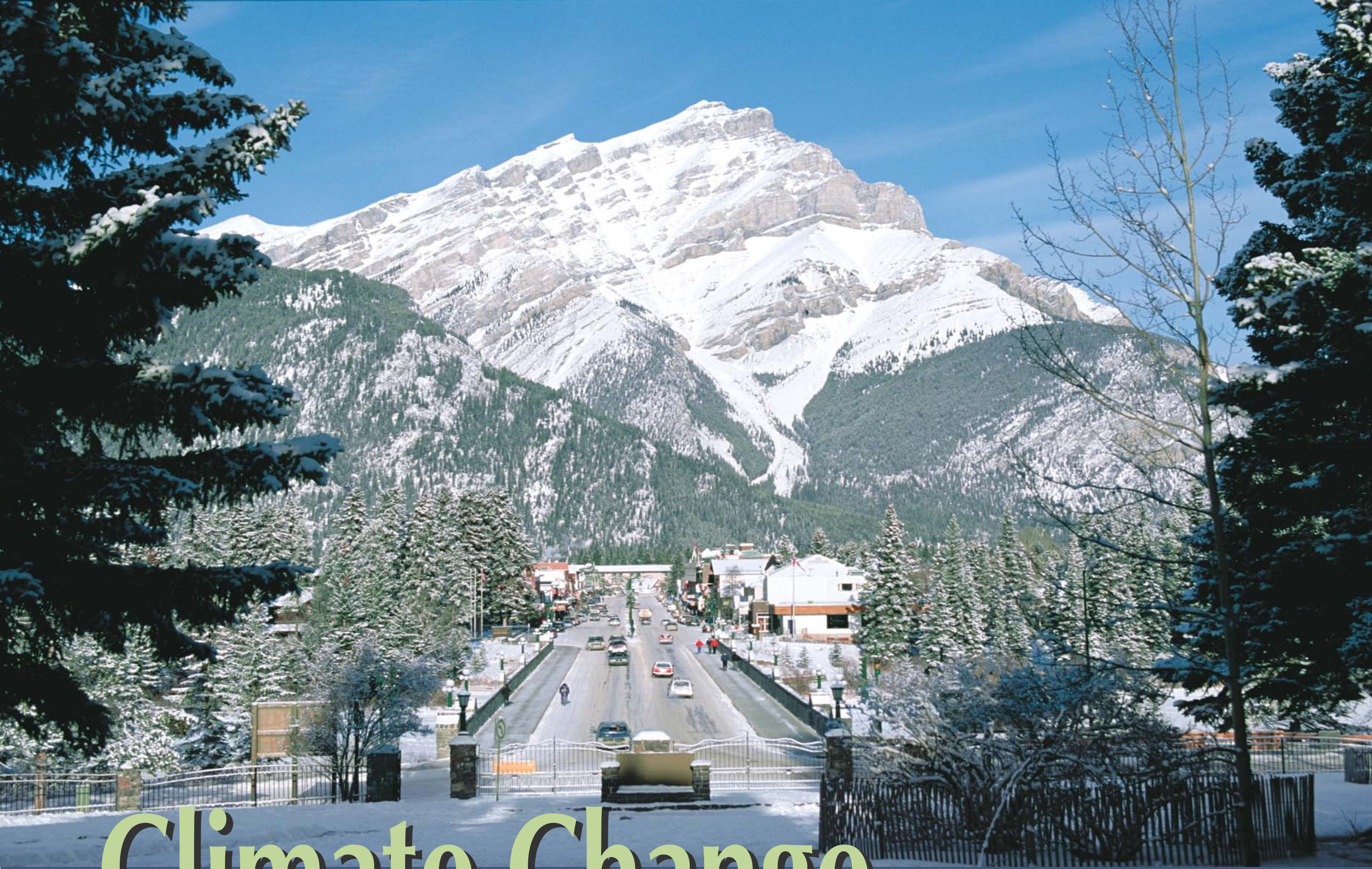

Climate Change & Banff National Park

IMPLICATIONS FOR TOURISM AND RECREATION

University of Waterloo

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Daniel Scott and Brenda Jones
Faculty of Environmental Studies, University of Waterloo

For further information, contact:
Dr. Daniel Scott
Canada Research Chair in Global Change and Tourism
Faculty of Environmental Studies
University of Waterloo, Waterloo, Ontario CANADA N2L 3G1
519.888.4567 ext. 5497; dj2scott@fes.uwaterloo.ca

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Background

National parks are important to Canada's tourism industry because their diverse natural environments and range of recreational amenities attract millions of people annually. The Rocky Mountain national parks are some of Canada's most internationally recognized and popular tourism destinations.

Banff National Park is one of Canada's oldest and most successful tourism destinations[1]. Established in 1885, Banff National Park encompasses over 6,600 square kilometres of mountains, glaciers, forests, alpine meadows, lakes, rivers and springs. Located within Banff National Park's boundaries is the Town of Banff (and the Hamlet of Lake Louise), an incorporated municipality situated on land (~5km^2) leased from the Canadian government. The Town of Banff is a world-class resort destination, service centre for park visitors, and home to around 8,300 permanent residents. For the purpose of this report, Banff National Park and the Town of Banff (and the Hamlet of Lake Louise) are collectively referred to hereafter as the destination Banff.

TOURISM AND RECREATION IN BANFF

The natural environment is both Banff's central attraction and the primary reason for its existence. Banff is a year-round tourism destination, attracting nearly as many people during its five-month winter season as it does during its three-month summer season[1]. Approximately three million people visit Banff annually, generating over C$700 million in direct tourism expenditures[2].

