts in British Columbia's lower mainland (e.g., Grouse Mountain, Cypress Mountain and Mount Seymour) were forced to close earlier than normal[16] • At Whistler-Blackcomb ski resort (British Columbia), 60% of its ski runs were closed before March Break due to a lack of snow[17]; skier-visits were down 14% for the 2004/05 season[18]. Cross-country skiing, which is traditionally done in the valley, had to be moved to higher elevations due to a lack of snow and to accommodate the early start of the mountain biking season[18]. **2005/06** • Large, late winter snowfalls in western Canada allowed Whistler-Blackcomb ski resort to extend the ski season on Whistler Mountain into early June[19]. • Snowmobile trails remained closed until late January/early February in many areas of Canada (e.g., Manitoba, Ontario), due to record warm winter conditions and a lack of snow[20,21].	**2002** • A cool, wet spring in western Canada in 2002 delayed the opening of some golf courses in Edmonton (Alberta) until May[22] • Low water levels on the Great Lakes since 1999 contributed to a range of complications for marina operators including inaccessible docks (too high out of the water) and launch ramps (did not reach waterline)[23,24]. The Canadian Government funded a $15 million Great Lakes Water Level Emergency Response Programme for emergency dredging[25]. • An unseasonably warm autumn in 2002 allowed many Winnipeg (Manitoba) golf courses to re-open in November[22] **2004** An unseasonably cool and wet spring and summer in parts of Canada impacted recreation negatively. • At Grand Bend (Ontario), campgrounds operated at less than 50% capacity during the first 'unofficial' long weekend of summer (May Victoria long weekend)[26]. • Rounds played at some Winnipeg-area golf courses were down over 30% during the spring golf season[27] • In Wasaga Beach (Ontario), a popular beach destination, summer occupancy rates at some accommodations were reduced by as much as 40%, while some beach merchants experienced business losses of up to 50%[26] • Wasaga Beach Provincial Park received 30% fewer daily visitors during its peak summer operating period[26] **2005** • Because of the record warm summer of 2005, day trips to Ontario's provincial parks increased 30%, with beach parks experiencing the largest increase in visitation. Sibbald Point, Sandbanks and Wasaga Beach provincial parks collectively had 700,000 more person visits in July[28]. • Above seasonal autumn temperatures in many parts of Canada, including Alberta, allowed golf courses to stay open longer than normal[29]

Is Canada's Climate Changing?

Climate is the long-term average of weather for a specific place and time period, and includes temperature, precipitation, wind, humidity and a range of other weather characteristics. A location's climate is normally defined by climatologists using at least 30 years of observed weather data[30]. Trends in long-term data (i.e., > 30 years) allow us to determine if a location's climate is changing.

Trends in climate data from across Canada suggest that the climate has been changing, although there are regional differences in the magnitude of change[31]. The mean annual temperature across Canada has increased 1.1°C since the late 1940s and six of the warmest 10 years have occurred since 1995 (1998, 1999, 2000, 2001, 2003 and 2005). Annual mean temperatures have increased 2.0°C in the Arctic, 1.3°C in the Prairies and 0.4°C in the Great Lakes region since the 1940s, while Atlantic Canada has experienced a slight cooling. Winters (December, January, February) in Canada are also warmer now than they were 70 years ago. On average, winters are 1.9°C warmer now than they were in the 1940s. The winter of 2003/04, for example, was 2.2°C warmer than Canada's long-term average; the warmest winter since the 1940s (2005/06) was 3.9°C above the long-term average.

Canada has experienced above normal annual precipitation since the 1970s[31]. The wettest year since the 1940s was 2005 (13.4% above normal) and among the driest was 2001 (4.3% below normal). On average, annual precipitation has increased in the Great Lakes region (+1.2%), Atlantic Canada (+0.4%) and the Arctic (+0.3%) and declined in the Prairies (-1.4%) and on the West coast (-1.0%) over the last 70 years.

Changes in snow cover have also occurred in Canada[32–34]. Winter snow cover peaked in Canada between the 1950s and 1970s, but has been on a decline since the 1970s. Analysis of snow trends indicates that snow cover seasons are becoming shorter in Canada and spring melts are occurring earlier, particularly in western Canada. On average, there has been 0.3 fewer days per year with snow cover since the 1950s in many regions of Canada[32].

In addition to climate station data, a growing body of biophysical evidence suggests that the climate in Canada is changing[35,36]. The duration of ice cover on many of Canada's lakes and rivers, for example, has diminished over the last century. Data for Lake Simcoe, the only known lake in Ontario with records dating back more than 100 years, indicate 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 ice break-up is occurring four days earlier on average[35]. Glacier coverage in the southern Canadian Rocky Mountains is estimated to have decreased 25% in the 20th century[37,38]. The terminus of the Athabasca Glacier, the main attraction at the Columbia Icefields, has retreated 1,200 metres since 1900[37]. Plant phenology also suggests that the timing 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[35].

Canada's Future Climate

Projections about future climatic changes still remain uncertain because of complexity in the global climate system and the human systems that are affecting it (i.e., greenhouse gas emissions, land use change). Inter-annual and climate variability will continue to occur and so projections of future changes refer to **average** changes in climate conditions in 30-year periods — the 2020s, the 2050s and the 2080s. The '2020s' (defined by 2010 to 2039) reflect **average** changes that are projected to occur 20 years from now. The '2050s' (defined by 2040 to 2069) reflect **average** changes projected for the middle of the 21st century (~50 years from now), while **average** changes at the end of the century (~80 to 100 years from now) are reflected by the '2080s' (defined by 2070 to 2099). Each period reflects changes with respect to a baseline period (1961–90).

Climate change projections for Canada are provided in Table 2 for the three aforementioned time periods — the 2020s, 2050s and 2080s. Canada's climate is projected to continue to become warmer under climate change[39]. Global climate models project that relative to the 1961–90 baseline period, Canada's mean annual temperature will increase between 1.7°C and 2.3°C by the 2020s, between 2.3°C and 7.0°C by the middle of this century (~2050s) and between 3.1°C to 9.5°C by the end of the century (~2080s). The largest increase in seasonal temperatures is projected to occur in winter (Table 2).

Canada's climate is also projected to experience more precipitation under climate change (Table 2)[39]. In the 2020s, annual precipitation is projected to increase 5% to 6% relative to baseline conditions (1961–90). By the middle of the century (2050s), annual precipitation is projected to increase between 7% and 15% and between 11% and 23% by the end of the century (2080s). On average nationally, winter and spring are projected to experience the largest increases in precipitation.

Research Objectives

Table 2. Projected changes in Canada's climate[39]

		Annual	Winter	Spring	Summer	Fall
Temperature change (°C)	2020s	+1.7 to +2.3	+2.1 to +2.5	+1.7 to +2.5	+0.8 to +1.6	+1.6 to +2.6
	2050s	+2.3 to +7.0	+3.3 to +8.2	+2.2 to +6.2	+1.3 to +4.2	+2.2 to +6.5
	2080s	+3.1 to +9.5	+4.9 to +13.2	+3.0 to +8.9	+1.6 to +6.3	+2.9 to +9.6
Precipitation change (%)	2020s	+5 to +6	+6 to +8	+6 to +11	+3 to +4	+5 to+ 5
	2050s	+7 to +15	+9 to +17	+9 to +23	+4 to +11	+8 to +13
	2080s	+11 to +23	+15 to +29	+15 to +31	+5 to +18	+11 to +20

The United Nations[40] and international community (including the Government of Canada) have concluded that some magnitude of climate change is unavoidable in the 21st century, irrespective of how successful the collective efforts of governments, communities and individual citizens are to reduce emissions of greenhouse gases. Consequently, climate change adaptation is a necessary planning strategy for governments and the outdoor recreation and tourism industry in Canada.

The exact size and economic value of Canada's outdoor recreation industry, or even individual sectors, is currently poorly documented. Estimates for three of Canada's larger outdoor recreation sectors however suggest that a considerable number of people and recreation infrastructure could be affected by projected changes in the climate (Table 3). A significant barrier to climate change adaptation within the Canadian recreation and tourism industry is the limited understanding of the disparate risks and opportunities that a changed climate could have on the country's diverse market of winter and warm-weather recreation and the resultant impact on competitive relationships among tourism regions.

This executive summary presents the main findings of a climate change impact assessment conducted by researchers at the University of Waterloo. The assessment was undertaken to assess the potential impact of climate change on natural seasonality in Canada's outdoor recreation and tourism industry. Specifically, the study had three principal goals:

1. To develop new methodologies to analyze the impact of climate variability on major winter and warm-weather outdoor recreation sectors in terms of supply (i.e., season length) and/or demand (i.e., visitor/use levels).

2. To examine how climate change might influence the season length and demand for major winter and warm-weather outdoor recreation sectors in Canada.

Table 3. Characteristics of Canadian recreation sectors

	Resource	Participants
Alpine skiing[41,42]	~250 ski areas	~1.5 million
Snowmobiling[43,44]	~135,000 km of trails; ~860 clubs	~550,000 permit holders
Golf[45,46]	~2,000 courses	~5 million

3. To explore the management implications of changes in natural seasonality for winter and warm-weather recreation.

It was beyond the scope of this study to examine the impact of climate change on a comprehensive range of outdoor recreation sectors. Consequently, five economically important outdoor recreation sectors were used as indicators of seasonality change. The winter sectors examined were alpine skiing and snowmobiling. Golf, beach use (public access to lakes and beaches) and camping were used as indicators for warm-weather recreation.

This executive summary provides an overview of the impacts of climate change for natural seasonality in five major outdoor recreation sectors in Canada. It identifies the ways in which recreation sectors could be negatively affected by projected changes in the climate and highlights new opportunities that may emerge as a result of a changed climate. The impacts of climate change to the skiing and snowmobiling industries are summarized first; they are followed by a summary of the projected impacts for the golf, beach recreation and camping sectors. Management implications of projected changes in seasonality and demand are discussed, along with possible adaptation strategies.



RESEARCH METHODS

This climate change impact assessment focused on a range of major outdoor winter and warm-weather recreation sectors that are climate sensitive and important to Canada. The nature of the physical resources that define the sensitivity of certain recreation sectors to climate and the availability of recreation sector data required the development of a variety of new assessment methods. The methods developed for each recreation sector have been published in professional, peer-reviewed journals and reports by the authors[4–7, 47–50]. While the methods are briefly described here, readers are referred to these publications for further details.