A wealth of recreation and tourism opportunities abound in Banff for locals and visitors. During the warm-weather months, people can enjoy site-seeing tours, canoeing, white-water rafting, fishing and hiking, biking and horseback riding on hundreds of kilometres of nature trails. Top-rated golf courses in Banff and nearby communities are major tourist attractions for visitors to Banff. The Fairmont Banff Springs operates an 18-hole championship golf course and a smaller regulation 9-hole course in the Town of Banff; there are also 11 golf courses near Banff (located mainly in community of Canmore). Glaciers are an important natural attraction in Banff. The Columbia Icefield is the premier glacial destination in the park, as visitors can participate in guided glacier tours and ice climbing adventures or self-guided walking tours on the terminus of the Athabasca Glacier. Winter recreational resources in Banff include alpine skiing at the area's three ski areas (Mount Norquay, Sunshine Village, Lake Louise), hundreds of kilometres of cross-country skiing and snowshoeing trails, and ice skating on frozen, glacier-fed lakes (e.g., Lake Louise).

TOURISM / RECREATION AND CLIMATE

Climate refers to average weather. More accurately, it is defined as the long-term average of weather for a specific place and time period. Many studies[3–6] document the importance of climate for tourism and recreation, and Banff is no exception. Climate influences tourism and recreation in two main ways:

Directly — by defining the length (e.g., skiing and golf operating seasons) and quality (i.e., overall comfort and enjoyment of outdoor activities) of tourism and recreation seasons and influencing tourist demand (i.e., natural seasonality);

Indirectly — by impacting the environmental resources (e.g., water levels, snow cover, glacier extent, biodiversity) on which tourism depends.

Because of the importance of outdoor recreation in Banff, its tourism industry is sensitive to extreme weather and potential changes in the climate. Over the last five years, aspects of Banff's tourism industry have been impacted by adverse climatic conditions (see Box 1).

Box 1. Recent examples of the adverse impacts of weather and climate on tourism in Banff

1999 — 62 cm of snow and 122 mm of rain in two days in July contributed to a slowdown in tourism business in Banff and cancellations to tour operators[7]

2003 — Forest fires forced the closure of hiking trails in Banff (e.g., Sulphur Mountain, Johnston Canyon, Morraine Lake)[8]

2004 — Above normal February temperatures contributed to an avalanche that killed three ice climbers[9]

2005 — Mount Norquay ski area closed for several days in January due to extremely cold temperatures (-40°C)[10]

IS BANFF'S CLIMATE CHANGING?

A location's climate is normally defined by climatologists using at least 30 years of observed weather data. 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 the Banff climate station suggest the local climate has been changing over the past seven decades. Mean annual temperatures have increased 1°C since the 1940s (Figure 1), with minimum temperatures showing the largest increase during this time. Winters (December, January, February) in Banff are also warmer now than they were 70 years ago. On average, winters are 1.2°C warmer now than they were in the 1940s. The winter of 2002/03, for example, was 1.6°C warmer than Banff's long-term average; the warmest winter since the 1940s (1985/86) was 3.6°C above the long-term average. On average, Banff receives less precipitation now than it did in the 1940s. Annual precipitation has decreased 5% since 1938. Annual natural snowfall has demonstrated substantial inter-annual variability over the last 70 years (Figure 2). Total annual snowfall increased in the three decades between 1940 and 1970, but has decreased 40% since peaking in 1971.

Trends at the Banff climate station are generally consistent with observed changes in the southern interior mountain region of British Columbia[11] and the southern Canadian Rocky Mountain region[12]. Over the last century, mean annual temperatures in the southern interior mountain region of British Columbia have increased 1.1°C; mean winter (December, January, February) temperatures have increased 1.8°C. However, unlike Banff, average annual precipitation in this region has increased, and winter precipitation shows no statistically significant trend, nor does snow depth. When data for 1888 to 1994 from multiple climate stations in the southern

Figure 1. Long-term trend in Banff's mean annual temperature

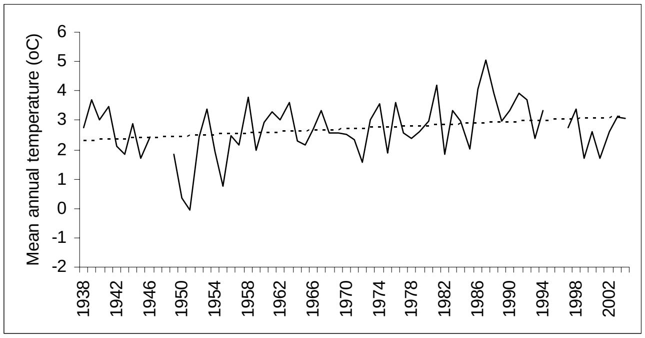
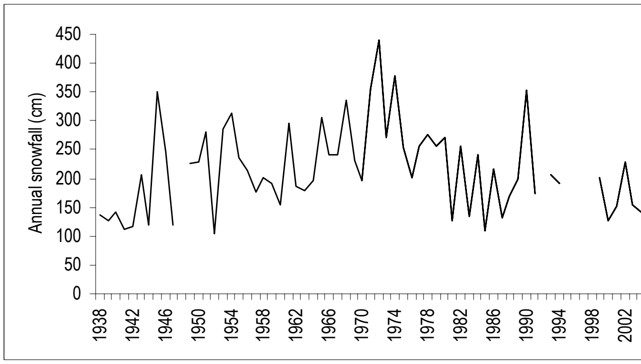


Figure 2. Banff's annual snowfall since the 1940s



Canadian Rocky Mountains (including Banff station) were analyzed, a much stronger warming trend was observed. According to the study[12], mean annual temperatures in the mid-1990s in the southern Canadian Rocky Mountains were 1.4°C warmer than 100 years ago; winters were 3.4°C warmer than a century ago.

BANFF'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 generally refer to 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). The changes projected for each future period reflect changes with respect to a baseline period (1961–90).