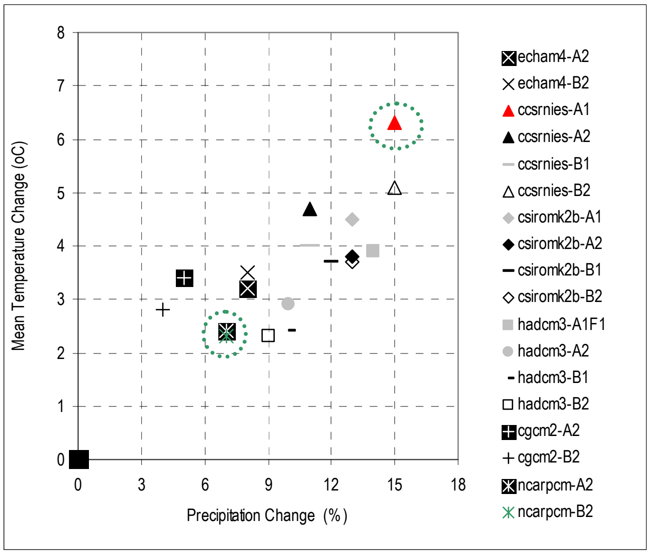
With an important focus of the research being methodological development, it was beyond the scope of the study to be geographically comprehensive. Methods were developed for specific study areas where necessary data were available. These study areas are identified in the following pages with respect to individual recreation sectors. Future research will need to apply these peer-reviewed methods to other regions of Canada.

Climate Data & Climate Change Scenarios

This climate change impact assessment required the use of many climate stations. Climate stations used with respect to each recreation sector contained a complete and quality-controlled historical record (i.e., 1961–90) and were also operational through to the present, so that recently archived data could be accessed.

In order to capture a full range of potential future climates in Canada, two climate change scenarios and different greenhouse gas emission scenarios (A1 and B2) were used in this study. The scenarios used are from the National Center for Atmospheric Research (NCAR) in the United States and the Center for Climate System Research (CCSR) in Japan. Climate change scenarios produced by these research centres have participated in the

Figure 1. Climate change scenarios for Canada (annual — 2050s)



Intergovernmental Panel on Climate Change's (IPCC) model inter-comparisons and are recommended for climate change impact and adaptation assessments by the IPCC's Task Group for Climate Change Impact Assessments. The specific scenarios utilized are the NCARPCM B21 and the CCSRNIES A11 scenarios. Figure 1 illustrates how these two scenarios (identified by dashed circles) compare with all other climate change scenarios available for Canada.

The NCARPCM B21 scenario generally assumes lower global greenhouse gas emissions and projects a small increase in temperature over the course of this century. In contrast, the CCSRNIES A11 scenario assumes higher global greenhouse emissions and projects a substantial warming this century. As a result of these differences, NCARPCM B21 is referred to as the 'least-change' scenario in this report and CCSRNIES A11 is referred to as the 'warmest' scenario. Climatic changes under the two scenarios are relative to the

1961–90 baseline, which is denoted as a black square (■) on most figures in this report.

Due to the nature of the outdoor recreation data used in this study to establish climate-recreation relationships, climate change information was needed at finer temporal and spatial scales than is generally available from the climate change scenarios. As a result, monthly scenarios were downscaled in this study to the daily level and parameratized to respective climate stations using the Long Ashton Research Station (LARS) stochastic weather generator[51]. Weather generators are inexpensive computational tools that replicate the statistical attributes of a local climate and can be used to produce site-specific, multiple-year climate change scenarios at daily time scales[52].

Winter Recreation

Alpine skiing

To assess the impact of climate change on Canada's alpine ski industry, a ski operations model was developed. The model consisted of several subcomponents (a snow model, a snowmaking module and ski operation decision rules) and was based on earlier research in eastern North America by the research team[4–6].

A physically based snow-depth model, parameterized to local climate stations was created to model natural snow cover in the study areas and to simulate ski seasons during the 1961–90 baseline period. A snowmaking module was integrated with the natural snow model to account for this important climatic adaptation by the ski industry. Snowmaking decision rules and technical capacities were based on earlier studies by the research team, and were originally derived from communication with ski industry stakeholders. The specific thresholds and decision criteria used are summarized in Table 4. The ski operations model was then run with the two climate change scenarios to project changes in the season length of alpine skiing in the 2020s, 2050s and 2080s. This methodology was also used to reassess earlier climate change impact assessments of the ski industry in Canada[53–56] that did not account for snowmaking and thus overestimated potential losses.

Snowmobiling

Canada's snowmobiling industry is reliant entirely on natural snow, as the linear nature and long distances of snowmobile trails make widespread implementation of snowmaking systems technically difficult and very expensive. The snow model developed for alpine skiing analyses was

Table 4. Parameters of the ski operations model

Snowmaking capacities & decision rules	
Start date	Nov 22
End date	Mar 30
Minimum snow base to maintain until end date	60 cm
Temperature required to start snowmaking	-5°C
Snowmaking capacity	10 cm/day
Skiable day	
Minimum snow base	30 cm
Maximum temperature	15°C
Maximum liquid precipitation over 2 consecutive days	20 mm
Ski area	
Size (acres)	250

also used to assess the impact of climate change on the snowmobile industry, but the snowmaking module was excluded[57]. Natural snow cover at study areas in Ontario and Québec was modelled to simulate an average snowmobiling season during the 1961–90 baseline period. The snow model was then run with the two climate change scenarios to project changes to the length of snowmobile seasons in the 2020s, 2050s and 2080s.

Minimum snow depths needed to safely open snowmobile trails vary among jurisdictions depending on terrain and safety regulations. Season length for snowmobiling in this study was defined as the number of days with a natural snow depth of at least 15 cm, which is considered the minimum snow depth for opening smooth terrain, ungroomed snowmobile trails in the Great Lakes region[4,57]. Other criterions such as minimum temperature were not used to define a 'snowmobiling day' because technical adaptations (e.g., thermal clothing, electric hand and foot warmers) have made participation comfortable even at very cold temperatures (e.g., <-20°C).

Warm-Weather Recreation

Golf

Over 60 mid- to high-quality golf courses from across Canada were contacted to provide golf-use data (i.e., daily rounds played) for this study, but golf course officials at most courses were unwilling to provide the necessary operations data due to proprietary and technical issues (e.g., could only retrieve average daily rounds per weekday with their record-keeping software)[48]. Four private to semi-private 18-hole golf courses provided the necessary data — one on the west coast, two in the Great Lakes region and one on the east coast. These four courses generally operate at between 80% and 90% capacity during their respective peak seasons and have been distinguished as some of the country's best courses (by the Canadian golf industry).

Analysis of the impact of climate on the golf industry was based on published methods developed by the research team in the Great Lakes region[48]. Statistical analysis (regression) was used to develop a model of the current relationship between climate (temperature and precipitation) and daily rounds played at each golf course, based on the years of golf data provided by golf course officials (west coast — 2004/05; Great Lakes — 2002 and 2003; east coast — 1996 to 1999). The regression models were then applied to climate data from the nearest high-quality (i.e., no prolonged periods of missing data) climate station in order to model rounds played at each location in a climatologically average year during the 1961–90 baseline period. In the final step, the models were run with the two climate change scenarios to project changes in the length of the golf season (based on current average number of rounds played during opening and closing weeks of the season) in different regions of Canada and the number of rounds played under climate conditions projected for the 2020s, 2050s and 2080s.

Beach recreation

Reliable visitation data were not available for public lakes and beaches in Ontario, including beaches located in provincial and other municipally operated parks. In order to provide insight into the potential impact of climate change on the public use of lakes and beaches at major beach destinations across the Province (e.g., Georgian Bay region, Toronto waterfront and Gatineau Park), climatological thresholds for defining swimming and beach recreation seasons were established based on consultations with facility/park managers and the scientific literature[58].

The thresholds used in this study reflect minimum climatic conditions required for specific recreation activities. It is recognized that there may be social and/or geographic differences with respect to thermal comfort, but for comparative purposes, a daily maximum temperature of at least 23^{o}C was used to define a suitable day for swimming, while a daily maximum temperature of at least 15^{o}C was used to define a suitable day for public beach recreation throughout the year[58]. The lower temperature threshold for beach recreation reflects the range of activities that can occur on the beach without venturing into the water (e.g., sunbathing, sports, leisure walks and picnicking). These thresholds were used to define average season lengths for each activity during the 1961–90 baseline period. Changes in the number of days that met these temperature thresholds were examined under the two climate change scenarios for the 2020s, 2050s and 2080s.

Camping

Camping data were sought from campgrounds in different regions of Canada. Similar to the golf sector, officials from privately and municipally operated campgrounds were unwilling to provide the necessary operations data due to its proprietary nature. Data limitations, such as differences in the type of data recorded (e.g., parties — number of people per vehicle; number of sites reserved, but not necessarily occupied) also posed an important barrier to the analysis, as the information was not sufficient to provide adequate insight into the role of climate in campground occupancy. Camping data, consisting of the total number of campsites occupied daily between January 1 and December 31 (for the years 1996 to 2001) were obtained from the Ontario Ministry of Natural Resources for two provincial parks in the Province of Ontario (Pinery and Presqu'ile).

Similar to the golf analysis, statistical analysis (regression) was used to develop a model of the current relationship between climate and daily, occupied campsites at each study area during its respective peak (July and August) and shoulder (September to June) seasons. The models were then applied to climate data from the nearest high-quality climate station in order to model the number of campsites occupied at each location in a climatologically average year during the 1961–90 baseline period. In the final step, the models were run with the two climate change scenarios to project the potential changes in the number of campsites occupied under climate conditions projected for the 2020s, 2050s and 2080s.

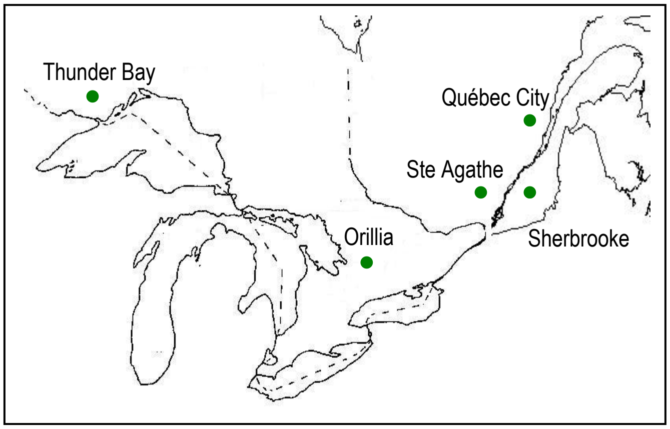
Winter Recreation

ALPINE SKIING

Alpine skiing is one of Canada's largest winter outdoor recreation sectors. Approximately 1.5 million Canadians actively participate in alpine skiing annually[59], with the majority of the domestic ski market coming from the Provinces of Ontario and Québec (~65%)[59]. There are also more than 250 alpine ski destinations nationwide[41], ranging from small municipally operated ski areas to large, resort-oriented ski areas operated by multi-national companies (e.g., Intrawest). Ski destinations in the mountainous region of western Canada (e.g., Whistler-Blackcomb, Banff-Lake Louise) are typically the country's most recognized alpine skiing areas.

Early research on climate change and the alpine skiing was conducted in the Great Lakes region, specifically the Provinces of Ontario and Québec[53–56]. These early studies however had some important limitations. For example, a minimum snow depth of 2.5 cm was used in some early studies to define a skiable day, based on Crowe et al. (1973)[60]. Few ski runs will operate with such little snow because it is unsafe and will cause damage to both ski equipment and the landscape. More importantly, snowmaking was neglected or given limited consideration. Snowmaking has been integral to the alpine ski industry in Ontario and Québec for more than 20 years, with resorts making multi-million dollar investments in snowmaking technology in order to reduce their vulnerability to current climate variability and to increase the average length of their ski seasons. All ski areas in southern Ontario and 40% of ski resorts in southern Québec today have snowmaking coverage on 100% of their skiable terrain[4,41]. Thus, this analysis focused on the eastern Provinces of Ontario and Québec to reassess the study areas where previous studies were done (Figure 2).

Figure 2. Alpine skiing study areas



Georgian Bay & Thunder Bay Ski Areas

Ontario's densest concentration of ski areas is located along the southeastern shores of Georgian Bay (~Orillia), in one of the Province's dominant snowbelt regions (Figure 2). Fifteen of Ontario's 40 alpine ski areas are located here, including some of the most popular and largest ski areas — Blue Mountain, Horseshoe, Hockley Valley, Mount St. Louis/Moonstone and Snow Valley[61]. The primary market for ski areas in the Georgian Bay region is southern Ontario, especially the Greater Toronto Area.

Under a warmer climate, the environmental conditions for skiing will become increasingly challenging, with the overall trends being toward shorter ski seasons and a greater need for machine-made snow and investment in snowmaking infrastructure. With the use of snowmaking, the current average annual alpine ski season in the Georgian Bay region is approximately 149 days (21 weeks) (Table 5). Under the

Table 5. Current average and projected ski seasons (days)

		1961-90		2020s	2050s	2080s
Ontario	Thunder Bay	164	NCARPCM B21	161	157	149
			CCSRNIES A11	136	105	84
	Orillia	149	NCARPCM B21	145	138	133
			CCSRNIES A11	121	81	59
Québec	Sherbrooke	152	NCARPCM B21	149	141	137
			CCSRNIES A11	129	93	70
	Québec City	160	NCARPCM B21	158	152	147
			CCSRNIES A11	139	106	74
	Ste Agathe (des Monts)	163	NCARPCM B21	163	156	152
			CCSRNIES A11	142	111	89

climate change scenarios examined, the average ski season is projected to be reduced between five and 29 days in the 2020s and between 12 and 69 days in the 2050s. Even with current levels of snowmaking, the region's alpine ski season is projected to be 91 days shorter (59-day season) in the 2080s, under the warmest climate change scenario.

Snowmaking has been an integral part of the alpine ski industry in Ontario for 20 years, as it is used to help alpine ski areas minimize the negative impact of inter-annual variability in natural snowfall. In this region of Ontario, ski areas have complete or nearly complete (80% to 100%) snowmaking capacity[4]. As the climate warms, snowmaking will help reduce the vulnerability of the region's industry to climate change, but more machine-made snow will be needed in the future to minimize reductions in the alpine ski season. If it is assumed that no change occurs in current snowmaking technology, the amount of snow required to maintain the shortened ski seasons for the Georgian Bay area increases on average between 47% and 66% in the 2020s (Figure 3). In the 2050s, between 62% and 151% more machine-made snow will be required. With additional warming by the 2080s, the warmest climate change scenario projects a 175% increase in snowmaking needs over current requirements.

Ontario's most northern ski area is located near Thunder Bay (Figure 2). On average, ski seasons in this area are 164 days in length (Table 5). In the 2020s, ski seasons are projected to be between three and 28 days shorter and between seven and 59 days shorter in the 2050s. Even with further reductions in the length of ski seasons projected for the 2080s, alpine skiing seasons in this region are projected to be two to four weeks longer than seasons in Georgian Bay.

If it is again assumed that no change occurs in current snowmaking technology, ski areas in northwestern Ontario are projected to need on average 28% to 52% more snow in the (Figure 3). In the 2050s, between 40% and 161% more machine-made snow will be required. In the 2080s, the warmest climate change scenario projects a 220% increase in snowmaking needs over current baseline requirements.

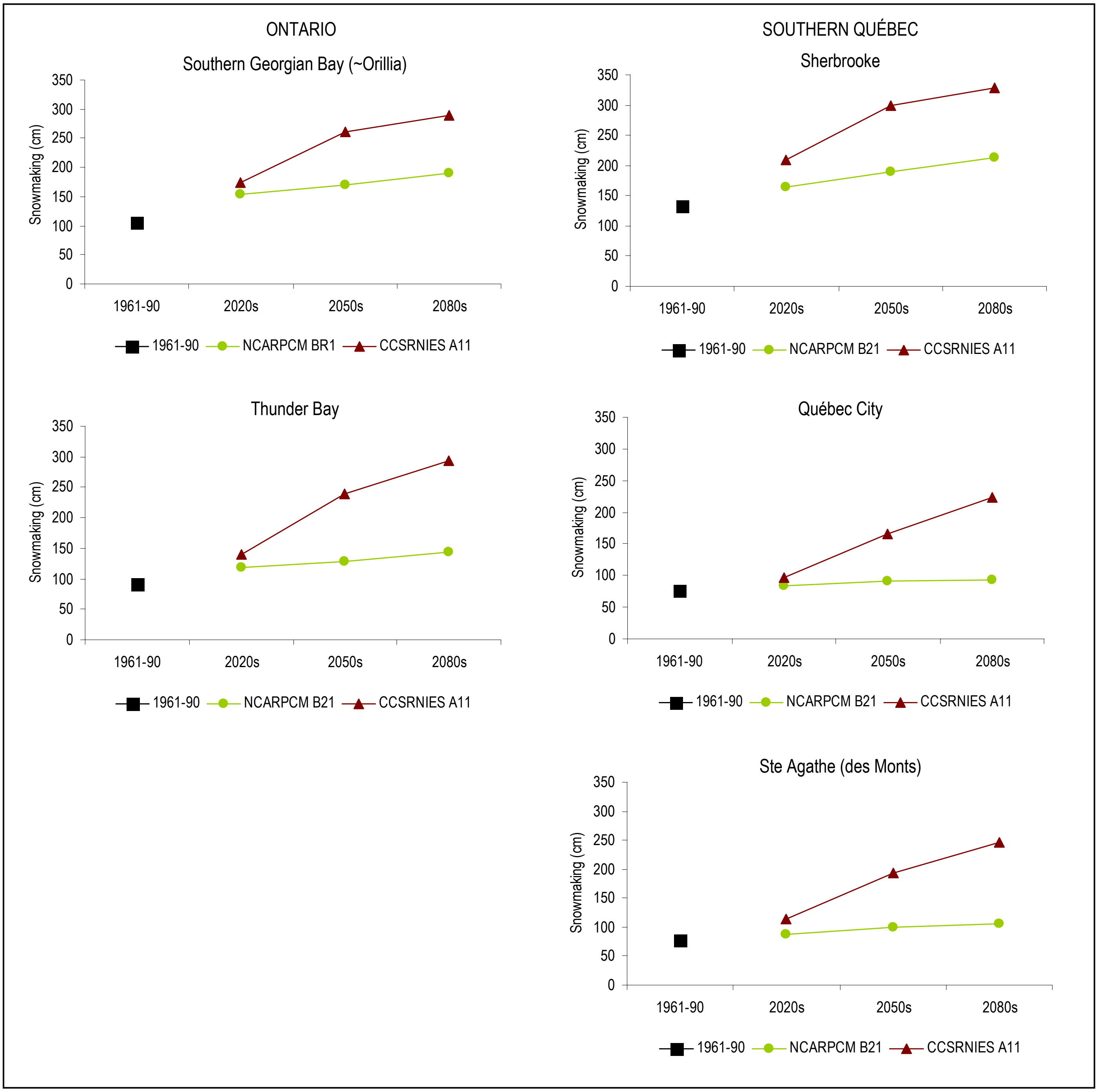
Southern Québec Ski Areas

Québec has one of the largest regional ski markets in Canada, with approximately 80 alpine ski areas concentrated in the southern portion of the Province[42]. Three ski areas in southern Québec were examined in this study: Ste Agathe, Sherbrooke and Québec City (Figure 2).

Southern Québec's alpine ski season is slightly longer than Georgian Bay's ski season, averaging between 152 and 163 days (Table 5). As the regional climate in southern Québec warms, ski areas will also experience trends toward shorter ski seasons and a greater need for machine-made snow. Under warmer winter climatic conditions, average ski seasons in southern Québec in the 2020s are projected to be zero to 23 days shorter. In the 2050s, average ski seasons are projected to seven to 11 days shorter under the least-change climate change scenario and between 52 and 59 days shorter under the warmest climate change scenario. Ski areas near Sherbrooke and Québec City are projected to be the most vulnerable in southern Quebec to climate change, as both are projected to lose at least half (~54%) their ski seasons in the 2080s. However, even with these losses, study areas in southern Québec are projected to have comparable ski seasons to Thunder Bay in the 2080s, and have ski seasons two to four weeks longer than in Georgian Bay under the warmest scenario.