		Annual	Spring	Summer	Fall	Winter
Temperature change (°C)	2020s	+1.1 to +1.2	+0.8 to +1.7	+1.1 to +1.1	+1.1 to +1.2	+0.3 to +1.7
	2050s	+1.6 to +4.8	+1.4 to +5.1	+1.9 to +3.8	+1.6 to +4.3	+1.4 to +5.9
	2080s	+2.1 to +7.1	+1.5 to +6.7	+2.3 to +6.3	+2.0 to +6.6	+2.7 to +9.0
Precipitation change (%)	2020s	-4 to +5	0 to +9	-15 to +8	+1 to +3	-1 to -1
	2050s	+4 to +7	+3 to +15	-2 to +5	+6 to +11	-3 to +12
	2080s	+15 to +16	+14 to +17	+13 to +16	+8 to +18	+10 to +27

Table 1. Climate change projections for Banff

Based on the best available science[(13)], climate change projections for the Banff area are provided for the three aforementioned time periods — the 2020s, 2050s and 2080s (Table 1). Banff's climate is projected to continue to become warmer under climate change. Global climate models (GCMs) project that relative to the 1961–90 baseline period, Banff's mean annual temperature will increase between 1.1°C and 1.2°C in the 2020s, 1.6°C and 4.8°C by the middle of this century (~2050s) and between 2.1°C and 7.1°C by the end of the century (~2080s). Of the four seasons, winters (December, January, February) are projected to experience the largest increases in temperature this century. Mean winter temperatures are projected to increase between 0.3°C and 1.7°C in the 2020s, 1.4°C and 5.9°C in the 2050s and between 2.7°C and 9.0°C in the 2080s.

Changes in temperature regimes could have important implications for many aspects of tourism in Banff. For example, warmer temperatures will contribute to an increase in growing degree-days, which in turn will alter vegetation patterns (e.g., bud break) and forest fire regimes. Increased evaporation during the summer could increase the need to irrigate golf courses. The probability of rain events and mid-season melts during the ski season will also increase as the climate warms. In addition, energy-use patterns and costs will change for all tourism businesses in Banff (as heating degree-days decrease and cooling degree-days increase) (Figures 3 and 4).

Banff is also projected to receive more precipitation under climate change (Table 1). In the 2020s, Banff is projected to experience a 5% increase in annual precipitation relative to the 1961–90 baseline period, although some models project a minor decrease in precipitation (-4%) for this period. By the middle of the century (2050s), Banff's annual precipitation is projected to increase between 4% and 7%, and between 15% and 16% by the end of the century (2080s). Spring and fall are projected to experience the largest increases in precipitation. Summer increases in precipitation, where projected, are not likely to be sufficient to offset increased evaporation. As a result, Banff could experience drier summer conditions.

Figure 3. Projected changes in heating degree-days[a]

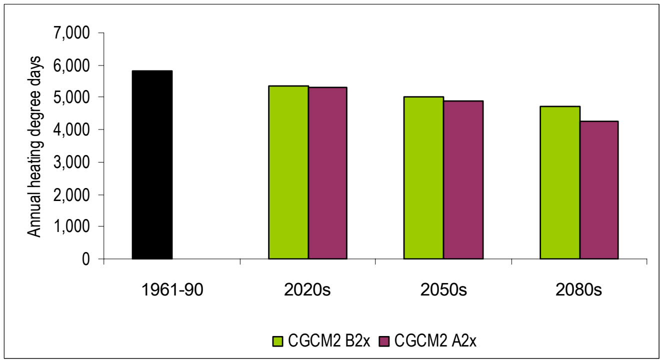
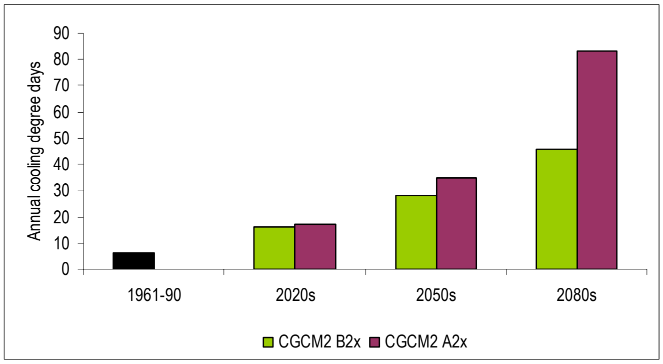


Figure 4. Projected changes in cooling degree-days[a]



[a] Accumulated departures in temperature (per year) above or below a particular threshold value; accumulated departures are averaged over a 30-year period

Heating degree-days: < 18°C; Cooling degree-days: >18°C

RESEARCH OBJECTIVES

The United Nations(13) and international community (including the Government of Canada) have concluded that some level of climate change in the 21st century is now inevitable, regardless of the success of collective efforts by governments, communities and individual citizens to reduce emissions of greenhouse gases. Consequently, it is necessary that the tourism industry assess the risks and opportunities climate change poses for its various sectors and develop appropriate adaptation strategies.

In a 2005 public survey(14), Canadians were asked about their perceptions of climate change and one in every two people indicated they were very concerned about the issue. Approximately 83% of Canadians indicated that municipal planners, engineers and natural resource managers should consider climate change in their planning initiatives.

This summary report presents the key results of a scoping-level climate change impact assessment conducted by the University of Waterloo for the Town of Banff (Environment Management Program). The assessment was undertaken to assess and draw attention to the potential impact of climate change on Banff's recreation and tourism industry. Specifically, the assessment examined three questions:

1. How does current climate variability affect visitor behaviour and recreation operations (e.g., ski season, snowmaking requirements) in Banff?

2. How might projected changes in the climate alter visitation levels and recreation operations in Banff?

3. How might climate change impact the natural environment that tourism and recreation in Banff depends on, and how might tourists respond to such changes?

This report provides an overview of the types of climate change impacts that could affect tourism and recreation in Banff. It identifies recreation sectors and tourism market segments that could be negatively affected by projected climate change and highlights new opportunities that may emerge as a result of a changed climate. The direct impacts of climate change are summarized first with respect to visitation to Banff National Park and Banff's ski and golf industries. Skiing and golf serve as indicators of winter and summer recreation seasons, respectively*. This is followed by a summary of the indirect impacts of climate change on visitation to Banff National Park. The broader implications of climate change for Banff's tourism industry and possible climate change adaptation strategies are discussed in the conclusion.

This assessment focused exclusively on the potential impacts of climate change for recreation and tourism assets in Banff. While the relative impacts of climate change on regional tourism markets and Banff's competitors (nationally and internationally) are clearly important for assessing the potential economic implications for Banff tourism, such an assessment was beyond the scope of the present study.

* It is recognized that more people may participate in other seasonal recreation activities (e.g., hiking, biking, canoeing). At the time of analysis, data on the number of visitors that participate in these activities or their economic value were not available. Thus, skiing and golf serve to provide a general indication of the potential changes in operating seasons under climate change.

Research Methods

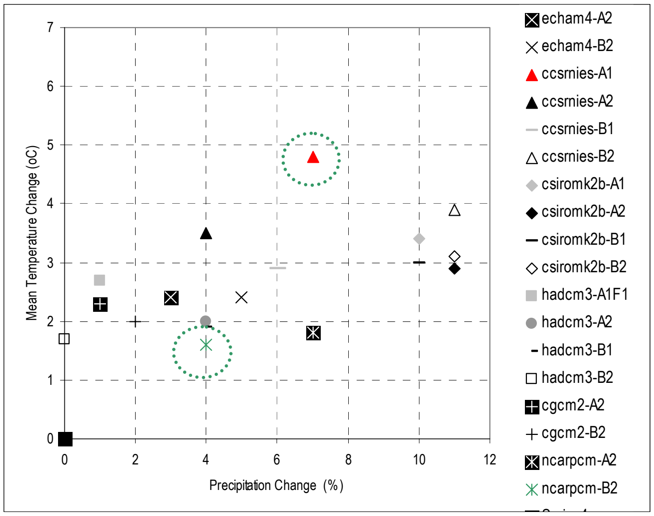
This scoping level climate change impact assessment focused on a range of key recreation activities and natural features in Banff's tourism and recreation industry. The nature of the physical resources that define the sensitivity of certain recreation activities to climate and the availability of data required the development of different assessment methods for each recreation sector analyzed. The methods for each component of the study are based on previous professional peer-reviewed research by the authors[15–22]. While the methods are briefly described here, readers are referred to these publications for further details.

CLIMATE CHANGE SCENARIOS

In order to capture a full range of potential future climates in Banff, two climate change scenarios were used in this study. The scenarios selected use global climate models 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 both research centres are approved by the United Nations Intergovernmental Panel Task Group for Climate Change Impact Assessments. Each of the GCMs are driven by different greenhouse gas emission scenarios from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios, which represent the range of high and low emission futures. The A1 scenario represents a future world with very rapid economic growth, a global population that peaks mid-century and declines thereafter, and rapid introduction of new technologies. The B2 scenario represents a world in which the emphasis is on local solutions to economic, social and environmental sustainability, with a continuous increase in population and intermediate economic growth.

The specific scenarios selected in this study are the NCARPCM B21 and CCSRNIES A11 scenarios. Figure 5 illustrates how these two scenarios (identified by dashed circles) compare with all other climate change scenarios available for the Banff region. The NCARPCM B21 scenario projects a small increase in temperature over the course of this century, while the CCSRNIES A11 scenario projects a substantial warming. These two scenarios effectively represent the high and low ends of anticipated change in the Banff region, and in this document are referred to as the 'least-change' climate change scenario (NCARPCM B21) and the 'warmest' climate change scenario (CCSRNIES A11). Climatic changes under these two scenarios are relative to the 1961–90 baseline, which is denoted as a black square (■) on graphs in this document. A third GCM is used in the winter recreation sections because of its previous use for snowfall modelling in western Canada. Done by the University of British Columbia (Faculty of Forestry), this scenario projects climatic changes near the least-change scenario (see Figure 5). The least-change climate change scenario (NCARPCM B21) signifies climate changes that are now thought to be inevitable regardless of foreseeable actions by governments and individuals to reduce greenhouse gas emissions.

Figure 5. Climate change scenario selection (annual—2050s)



DIRECT IMPACTS OF CLIMATE CHANGE ON TOURISM AND RECREATION

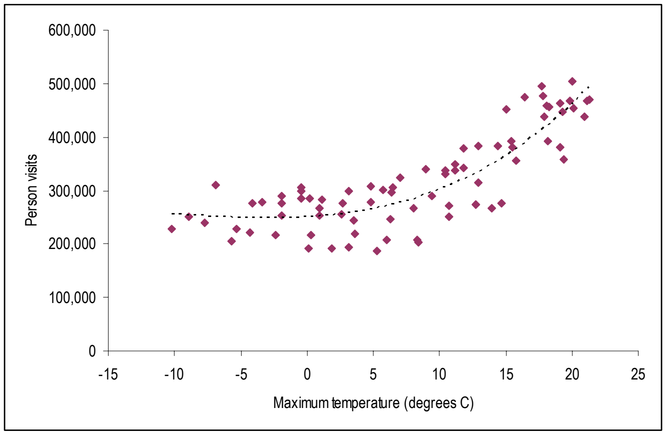
Visitors to Banff National Park

Banff National Park attracts more people than any other national park in Canada. An empirical assessment of park visitation was undertaken to determine how visitation patterns may be altered by climate change. The assessment of park visitation also considered the potential impacts of demographic change through to the 2020s, and the synergistic impacts of climatic and demographic change.