Alpine ski areas in southern Québec have also adapted to climate variability and rely heavily on snowmaking to minimize interruptions to their winter operations. Only modest increases (8% to 25%) in machine-made snow are projected for southern Québec ski areas in the 2020s (Figure 3). In the 2050s, increases of 18% to 44% are projected under the least-change climate change scenarios, while increases of 116% to 150% are projected under the warmest climate change scenario. With additional warming by the 2080s, the warmest climate change scenario projects that between 149% and 216% more machine-made snow will be required over current requirements to maintain ski seasons.

Figure 3. Projected changes in snowmaking requirements



Reassessment Comparison

The results of this study indicate that alpine skiing will be impacted negatively as Canada's climate warms during the 21st century. Snowmaking however significantly reduces the impact of climate change on alpine ski areas. Changes in average season lengths suggest that ski areas in southern Québec could be less vulnerable to climate change than ski areas in northwestern (Thunder Bay) and central (Georgian Bay) regions of Ontario.

Comparison of the results of this study with previous climate change impact assessments of alpine skiing in similar study areas of Ontario and Québec clearly demonstrate the importance of snowmaking (Table 6). Previous studies, which did not consider snowmaking, suggested that average ski season in southern Ontario and Québec would contract substantially or possibly be eliminated in the 2050s(53–56). With snowmaking, the vulnerability of the ski industry in these areas is reduced substantially. At most of the locations examined in the reassessment, the losses projected under the 'worst case' 2050s scenario approximated the 'best case' scenario from earlier studies (Table 6).

While snowmaking minimizes the vulnerability of alpine skiing to climate change, it does represent a significant proportion of the annual operating expenses at individual ski areas in the Ontario and Québec study areas. Snowmaking will still be possible in the future, but there are projected to be fewer days suitable for efficient snowmaking as winters become warmer(4–6,50). Making additional snow at warmer temperatures will increase the cost of snowmaking substantially under the warmest climate change scenario. As a result, it is not the shorter ski seasons, but shorter ski seasons in combination with higher snowmaking costs that are projected to pose a greater risk to ski areas.

Table 6. Comparison of ski season losses

Previous studies	Ski season loss (2050s)
northern Ontario(53)	-30% to -40%
southern Ontario(53)	-40% to -100%
southern Quebec(54,55)	-40% to -89%
southern Quebec(56)	-42% to -87%
This study	**Ski season loss (2050s)**
northern Ontario	-4% to -36%
southern Ontario	-8% to -46%
southern Quebec	-5% to -39%

Climate Change & Alpine Skiing in Canada's Rocky Mountains

Environmental conditions for alpine skiing in Canada's mountainous region are substantially different from conditions in Ontario and Québec. For example, elevational ranges often exceed 2,000 m; annual snowfall can exceed 500 cm, often varying significantly between ski areas in the same mountain valley; operations are generally larger than 2,000 acres; and, snowmaking is not heavily used (0% to ~20%)(41).

Snow model projections for the mountainous region of western Canada and the United States(7,62) suggest that the alpine ski industry in Canada's Rocky Mountains is expected to be impacted negatively by climate change. A preliminary analysis of ski operations near Banff and Lake Louise was conducted as part of a broader study on climate change and tourism in Banff National Park(7). When only natural snow is considered, average ski seasons at low elevations (~1,600 m) at Banff are projected to decrease 50% to 57% in the 2020s and 66% to 94% in the 2050s; ski seasons at higher elevations (~2,600 m) are projected to experience much smaller reductions. Reductions in average ski seasons are projected for Lake Louise as well, but the magnitude of change at low (-27% to -35% in the 2020s; -31% to -87% in the 2050s) and high (-2% to -3% in the 2020s; -2% to -19% in the 2050s) elevations is much less than at Banff.

Snowmaking helps reduce the negative impact of less natural snow and will likely become an increasingly important climate adaptation at low elevations. When snowmaking is factored in, average ski seasons at low elevations at Banff are projected to decrease 7% to 15% in the 2020s, but decrease 9% to 43% in the 2050s; ski seasons at higher elevations are projected to experience little change. Minimal reductions in ski seasons are projected for Lake Louise at low elevations in the 2020s (0 to -1%) and 2050s (0 to -12%). More research is needed to understand the role of microclimatic factors on natural snowfall in mountainous regions, how to incorporate them into snow models, and the impact of climate change on alpine skiing at different elevations.

For more information, see: **Banff National Park and Climate Change: Implications for Tourism and Recreation**(7)

SNOWMOBILING

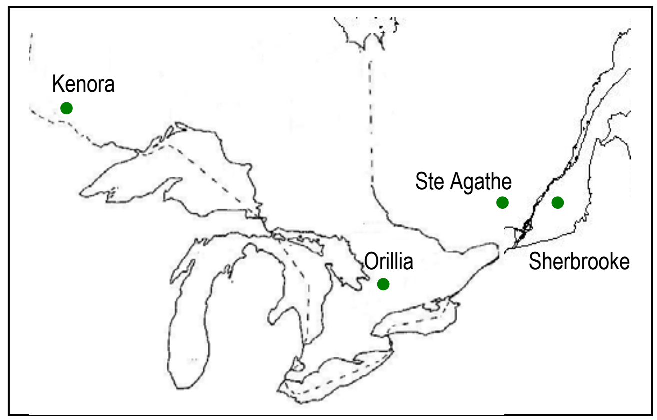
Snowmobiling is one of Canada's largest winter outdoor recreation sectors. Approximately 500,000 Canadians engage in snowmobiling each year, generating billions in economic activity(43). Canada's largest regional snowmobile industries are located in eastern Canada; the Provinces of Ontario and Québec collectively account for approximately 60% of Canada's snowmobiling resources (i.e., snowmobile trails and clubs)(44,53)(Table 7).

Table 7. Snowmobiling resources

	Ontario	Québec
Trails (km)(43)	49,000	33,000
Clubs(43)	268	233
Registered machines(43)	363,437	145,843
Economic worth(63,64)	$1 billion	$1.6 billion

Snowmobiling is highly sensitive to climate. This outdoor winter recreation sector relies entirely on natural snowfall because the linear nature and long distances of snowmobile trails make widespread implementation of snowmaking systems technically and economically impractical. Due to its reliance on natural snowfall, it has been argued that snowmobiling would be at greater risk than alpine skiing under a warmer climate(4). The analysis presented here examined this argument for the Great Lakes region (Figure 4).

Figure 4. Snowmobiling study areas



Ontario

Northwestern Ontario

Northwestern Ontario currently has some of the longest snowmobile seasons in the Province. Although there is some regional variability in season length, the current average snowmobiling season in northwestern Ontario (~Kenora) is 100 days (Table 8). Under a warmer climate, the region's snowmobiling season is projected to be reduced between 25 and 45 days as early as the 2020s. In the 2050s, the snowmobile season is reduced by 32 days under the least-change climate change scenario, and reduced by 12 weeks (87 days) under the warmest climate change scenario. In the 2080s, the warmest climate change scenario projects that the snowmobile season is eliminated in this region.

Southern Georgian Bay

In addition to its large concentration of alpine ski areas, the Georgian Bay region encompasses some of the densest networks of snowmobile trails in Ontario(21,63). Provincial trails, operated by the Ontario Federation of Snowmobile Clubs (OFSC), are located near or traverse the properties of many of the region's popular winter resort destinations.

Currently, the average snowmobile season in the Georgian Bay area (~Orillia) is about 69 days (Table 8). In the 2020s, snowmobiling seasons are projected to be shorter, by 30 to 47 days. In the 2050s and 2080s, the least change climate change scenario projects 39 and 52 fewer days for snowmobiling, respectively. By comparison, the

Table 8. Current average and projected snowmobiling seasons (days)

		1961-90		2020s	2050s	2080s
Ontario	Kenora	100	NCARPCM B21	75	68	62
			CCSRNIES A11	55	13	3
	Orillia	69	NCARPCM B21	39	30	17
			CCSRNIES A11	22	0	0
Québec	Ste Agathe	94	NCARPCM B21	84	77	64
			CCSRNIES A11	57	9	3
	Sherbrooke	68	NCARPCM B21	40	36	24
			CCSRNIES A11	29	3	0

snowmobiling season is eliminated from the region under the warmest climate change scenario as early as the 2050s.

Southern Québec

The Province of Québec has a large network of groomed snowmobile trails, most of which are located in the southern portion of the Province and operated by the Quebec Federation of Snowmobile Clubs (FQSC)[(64)]. In Ste Agathe (des Monts), snowmobiling seasons currently average about 94 days (Table 8). As winters in the area become warmer, snowmobiling seasons in the 2020s are projected to be 10 to 37 days shorter. Under the least–change climate change scenario, snowmobiling remains feasible in the Ste Agathe area through to the end of the 21st century. Similar to other study areas, snowmobiling seasons are projected to be reduced to less than two weeks (9 days) by the middle of the century (2050s) under the warmest climate change scenario.

Around the Sherbrooke area, snowmobilers are able to pursue their recreational pastime on average for approximately 10 weeks (~68 days) each year (Table 8). In the 2020s, snowmobiling seasons are projected to be reduced by between 28 and 39 days, and by between 32 and 65 days in the 2050s. In the 2080s, the snowmobile season is projected to be three weeks long under the least change climate change scenario, and be eliminated under the warmest climate change scenario.

Management Issues

It would appear that the snowmobiling industry in eastern Canada is highly vulnerable to climate change. If these results are indicative of the long-term effects of climate change for the snowmobiling sector, there could be substantive economic implications. Communities that are dependant on snowmobiling and associated tourism events (e.g., charity rides, competitions/championships, winter festivals) could experience a loss in revenues. Shorter and less reliable snowmobile seasons could potentially also alter competitive relationships between snowmobiling districts. For example, over the next 30 to 40 years as snowmobiling seasons become shorter in central Ontario (or stateside — Vermont, Michigan), snowmobile destinations in northern Ontario may become more attractive, as long as their season remains reliable in the near term.

Snowmobiling seasons are relatively short. As snowmobile seasons become even shorter, snowmobilers may choose to discontinue investing in snowmobiles and other related equipment. Reductions in the availability of suitable snow conditions could also motivate snowmobilers to substitute their snowmobiles for all-terrain vehicles (ATVs), which are not limited by snow conditions. Although ATVs provide a potential adaptation to climate-induced reductions in natural snow cover in the decades to come, such a change would require important changes by recreation suppliers and how trails are managed, as ATVs are currently banned from most snowmobile trails. Future government investments in snowmobile trail development and to enhance snowmobile tourism would also need to be re-evaluated.