Climate change

To assess the direct impact of climate change on visitation, statistical analysis (regression) was used based on methods developed by the research team[17,19]. Regression analysis was first used to develop a model of the current relationship between climate and monthly person visits to Banff National Park during its peak (July and August) and shoulder (September to June) tourism seasons (Figure 6). This analysis was based on visitation data provided by Parks Canada for the 1996 to 2003 tourism seasons. The resulting regression model was then used to model visitation for a climatologically average year during the 1961–90 baseline period. The model was then run with the two climate change scenarios to project changes in the monthly number of people visiting Banff National Park with the types of climates projected for the 2020s, 2050s and 2080s. The regression model performed well, as modelled annual visits to Banff National Park were within 5% of observed visits.

Figure 6. Regression relationship for Banff's shoulder season



Without data that correlates activities (e.g., skiing, hiking) with visitors, the climate change projections presented in this analysis provide insight into the expansion of suitable climatic conditions for warm-weather recreation and tourism. Any impacts on the length of the winter recreation seasons are examined separately.

Demographic change

The proportion of people of Canadian and international origin visiting Canada's national parks varies by park depending on natural and recreational amenities and accessibility. Parks Canada estimates that system-wide most visitors to its national parks are from Canada (~70%), while the remainder come primarily from the United States[23]. Town of Banff documents suggest that Canadians account for 80% of the visitors to Banff[1]. The Province of Alberta[24] estimates that Canadians represent 70% of all visitors to the Rocky Mountain Tourism Destination Region (TDR) (with 58% from Alberta), while 14% are from the United States and 16% from overseas. Regardless of the proportions, population growth and demographic changes in Canada and the United States over the next two decades could interact synergistically with climate change to influence future visitation levels in Banff National Park.

The 'soft outdoor adventure' tourism market encompasses many of the recreational activities pursued by visitors to Banff National Park (e.g., hiking, canoeing, biking). According to the Canadian Tourism Commission, this tourism market is projected to increase 9% in Canada and 25% in the United States by 2025[25]. Using both visitor ratios (Parks Canada — 70% Canadian, 30% US/international; Town of Banff — 80% Canadian, 20% US/international) and the projections for the soft outdoor adventure market, the projected impact of demographic change on visitation to the mid-2020s was estimated.

Alpine ski industry

In order to assess the impact of climate change on Banff's alpine ski industry, a ski operations model was established. The model consists of several subcomponents (physically based snow model, snowmaking module, ski operation decision rules and climate change scenarios) and is based on earlier research in eastern North America by the research team[15,16,18]. Detailed explanation of the snow operations model can be found in these publications, but a brief summary is provided below.

A physically based snow-depth model, parameterized to the Banff climate station, was created to model natural snow cover in the area 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 industry stakeholders in Ontario and Quebec and the eastern United States. The approach allows for comparisons with previous studies elsewhere in North

America to determine if skiing in the Banff area is more or less vulnerable to climate change. The modelling parameters could also be customized to Banff-area ski operations if detailed analysis is desired in the future. The ski operations model was run with the climate change scenarios to project changes to the season length of alpine skiing in the 2020s, 2050s and 2080s. The specific thresholds and decision criteria used in the model are summarized in Table 2.

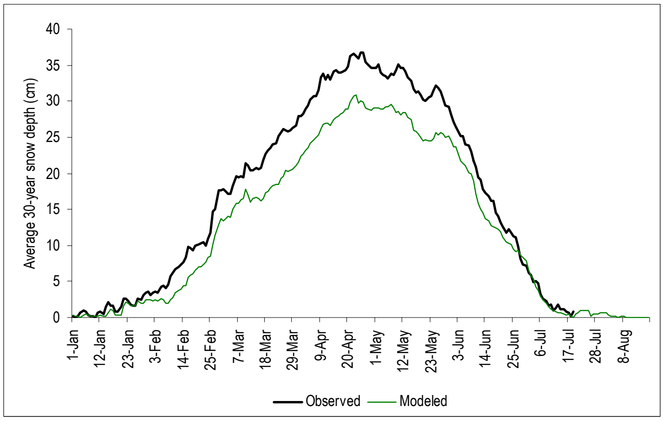
Table 2. Parameters of the snow operations model

Snowmaking capacities & decision rules	
Start date	Nov 1
End date	May 30
Minimum snow base to maintain until end date	60 cm
Temperature required to start snowmaking	-5°C
Snowmaking capacity	10 cm/day
Power cost as a % of total snowmaking costs	32%
Skiable day	
Minimum snow base	30 cm
Maximum temperature	15°C
Maximum liquid precipitation over two consecutive days	20 mm
Ski area	
Size (acres)	250

There were two known limitations to the approach used to assess the impact of climate change on Banff's ski industry. First, the research team received little information from Banff-area ski-area managers with which to customize the model parameters to local circumstances (i.e., snowmaking capacities, operational snow depth). Consequently, the only model parameter to be changed from previous analyses was the length of the potential ski season. In this research, the period from November 1 to May 30 was examined (Table 2).

Second, the snow model as parameterized, which was designed to work with climate data that is generally available at any climate station in Canada, was found to underestimate daily average snow depth at the Banff station (Figure 7) and the Lake Louise station (where only limited historical data was available). It is also important to note that the results represent the location of the respective climate stations and surrounding areas that exhibit similar climatological characteristics. Ski areas in the Banff region are sometimes several kilometres away from the nearest climate station and may have microclimatic features that enhance or reduce natural snowfall or conditions for snowmaking. These cannot be accounted for without site-specific climate data.

Figure 7. Observed and modelled daily snow depth at the Banff climate station



Golf industry

Banff has two golf courses — an 18-hole championship course and a 9-hole course — both owned and operated by the Fairmont Banff Springs. Fairmont officials were unwilling to provide golf-use data for this study due to its proprietary nature; officials at similar calibre golf courses in nearby areas (e.g., Canmore) cited similar reasons for not releasing operations data. Consequently, the relationship between weather and daily golf rounds played from an earlier study in the Greater Toronto Area (GTA)[20] was used as a proxy to model the impact of climate change on Banff's golf industry.

Statistical analysis (regression) was used to first develop a model of the current relationship between climate and daily rounds played in the GTA. The model was then applied to data from the Banff climate station to model rounds played in Banff during the 1961–90 baseline period and then validated against observed recreation data. In the final step, the model was run with two climate change scenarios to project changes in the length of Banff's golf season (currently May to October) and the number of rounds played under climate conditions projected for the 2020s, 2050s and 2080s.

The climate-golf model yielded a seasonal average of 27,423 rounds for a 27-hole course (or 18,282 rounds for an 18-hole course) in Banff. The regression model performed well, as the Fairmont Banff Springs 27-hole golf course averages 30,000 rounds annually[26,27]. The 9% difference between modelled and reported rounds played likely reflects business operations (e.g., spacing of tee times, hours of operation, daylight hours) that could not be accounted for in the model.

INDIRECT IMPACTS OF CLIMATE CHANGE ON TOURISM & RECREATION

Any projected changes in Banff National Park's visitation from extended warm-weather seasons will not occur in isolation, as visitation will be indirectly influenced by climate change-induced impacts on its natural landscape. To explore how environmental changes could influence Banff's future level of visitation, a visitor survey was administered in Banff National Park during the summer of 2005 at a variety of locations (e.g., town sites, campgrounds, scenic rest stops, backcountry hiking areas and visitor parking lots). The survey design and questions were consistent with a study by the research team[19,22] completed in Waterton Lakes National Park in 2004.

Visitors to Banff National Park were presented with three environmental change scenarios that were developed with region-specific scientific literatures[28–33]. The scenarios outlined how climate change could affect ecosystems in the southern Canadian Rocky Mountains over the next century (Figure 8). The time period for each scenario was not provided to participants in order to avoid biasing responses (e.g., I will not be alive in 2080, so these changes are not relevant to me). However, scenario 1 was designed to reflect early potential environmental changes (i.e., 2020s), while scenarios 2 and 3 reflected moderate and extensive environmental changes projected later in the 21st century (i.e., 2050s and 2080s).

Participants were asked to reflect on each scenario as a holistic package of environmental changes and consider whether they would still visit Banff National Park if the changes occurred. Willing participants took the survey with them and returned it by mail. A total of 720 surveys were distributed; 382 were completed and returned for a response rate of 53%.

Figure 8. Survey — environmental change scenarios

TYPES OF ENVIRONMENTAL CHANGE	Scenario 1	Scenario 2	Scenario 3
Number of existing mammal species lost from the park (currently = 60)	0	6	12
Number of new mammal species found in the park	0	10	15
Population of grizzly bears, moose and big horn sheep	no change	small decline	moderate decline
Number and size of glaciers in the park	Continue to shrink, but none lost	Many small glaciers disappear and only the highest remain	All glaciers have completely disappeared
Vegetation composition in the Park	(% of park)	(% of park)	(% of park)
Alpine Meadows & Tundra	40%	25%	10%
Forest	55%	65%	75%
Grassland	5%	10%	15%
Number of rare plant species lost from the park	0	5	10
Occurrence of forest fires	no change	moderate increase	large increase
Chance of a campfire ban during your visit	10%	33%	75%

National Park Visitation

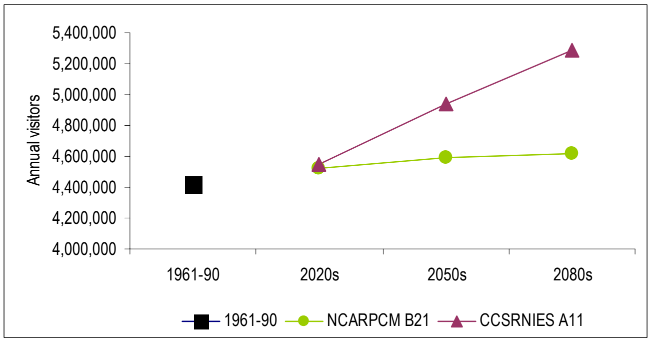
Situated in the heart of the Canadian Rocky Mountains, Banff National Park is an important tourism destination in Canada. It attracts more people annually than any other national park in Canada. Most tourists to Banff National Park visit the town sites (Town of Banff and the Hamlet of Lake Louise), which boast an extensive array of visitor amenities (Table 3). Banff is, however, first and foremost a national park in which preservation of ecological integrity is a priority. Any changes in visitation, including those induced by climate change, will have implications for both tourism and park management.

Table 3. Visitor amenities in Banff[1, 34]

Hotels, motels and lodges	51
Bed and breakfasts	47
Number of beds	8,800+
Campsites	2,488
Restaurants	118
Retail outlets	250+

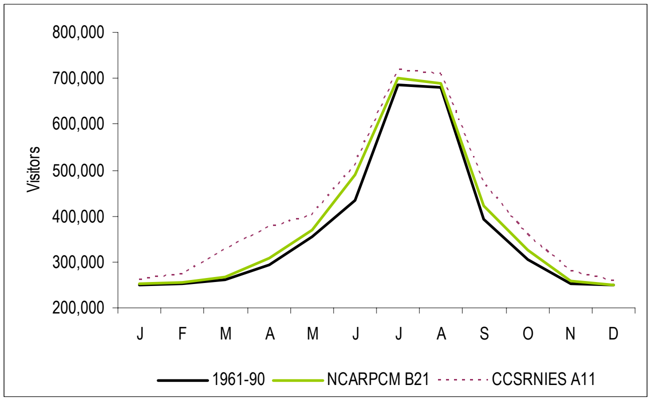
When visitors come to Banff National Park, most (75%) participate in some form of outdoor recreation activity[1]. Assuming the period for warm-weather recreation is extended under climate change and tourist demand patterns remain unchanged, Banff's annual visitation is projected to increase to 4.5 million (~+3%) in the 2020s and to between 4.6 million (+4%) and 4.9 million (+12%) in the 2050s, relative to baseline conditions (Figure 9)[†]. With further warming by the end of the century (2080s), Banff could expect between 4.7 million (+5%) and 5.3 million (+20%) visits annually. Most of the increase in visitation is projected to occur during the spring (March to May) and fall (September to November) months (Figure 10).