GOLF

Golf is one of the largest outdoor recreation industries in Canada. Approximately 5 million participants generate $4 billion in annual revenues for the industry. It is estimated that more than 20 new golf courses are opened to the public each year across Canada(46).

There are significant regional differences in the seasonality of the golf sector in Canada. As demonstrated by the three golf courses examined in this study (Figure 5), average golf seasons in southern Canada range from just over five months (168 days) on the east coast to year round on the west coast (Table 9). In this climate change impact assessment, it was assumed that golf courses would adapt to the new opportunities provided by a changed climate and extend the golf season, to the extent possible, when suitable conditions existed. Based on a regional comparison of three golf courses across Canada, golf courses on the west coast are projected to benefit the least from a changed climate, while golf courses on the east coast could benefit the most.

West Coast

Golf courses on the west coast, specifically on the Lower Mainland of British Columbia (i.e., Greater Vancouver Regional District) and on Vancouver Island where temperatures rarely fall below 0°C, have the longest golf seasons in the country (Table 9). Since many courses (including the one analyzed) in this region have the potential to operate year-round, projected changes in the region's climate will have little to no impact on the length of the golf season (Table 10).

Figure 5. Golf study areas

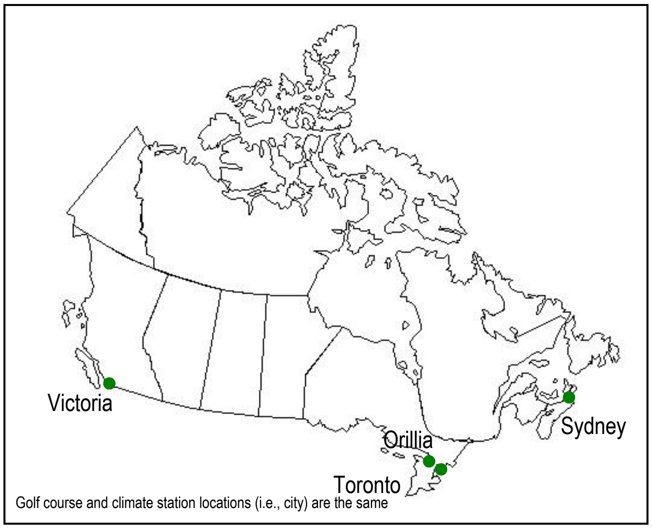


Table 9. Current average golf seasons

	West coast	Great Lakes		East coast
	(~Victoria)	Southern (~Toronto)	Central (~Orillia)	(~Sydney)
Season	~365 days	~214 days	~192 days	~168 days
Period	~early Feb. to late Jan.	~mid-Apr. to late Nov.	~mid-Apr. to late Oct.	~mid-May to late Oct.

Table 10. Projected golf seasons (days)[a]

	Current average		2020s	2050s	2080s
West coast (Victoria)	365	NCARPCM B21 CCSRNIES A11	365 365	365 365	365 365
Great Lakes — southern (Toronto)	214	NCARPCM B21 CCSRNIES A11	231 265	238 300	241 323
Great Lakes — central (Orillia)	192	NCARPCM B21 CCSRNIES A11	202 218	202 229	220 260
East coast (Sydney)	168	NCARPCM B21 CCSRNIES A11	196 213	196 224	207 253

[a] Based on average number of rounds played during the opening and closing weeks at each golf course

If it is assumed that current levels of golf demand and supply on the west coast remain unchanged, both climate change scenarios suggest that projected changes in the climate will have some impact on the number of rounds played in this region, but it will be minimal, even under the warmest climate change scenario (Figure 6—A). Under the least-change climate change scenario, there is little noticeable increase (less than 5%) in the average number of rounds played per season through to the end of the 21st century. Under the warmest climate change scenario, the average number of rounds played annually at an average mid- to high-quality 18-hole golf course increases 2% in the 2020s, 11% in the 2050s and 18% in the 2080s. Most of the increase in rounds played is projected to occur during the summer months of July and August (Figure 6—B). This increase suggests that coastal maritime climatic conditions during the summer become more suitable for playing golf (i.e., warmer daytime temperatures).

Southern Great Lakes

After the west coast, golf courses in the southern Great Lakes region enjoy some of the country's longest golf seasons (Table 9). The Great Lakes region also has some of the largest concentrations of golf courses per capita in North America.

The golf industry in the Great Lakes region is expected to benefit substantially from climate change, but the magnitude of change varies regionally. In the central Great Lakes (~Orillia), there is a moderate increase (10 to 18 days) in the average golf season under the least-change climate change scenario through the end of the 21st century (Table 10). Under the warmest climate change scenario however, golf seasons are projected to be approximately 16 days longer in the 2020s, 37 days longer in the 2050s and 68 days longer in the 2080s. By comparison, in the southern Great Lakes (~GTA), the average length of the golf season is projected to be 17 days longer in the 2020s under the least change scenario, with only modest additional increases in the 2050s and 2080s (up to 27 additional days longer by the 2080s) (Table 10). Under the warmest climate change scenario, the golf season is projected to be 51 days longer in the 2020s, 86 days longer in the 2050s and 109 days longer in the 2080s.

Under the warmest climate change scenario for the 2080s, the potential exists for a year-round golf season in the southern Great Lakes region. Although plausible, a year-round golf season would remain intermittent at best because daily mean temperatures during the winter months (December to February) are projected to be remain relatively cool (~2.5°C) with extended periods of frost and snow cover in some years.

As for average rounds played per season, 18-hole golf courses in the central and southern areas of the Great Lakes region are projected to experience similar rates of increase in golf participation, but the timing of the increases varies to some degree. Annual rounds played per year in the central Great Lakes are projected to increase between 21% and 35% in the 2020s, between 25% and 59% in the 2050s and between 30% and 74% in the 2080s (Figure 6—A)*. Most of the increase in rounds played is projected to occur in the spring shoulder season, particularly March through to May (Figure 6—B). In the southern Great Lakes region, the increase in rounds played is projected to occur in both the spring (April to June) and fall (September to November) shoulders (Figure 6—B). Average annual rounds played are projected to increase between 23% and 37% in the 2020s and between 27% and 61% in the 2050s (Figure 6—A). In the 2080s, an 18-hole golf course in the southern Great Lakes could experience between 32% (~8,500 rounds) and 73% (~19,700 rounds) more rounds annually.

* Daylight hours were not accounted for.

East Coast

Compared to the other regions, the golf season on Canada's east coast is more climate-limited. Although it is acknowledged that some regional variability in season length occurs, golf seasons in this region tend to average about 168 days (Table 6).

As the warm-weather recreation season is extended on the east coast, the region's golf industry is projected to experience substantial benefits. The average golf season in the region is projected to be extended between 28 and 45 days in the 2020s and between 28 and 56 days in the 2050s (Table 7). In the 2080s, the east coast region could have a golf season of 207 days (39 additional days) under the least change climate change scenario and a season length of 253 days (85 additional days) under the warmest climate change scenario. The latter projection rivals the golf season in the central Great Lakes region by the end of the century.

Golf courses in the east coast region are also projected to experience an increase in the number of rounds played annually. Annual rounds (per 18-hole golf course) are projected to increase between 40% and 49% in the 2020s and between 48% and 74% in the 2050s over current conditions (Figure 6—A), with the increases generally spread out throughout the season (Figure 6—B). The increase in golf participation in the 2050s translates into an additional 11,400 to 17,200 rounds being played annually per 18-hole course. As the length of the golf season is further extended in the 2080s, golf courses in the region are projected to experience increases in rounds played of between 53% and 94% over baseline conditions.

Management Issues

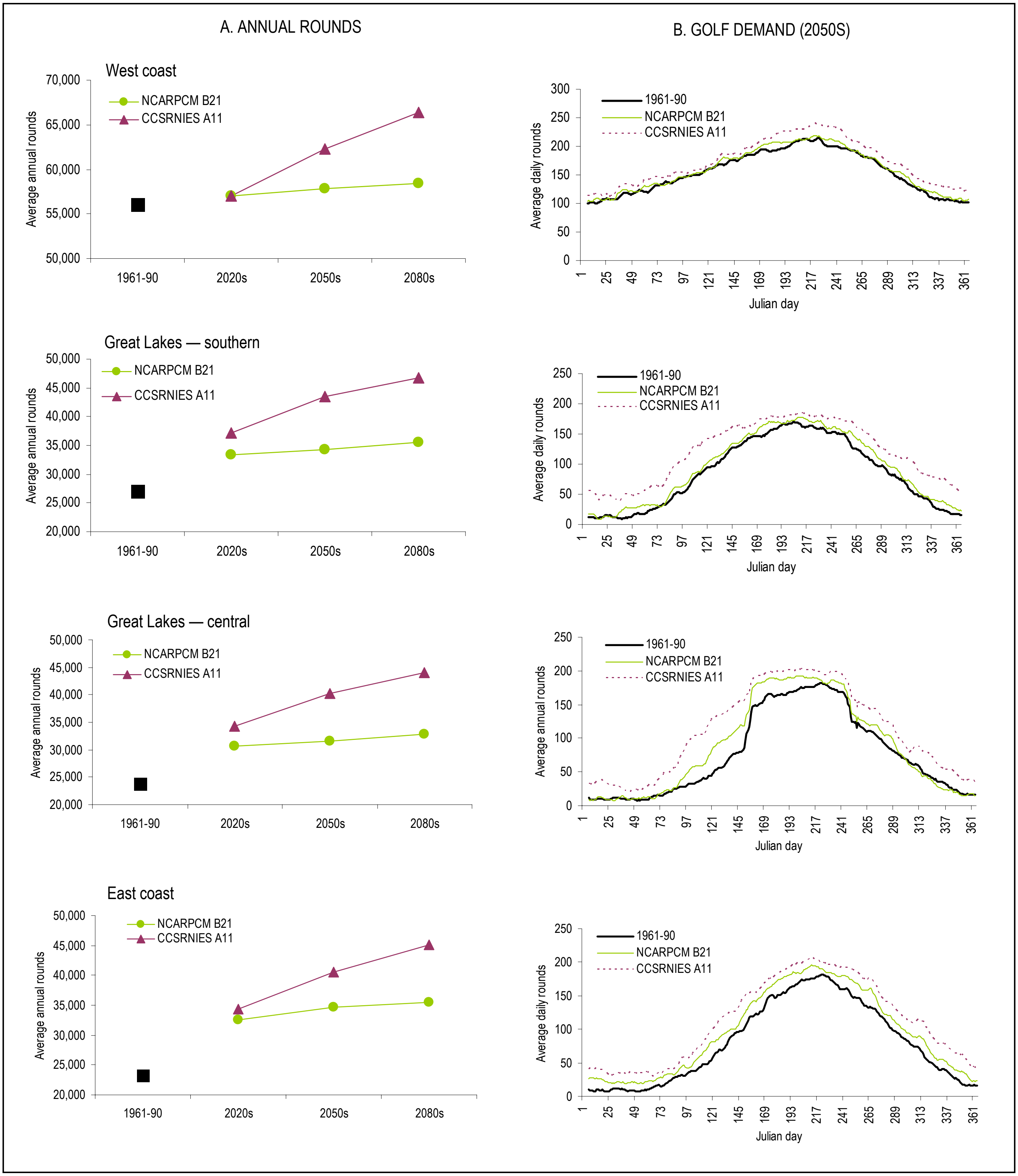
It would appear that Canada's golf industry could benefit substantially from climate change. Individual golf courses and golf tourism destinations would benefit economically, as longer golf seasons and the potential for additional rounds played would contribute to substantially higher golf course revenues (e.g., from green fees, cart rentals, pro shop, food/beverage sales) and related tourism spending. One destination that could benefit from improved climatic conditions for playing golf is Prince Edward Island. With 25 golf courses, the Province has successfully marketed itself as a celebrated golf destination — it has been distinguished as Canada's premier golf destination three times in the last five years (2001, 2003 and 2005) and as North America's best golf destination in 2005[65,66]. The economic importance of Prince Edward Island as a golf destination could continue to improve as the golf season is extended on the east coast, so long as it can be achieved in a sustainable manner.