Figure 9. Projected direct impact of climate change on visitation to Banff National Park[a]



[a] Baseline (1961–90) defined as person visits: each time a person enters Banff National Park for recreation, cultural or educational purposes during business hours

Figure 10. Average monthly visitation to Banff National Park in the 2050s



† Projections reported here are based on the regression model developed with visitation data provided by Parks Canada before the visitation counting methodology was adjusted in 2004. According to this data, Banff received just over 4 million visitors annually. When these visitation records (2000 to 2003) were adjusted to reflect the new counting methodology, Banff had 3 million visitors annually (a reduction of ~33%). If the same magnitude of change in Figure 9 is applied to the new baseline, visitation increases to just under 3.1 million in the 2020s, to between 3.1 and 3.4 million in the 2050s and to between 3.1 and 3.6 million in the 2080s.

Compared to the five other Rocky Mountain national parks in Canada, Banff is projected to experience the smallest average increase in visitation from climatic changes (Table 4).

Table 4. Projected impact of climate change on Rocky Mountain park visitation in the 2020s

	Modelled annual visitors (1961–90)	NCARPCM B21	CCSRNIES A11
Banff*	4,413,741	+3%	+3%
Jasper	1,879,078	+4%	+6%
Kootenay	1,628,373	+6%	+10%
Yoho	1,066,544	+4%	+6%
Mt. Revelstoke & Glacier	462,448	+9%	+15%
Waterton Lakes	418,358	+6%	+10%

* See footnote on page 9

Of course, climate change-induced impacts on visitation will not occur in isolation. Other factors such as population growth, an ageing society and travel costs could affect future visitation patterns to Banff National Park.

One factor that will act synergistically with climate change to affect visitation to Banff National Park is demographic change. Using Parks Canada's ratio of visitor origins (70% Canadian; 30% US/international), the impact of demographic change on Banff's visitation in the mid-2020s could be five times greater (+14%)‡ than climate change alone (+3%). The combined impact of demographic change and climate change is projected to increase visitor levels approximately 17%, which would translate into an additional 800,000 people visiting Banff National Park annually in the mid-2020s.

IMPLICATIONS OF HIGHER VISITATION

If these findings are suggestive of the longer-term effects of climate change on visitation, to say nothing of future increases in use from population growth, the implications for tourism and park management in Banff are substantive. For instance, higher visitation would certainly contribute to higher revenues for Parks Canada (e.g., from entrance fees and recreation service fees). The Town of Banff would also benefit from higher visitation (e.g., accommodations, food and beverage retail sales) if opportunities to increase visitation can be accomplished in a sustainable manner.

Significant increases in visitation or changes in the seasonal pattern of visitation could also exacerbate existing visitor pressures, which are referred to in the *State of the National Parks Report*(35), and were largely responsible for Banff National Park's ranking of 44th out of 55 North American national parks on National Geographic's(36) 'stewardship index.' Higher visitation would exacerbate crowding issues at popular attractions (e.g., Banff town site, Cave & Basin Hot Springs, Sulphur Mountain, Chateau Lake Louise and area). More intensive visitor management strategies may need to be considered in some locations.

Although Parks Canada and the Town of Banff stand to benefit financially from higher visitation, there could also be financial costs associated with accommodating additional visitors. Higher visitation and extended tourism seasons would result in additional staff costs for visitor and environmental services. Much of this future cost would be incurred during the spring and fall shoulder seasons (rather than the summer) when seasonal staffing is usually lower. The additional stress placed on existing park infrastructure (e.g., roads, trails, campgrounds, water supply, sewage waste management) could also lead to increased annual maintenance costs and may require further infrastructure investment. Parks Canada operates on a partial cost-recovery system, but is currently uncertain whether the additional revenue that could be generated would be sufficient to offset the additional costs of higher visitation.

‡ Using the Town of Banff's visitor ratio (80% Canadian; 20% US/international), the combined impact is +12%



Ski Industry

The opportunity to ski in the breathtaking beauty of the Rocky Mountains makes Banff a popular tourism destination in the winter. It is estimated that one in every 10 visitors to Banff comes to ski[1]. Banff's three alpine ski areas provide some of the world's finest skiing, and collectively have the capacity to accommodate approximately 44,000 skiers an hour (Table 5). Mount Norquay is the smallest ski area in Banff and it is located at the lowest elevation; it has the capacity to cover most (90%) of its skiable terrain with machine-made snow, if required.

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.

CLIMATE CHANGE AND THE SKI INDUSTRY

Winter tourism is repeatedly identified as highly vulnerable to climate change[40–43]. Climate change impact assessments of the ski industry have been conducted in a number of countries (Australia, Austria, Canada, Japan, Scotland and Switzerland) and all project varying negative consequences for the industry. Based on these studies, in 2003 the International Olympic Committee indicated that it would include climate change in its considerations of where to hold future winter games. The Canadian Tourism Commission's[44] winter tourism product development strategy also identified climate change as one of three key threats to Canada's winter tourism market (ageing populations and the decline in long-haul travel after September 11, 2001 were the other two). While not all ski industry executives share his view, Patrick O'Donnell, the Chief Executive Officer of Aspen Skiing Company, recently referred to climate change as "the most pressing issue facing the ski industry today"[45].