Although the golf industry nationally would benefit from projected climate change, there could also be other important impacts to overcome in the decades to come. Longer golf seasons could potentially alter competitive relationships between major golf destinations within the country and internationally. For example, as golf seasons are extended in the Great Lakes region and on the east coast, the attractiveness of winter golf tourism destinations in the southern United States (e.g., Myrtle Beach, Palm Springs and Phoenix) for Canadians may diminish.

Climate change could also pose challenges for the operation of golf courses, particularly under the warmest climate change scenario. As the climate warms, there is likely to be greater demand for irrigation in some regions of the country to keep turf grass in optimal playing condition. The change in projected moisture deficits among the three study areas supports this[67]. During the summer, moisture deficits are projected to increase, becoming particularly severe in the Great Lakes region (increasing 24% in the 2020s, 40% in the 2050s and 85% in the 2080s).

Aspects of pest and disease management could also be impacted by projected changes in the climate, posing challenges to the maintenance of playing conditions and the perception of what a healthy golf course resembles. Insect pests that currently have only one life cycle in many parts of Canada could begin to have two life cycles under warmer conditions[68]. Warmer average winter temperatures and less natural snow cover could reduce the occurrence of some winter turf grass diseases (e.g., snow moulds), but summer diseases that thrive in warm humid conditions (e.g., Brown Patch and Dollar Spot) could become more problematic. Turf grass diseases and pests currently limited to latitudes that are more southerly could also expand northward and require management interventions. It remains uncertain how changes in irrigation and turf grass disease/insect management would affect the ability of golf course managers in different regions of Canada to take advantage of opportunities for a longer and more intensive golf season under climate change.

Figure 6. Projected changes in the golf sector in Canada





BEACH RECREATION

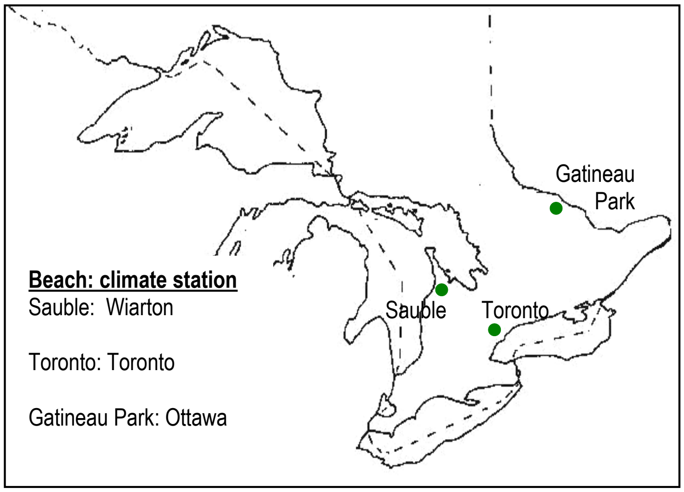
Public access to Canada's multitude of lakes and beaches provides Canadians with a range of leisure opportunities. Beaches, for example, provide opportunities for sunbathing, beach volleyball, leisure walks, picnicking, and depending on the location, campfires. The shallower near-shore environments of the country's numerous lakes provide ample opportunities for public swimming in the summer.

Public use of lakes and beaches in Canada is highly seasonal. Use tends to be highest during the summer, particularly during heat waves, as beaches provide a popular refuge for urban residents escaping the heat and humidity. As climatic conditions suitable for public swimming and beach use are extended, and heat waves potentially become more common under a changed climate[69,70], the popularity of public beaches throughout Canada is likely to increase. Previous climate change studies have speculated that lower water levels on the Great Lakes, for example, will expose more beach area and increase beach recreation[71–73]. Because there is currently no shortage of beach area, we contend that this is unlikely to be the case, and thus we focus solely on the more salient direct influence of climate on beach recreation in this study.

Previous research has endeavoured to develop climatic thresholds for warm-weather outdoor recreation in Ontario, including beach recreation (e.g., Crowe et al., 1977 [74])†. In this study, we employ temperature thresholds for swimming (at least 23°C) and beach use (at least 15°C) originally developed through statistical analysis of climate and actual visitor data to public beaches in Ontario[58]. As a result, we are focusing our pilot study in Ontario (Figure 7). Validation of these thresholds, either through consultations with recreation providers or participants, is needed before expanding the analysis to other regions of Canada.

† Beach recreation (e.g., humidex >21°C and winds less than 24 kph)

Figure 7. Beach recreation study areas



Southern Georgian Bay Beaches

Ontario's most popular beach destinations are located on the southeastern shores of Lake Huron and Georgian Bay (Figure 7), a region that has the longest freshwater beaches in the world (Sauble Beach and Wasaga Beach). Sauble Beach is ranked as the premier beach destination in Ontario[75,76]. The current average swimming season in this region is 59 days, encompassing essentially the months of July and August (Table 11). Under a warmer climate, the swimming season is projected to be 15 to 40 days longer as early as the 2020s and 23 to 76 days longer in the 2050s. In the 2080s, the warmest climate change scenario projects a swimming season almost three times longer than at present.

As the regional climate warms, the season for beach recreation will also be extended. Currently, climatic conditions limit public use of the region's sandy beaches for lightly dressed, warm-weather activities to about 152 days out of the year; typically from mid-May to mid-October (Table 11). The beach recreation season is projected to be extended nine to 30 days in the 2020s and 14 to 64 days in the 2050s. In the 2080s, the season for beach recreation is projected to be extended 20 days (to 172 days) under the

Table 11. Projected season lengths for the public use of lakes and beaches (days)

Beach use	1961-90		2020s	2050s	2080s
Wiarton	152	NCARPCM B21	161	166	172
		CCSRNIES A11	182	216	239
Toronto	167	NCARPCM B21	176	180	187
		CCSRNIES A11	196	229	252
Ottawa	158	NCARPCM B21	168	172	177
		CCSRNIES A11	185	210	227
Swimming					
Wiarton	59	NCARPCM B21	76	83	88
		CCSRNIES A11	99	135	158
Toronto	86	NCARPCM B21	102	107	113
		CCSRNIES A11	122	152	172
Ottawa	80	NCARPCM B21	97	102	107
		CCSRNIES A11	113	140	159

least-change climate change scenario. Under the warmest climate change scenario, the beach recreation season could be extended 87 days (over 12 additional weeks) for a season length of 239 days.

Toronto's Waterfront

The City of Toronto, located on Lake Ontario, operates 14 public beaches along its waterfront, many of which are staffed with lifeguards between June and September. At present, the climatically suitable swimming season along Toronto's waterfront averages about 86 days (Table 11). As climatic conditions suitable for outdoor swimming improve and the warm-weather recreation season is extended, Toronto's average swimming season is projected to be extended between six and 36 days in the 2020s and between 11 and 66 days in the 2050s. Under the warmest climate change scenario for the 2080s, Toronto's swimming season is projected to double (from 86 days to 172 days).

Toronto's beach recreation season is among the longest in the Province, averaging approximately 167 days (mid-May to late-October) (Table 11). The beach recreation season is projected to be extended 9 to 24 days in the 2020s and 13 to 62 days in the 2050s. In the 2080s, the beach recreation season is projected to range between 187 days (20 additional days) and 252 days (85 additional days).

Gatineau Park

Located in Canada's National Capital Region (Ottawa-Gatineau), Gatineau Park is a popular summer recreation destination for locals and visitors to eastern Ontario. The six public beaches in the park are staffed with lifeguards in the summer months[50]. On average, the current swimming season in Gatineau Park is 80 days, stretching from mid-June to the Labour Day weekend in September. Under warmer climatic conditions, the swimming season is projected to be extended 17 to 33 days as early as the 2020s and 22 to 60 days in the 2050s (Table 11). In the 2080s, both climate change scenarios project swimming seasons in excess of 100 days, with the warmest climate change scenario projecting a doubling of the swimming season (from 80 days to 159 days).

Gatineau Park's season for beach recreation is approximately 158 days (May to October). In the 2020s, the beach recreation season is projected to be extended 10 to 27 days and 14 to 52 days in the 2050s. In the 2080s, the warmest climate change scenario projects that the beach season could be extended 69 days (six additional weeks), contributing to a 200-day beach recreation season in Gatineau Park.

Management Issues

As the beach recreation season in different regions of Ontario becomes longer under climate change, a number of issues may pose challenges to maintaining the quality of the beach experience for locals and visitors. Higher visitor levels during the peak summer period could lead to overcrowding and conflicts among beach users in isolated locations. The development of new tourism-related beach businesses (e.g., restaurants, souvenir shops) to take advantage of new climate-induced beach opportunities may cause conflicts with local residents (e.g., communities of Sauble Beach, Goderich, Wasaga Beach; Georgian Bay cottage owners) who may object to the development and promotion of an extended season. With a longer season outside of July and August summer holiday period, government agenicies will need to determine whether to provide lifeguard service to ensure public safety. Government agencies may have some difficulty with staffing however, particularly with respect to student lifeguards, who will still be in school during these periods.

Warmer summers may have a negative impact on water quality. As lake bodies warm, their oxygen-carrying capacity is diminished, which can contribute to enhanced algae growth and other water pollution[77]. Bacterial contamination could also degrade the aesthetics of beaches and pose a health risk to swimmers. How climate change may affect the frequency of beach closures and swimming bans remains uncertain, but increased water testing and public communication may be required in the future.



CAMPING

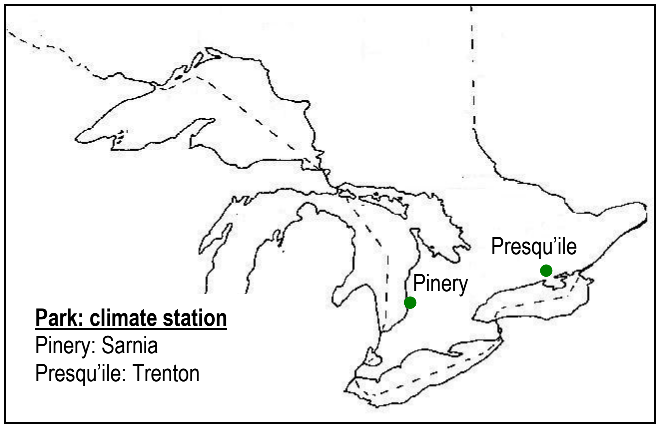
Camping is a popular recreational pursuit for many Canadians. For example, approximately 1.5 million people camped in Alberta's provincial parks in 2002/03[78]; 1.7 million people camped in Ontario's provincial parks in 2003[79]. The camping experience can range in duration from a single weekend (e.g., July 1 long weekend) to extended periods of time (e.g., many weeks). Canada has a diverse system of campgrounds, which includes local campgrounds with many visitor amenities to more remote, wilderness settings.

Provincial parks are an important camping resource in Canada, and in many parks, it is a year-round activity. However, campground use tends to be highly seasonal, with the highest demand for campsites occurring during the summer months of July and August when climatic conditions are generally suitable and most Canadians have school and work-related holidays.

Similar to skiing and beach recreation, previous research has endeavoured to develop climatic thresholds for camping (i.e., Crowe et al. 1977[74]), and to use these thresholds to assess changes to camping in Ontario's provincial parks under climate change[74,80]‡. However, these climatic thresholds, which were developed through consultation with recreation providers, were not validated with camping participation data. Further, the climate change impact assessment that used Crowe et al.'s (1977) thresholds could only explore season length, not changes in demand. In this study, we conducted a reassessment of camping in Ontario's provincial parks to determine if season length projections (based on participation data) would be the same, and examined implications for demand and campground capacity issues. Two parks were examined — Pinery and Presqu'ile (Figure 8).

‡ Reliable camping season: days with a daily maximum temperature of at least 18°C (or humidex values of at least 12°C).

Figure 8. Camping study areas



Pinery Provincial Park

Pinery Provincial Park, located on the shores of Lake Huron, is a popular destination for residents in southern Ontario (~500,000 people annually)[79]. The park has 1,000 campsites, making it the second largest camping destination within Ontario's provincial park system after Algonquin Provincial Park (1,312 campsites)[79]. Peak demand for Pinery's campsites is in July and August (Figure 9).

Assuming current levels of camping demand and supply remain unchanged Pinery Provincial Park could experience pressure in the next two decades to open additional campsites during the peak camping period of July and August. Occupancy rates during July and August are projected to increase modestly from a current average of 89% (~890 campsites per day) to 92% in 2020s under the least-change climate change scenario, with only minimal increases toward the middle and end of the century (Figure 10). Under the warmest climate change scenario however, average summer occupancy rates are projected to be 97% in the 2020s, and 105% and 112% in the 2050s and 2080s, respectively. The latter two figures suggest that Pinery Provincial Park would not have enough campsites to meet peak demand. If population growth is also considered, the campground could reach full capacity in July and August as early as the 2020s.

Occupancy rates during the park's shoulder season (September to June) are also projected to increase under climate change. Currently, camping demand is much lower during the shoulder season, only averaging 9% (~90 campsites per day) between September 1 and June 30. In the 2020s, the average occupancy rate in the shoulder season is projected to increase to between 10% and 13% and to between 11% and 18% in the 2050s (Figure 10). Increases in camping demand are projected to occur throughout the year (Figure 10). Under the warmest climate change scenario, average shoulder-season occupancy rates could be as high as 23% in the 2080s. However, the most significant increases in camping demand will occur during the spring (May and June) and fall months (Figure 10). In the 2080s, it is projected that 76% of Pinery's camping demand will occur between May and September, compared to only 50% today.

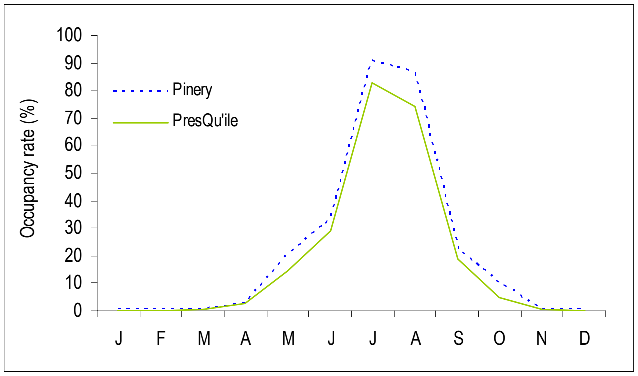
Presqu'ile Provincial Park

Presqu'ile Provincial Park is located on the eastern shores of Lake Ontario near the community of Kingston. With 394 campsites[79], Presqu'ile's camping capacity is considered mid-size, and is fairly representative of the number of campsites contained in most of Ontario's popular provincial-park camping destinations. Peak demand for campsites at Presqu'ile is also during July and August (Figure 9).

Under a warmer climate, Presqu'ile Provincial Park's campgrounds could come close to reaching full capacity during the summer months of July and August. Occupancy rates during July and August are projected to increase moderately under both climate change scenarios from a current average of 79% (~311 campsites per day) (Figure 10). In the 2020s, occupancy rates during these two months are projected to increase to between 80% and 82% and to between 81% and 86% in the 2050s. By the end of the century (2080s), summer occupancy rates are projected to range between 82% and 90%.

Occupancy rates during the park's shoulder season (September to June) are also projected to increase, but to a lesser degree than in Pinery Provincial Park. Camping demand during Presqu'ile's shoulder season only averages 7% (~28 campsites per day). In the 2020s, the average shoulder occupancy rate is projected to increase to between 8% and 11% and to between 9% and 16% in the 2050s (Figure 10). The most significant increases in camping demand will occur during the spring months (April to June)

Figure 9. Average monthly occupancy rates, 1996–2001



(Figure 10). Under the warmest climate change scenario, average shoulder-season occupancy rates (~21%) in the 2080s could be similar to that of Pinery Provincial Park. In the 2080s, it is projected that 66% of Presqu'ile's camping demand will occur between May and September, compared to only 43% today.

Reassessment Comparison

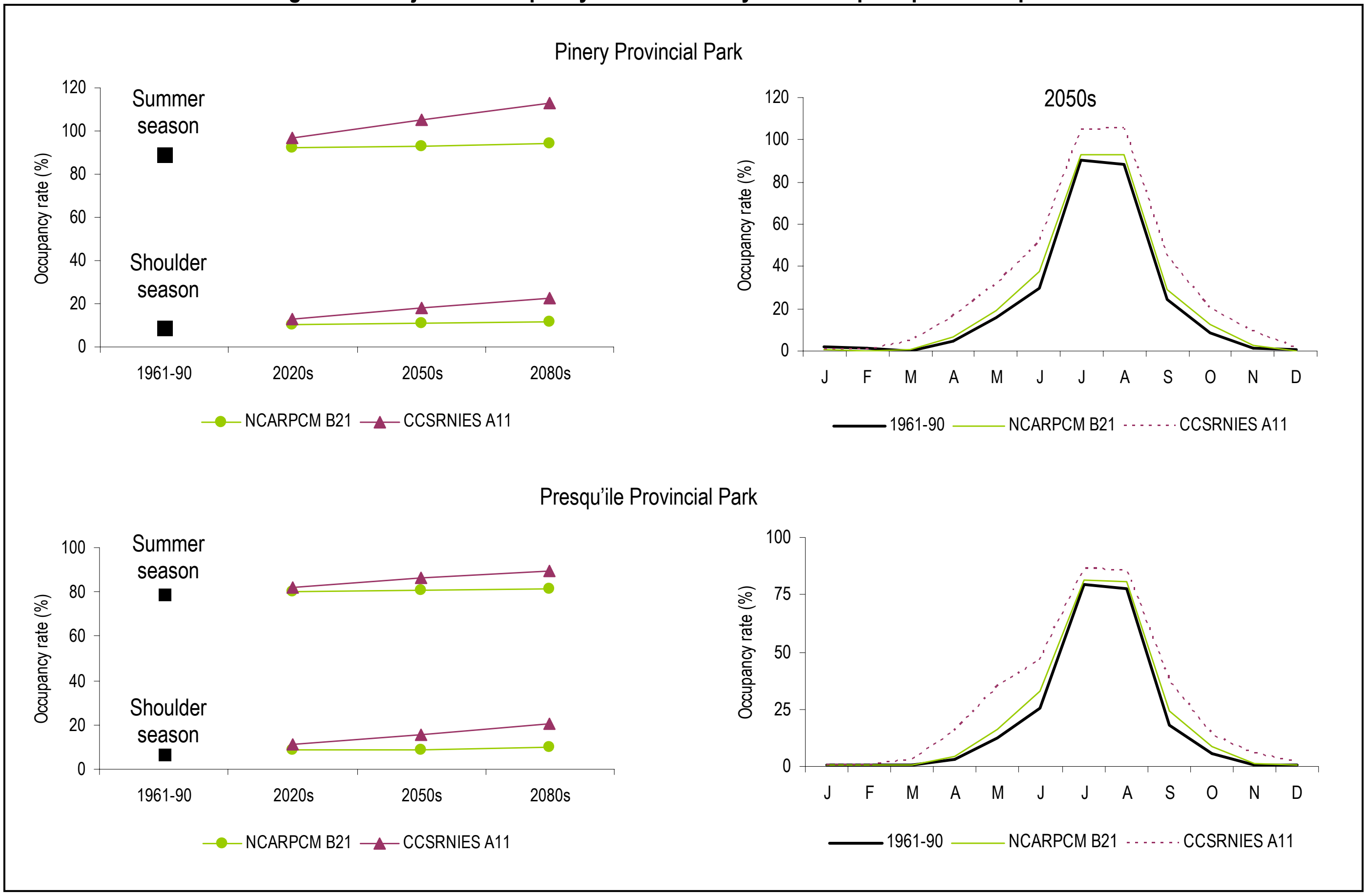
The results of this study indicate that there could be increased use of campgrounds at Pinery and Presqu'ile provincial parks as Canada's climate warms during the 21st century. The results of this study were generally consistent with an earlier study by Wall et al. (1986)[80]. Although the camping analysis in this study did not directly assess season length, use of specific occupancy rates resulted in similar camping seasons projected by Wall et al. (1986) (Table 12).

Table 12. Camping season comparison

Study	Season	Pinery	Presqu'ile
Wall et al. 1986[80][1]	Reliable[a]	mid May to late Sept	mid May to early Sept
	Marginal[b]	Apr; Oct	early May; late Sept
This study[2]	Reliable[a]	May to Sept	May to Sept
	Marginal[b]	Apr; Oct	Oct

[1] based on temperature threshold: a) at least 18°C; b) 11 °C to 18°C
[2] based on occupancy rate: a) at least 30%; b) 15 to 29%

Figure 10. Projected occupancy rates for Pinery and Presqu'ile provincial parks



Management Issues

Although the geographic scope of the camping analysis is limited, it would appear that the camping industry in Ontario would be impacted positively under climate change. Individual provincial parks would benefit economically, as longer camping seasons would contribute to substantially higher revenues for Ontario Parks (e.g., from service fees). Private and public campgrounds elsewhere in the Province are likely to experience similar benefits.

The increased use of campgrounds and changes in the timing of that use identified in this study however could create challenges for management. Higher use of campgrounds during peak periods (e.g., July and August) could exacerbate crowding issues at popular campgrounds, and make advance reservations even more difficult at some parks. If crowding becomes a critical issue for visitors, park mangers may experience pressure to develop additional campsites. Depending on the experience campers seek (e.g., weekend get-away, get out of the city for peace and quiet, wilderness adventure), crowding may serve as an important motivator for some user groups to seek out smaller, less visited or even more remote provincial parks for their camping trip. As mentioned earlier, changes in the seasonal demand for campsites could also place pressure on Ontario Parks to extend the season in which they provide certain services (e.g., food, firewood, water, rentals).

Higher use of campgrounds in Ontario's provincial parks and extended camping seasons could result in additional staff costs for environmental services and park patrols in order to ensure visitor safety and compliance with regulations (e.g., alcohol or open fire bans). In 2003, park wardens and other park staff accumulated more than 21,000 person-days of employment[79]; this would certainly increase in the future. The additional stress placed on existing park (roads, trails) and campground infrastructure (fire pits, showers, water systems) could also lead to increased maintenance costs. A detailed economic analysis would be required to determine whether the additional revenue (using Ontario Parks' existing fee structures) that would be generated from higher visitation would be sufficient to offset additional operating costs.



CONCLUSIONS

Outdoor recreation is an important element of Canada's tourism industry. This executive summary has highlighted the importance of climate for several major outdoor recreation sectors in Canada. It has also demonstrated that projected changes in the climate over the next century will create opportunities for some outdoor recreation sectors and pose substantial challenges for other sectors.

Summary of Findings

Winter recreation in Canada is at risk to climate change. The alpine skiing industry in Ontario and Québec is projected to be negatively impacted, although not nearly to the extent projected in earlier studies that did not incorporate snowmaking. Snowmaking will help minimize the negative impact of less natural snow in the decades to come, but the associated economic costs may become too high for some smaller ski operations. Snowmobiling, as it relies entirely on natural snowfall, is at greater risk to climate change. The magnitude of snowmobile season losses is far greater than for alpine skiing. Under the warmest climate change scenario, snowmobiling opportunities would largely be eliminated by the middle of the century in the highly populated areas of Ontario and Québec.

Warm-weather recreation in Canada is projected to benefit from changes in the climate. For example, annual rounds of golf played are projected to increase, and as the climate warms, the golf season is projected to be extended in most regions of the country. The season length for the public use of lakes and beaches will also be extended at many popular beach destinations; in some cases, the season is projected to double by the end of the century. In addition, it is projected that demand for campgrounds will increase, and a warmer climate could lead to the extension of current camping seasons in the decades to come.

Future Research

Canada would be a very different country under the climate change scenarios projected for the 2050s and 2080s, and this study has demonstrated these climatic changes could have important implications for the outdoor recreation and tourism industry in Canada. Climate change will need to be considered in strategic planning so that the outdoor recreation industry can realize opportunities of a changed climate and confront the challenges posed by a changing climate in a sustainable manner.

Climate change is a very complex and rapidly evolving research and policy area. This study has identified a number of additional research areas.

- Climate change is only one factor that will influence outdoor recreation in the decades to come. Research is needed that examines how climate change may interact with other social (i.e., population growth, ethnic diversity, aging society), economic (i.e., cost of participation, recreation supply and operation) and environmental change factors to determine the net impact on the future of specific sectors.

- Extremely warm summers, cool wet springs and heavy precipitation events have an impact on different aspects of the golf sector, just as warm winters and poor snow conditions influence different aspects of the snowmobiling sector. Analysis of the impact of these events (called 'climate analogues') on outdoor recreation should be undertaken to improve our understanding of the vulnerability of individual outdoor recreation and related tourism sectors to climate variability and the effectiveness of climate adaptation strategies.

- This assessment focused exclusively on the potential impacts of climate change for outdoor recreation and did not explicitly examine these changes in the context of regional competitors or tourism markets. An important dimension of future research would be to expand the geographic scope of this research and assess the potential impacts of climate change on a recreation sector's regional and international competitors in order to understand more fully the climate change implications that sector (i.e., where transfers of recreation/tourism demand may occur).

- With longer warm-weather outdoor recreation seasons (e.g., walking, hiking, gardening, swimming, golf), general health benefits (physical and mental) could be realized in virtually all Canadian communities because a greater proportion of the population engage in such activities. An important avenue for future research will be collaborations between health professionals and the recreations sector to asses the potential benefits of climate-induced changes in seasonality on human health.

- A successful adaptation to climate-induced natural seasonality is the development of four-season recreation and tourism destinations, yet little is known about the viability of four season operations under a changed climate. For example, it remains uncertain at this time whether longer golf seasons would offset losses associated with shorter ski seasons at four-season resorts in central Ontario. Research is needed that examines the differential vulnerability of outdoor recreation sectors and related businesses in major tourism regions to climate change as a system.

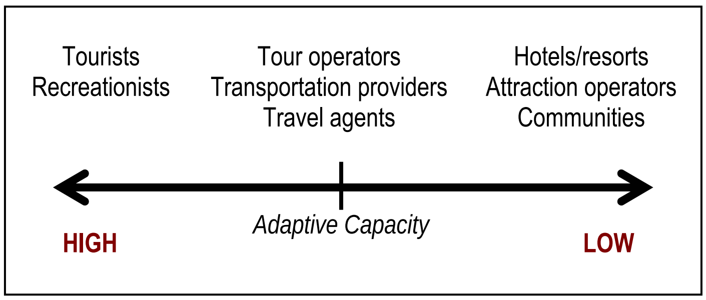
- Research into how tourists perceive and respond to climate change with respect to outdoor recreation is in its infancy. Survey-based research is needed to understand demand-side adaptations of recreationists, particularly how recreationists may respond to climate-induced changes in natural seasonality.

- Lack of data and unwillingness to participate were major barriers limiting the geographic scope of this study. With limited participation of local tourism stakeholders, the potential economic impact of climate change is difficult to ascertain and remains an important uncertainty.

- The recreation and tourism industry is thought to have high adaptive capacity, although adaptive capacity varies between seasonal activities (e.g., winter and warm-weather sectors), actor groups (e.g., between tourists and tourism business operators) and within actor groups (e.g., between individual ski area operators). Differences in adaptive capacity are illustrated conceptually in Figure 11. Future progress in understanding the level of vulnerability of specific outdoor recreation sectors to climate change (i.e., winners and losers), climate adaptation options, the role of other stressors in recreation operations and the business perceptions of climate change will require the involvement of communities and the tourism industry.

- Tourism stakeholder awareness of climate change is growing(81-83). For example, the golf course advisory panel at the Royal and Ancient Golf Course of St. Andrews (Scotland) identified climate change as one of six strategic issues facing the golf industry over the next twenty years(81), while the chief executive officer of Aspen Skiing Company recently referred to climate change as the most pressing issue facing the ski industry today(82). Climate adaptation research in the outdoor recreation and tourism sector is about five to seven years behind other economically important sectors in Canada (i.e., agriculture, water resources, construction)(84). Inadequate consideration of adaptation in climate change vulnerability studies within the tourism-recreation sector has lead to overestimates of future risk. Future research in this area needs to identify the minimum range of adaptation options available and discuss how adaptation could alter projected impacts. It is hoped that such an approach will help engage tourism stakeholders in collaborative work in the decades to come.

Figure 11. Conceptual model of adaptive capacity in the tourism sector



Final Thoughts

The United Nations Intergovernmental Panel on Climate Change and the Government of Canada have both indicated that despite efforts to reduce greenhouse gas emissions, some level of human-induced climate change will need to be realized in the 21st century. This study has demonstrated that climate is important to outdoor recreation and tourism in Canada and that projected changes in the climate will create disparate challenges and opportunities among recreation sectors. It is apparent then that given the economic importance of outdoor recreation to Canada's economy, climate change adaptation is a necessary policy strategy for the industry.

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