Table 5. Characteristics of Banff's alpine ski areas[1, 37–39]

	Mount Norquay	Sunshine Village	Lake Louise
Acreage (acres)	190	3,358	4,200
Base elevation (m)	1,630	1,660	1,645
Summit elevation (m)	2,133	2,730	2,637
Average snowfall (cm)[a]	300	875	360
Number of runs	28	107	113
Lift capacity (people/hr)	7,000	20,000	17,000
Snowmaking capacity (skiable terrain)	90%	8%	20%
Season length	early Dec to mid-April	mid-Nov to late May	mid-Nov to mid-May

[a] As reported by ski areas (i.e., not based on climate station records)

The North American skiing industry is affected by climate and experiences considerable inter-annual variability in operating conditions. For example, between 1982–83 and 2001–02 the length of the ski season in major ski regions of the United States varied as follows: Pacific 109–151 days, Rocky Mountains 121–145 days, Midwest 78–105 days, Northeast 101–136 days and Southeast 78–110 days[46]. Although some studies have examined the potential implications of climate change for skiing in eastern North America[15,16,18], to date there has been no assessment of the potential implications of climate change for the ski industry in the western mountainous regions of North America.

SKIING IN BANFF NATIONAL PARK

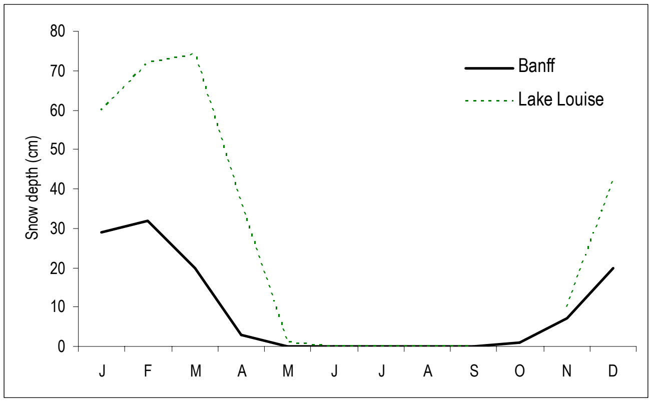
Natural snow conditions at lower and higher elevations in Banff National Park are projected to be adversely affected by climate change (Table 6). In the 2020s, reductions in annual snowfall at 1,400 m (elevation of Banff climate station) and 2,600 m (approximate elevation of the summit of Lake Louise and Sunshine Village ski areas) are minimal under both climate change scenarios (<10%). Much larger losses in snowfall are projected for the 2050s at both elevations: 15% to 20% at 1,400 m and 7% to 11% at 2,600 m. Because snowfall differs substantially between Banff and Lake Louise (Figure 11), the implications of climate change for snow conditions and skiing are assessed separately for each location using three climate change scenarios (NCARPCM B21, CCSRNIES A11 and CGCM2 A2).

Table 6. Projected changes in annual snowfall

Elevation	Modelled snowfall (1961–90)	Climate Change Scenarios[a]			
		2020s		2050s	
		CGCM2 B2	CGCM2 A2	CGCM2 B2	CGCM2 A2
1,400 m	241 cm[b,c,d]	-7%	-8%	-15%	-20%
2,600 m	344 cm	-3%	-3%	-7%	-11%

[a]Data source: ClimateBC[47]
[b]1971–2000 average snowfall at Banff station (1,384 m) was 234 cm
[c]1971–2000 average snowfall at Lake Louise station (1,520 m) was 304 cm
[d]1971–2000 average snowfall at Kananaskis Pocaterra station (1,610 m) was 270 cm

Figure 11. Comparison of average monthly snow depth (1971–2000) at Banff and Lake Louise



Banff — natural snow conditions

Continuing trends observed in the late 20th century (see Banff's Future Climate), reduced snowfall and higher melt-rates from warmer temperatures are projected to reduce the natural snow pack at lower elevations (~1,600 m) in the 2020s (Figure 12). A reduced natural snow pack at lower elevations would make ski operations marginal during some winters and would require the use of snowmaking to ensure adequate snow conditions near the base of ski runs. This is generally the situation today, but the lack of sufficient snow depth for ski operations would occur more often in the 2020s. Because snowmaking is currently used at the base of ski runs, the only change in operations would be an increased requirement for machine-made snow. From an aesthetic perspective, the modelled average snow cover would be sufficient to provide a 'white Christmas' in the Town of Banff (approximately 10 cm on average) and throughout most of the winter tourism season (January to mid-March).

In the 2020s, changes in the temperature regime projected for higher elevations (~2,600 m) are not sufficient to adversely affect the natural snow pack (Figure 13). Consequently, there would be little impact to ski operations at this elevation, and there would continue to be the characteristic snow-capped mountain vistas from late November through until mid-May.

In the 2050s, projected changes in Banff's climate pose a more significant threat to the region's natural snow pack. Average natural snow depth in the 2050s at low elevations (1,600 m) is reduced by over 50% throughout most of the winter tourism season under all three climate change scenarios (Figure 14) and becomes largely unsuitable for ski operations unless augmented with snowmaking. The snow cover required for the picture-postcard winter aesthetics in the Town of Banff is projected to remain during the Christmas season in two of the three climate change scenarios, with only the warmest scenario projecting a marginal average snow cover (less than 5 cm).

At higher elevations (2,600 m), the average ski season in the 2050s would be shortened because of a reduction in the natural snow pack (Figure 15). However, only under the warmest climate change scenario is there a notable decline in the projected length of the ski season. The snow-capped mountain vistas would also continue to occur during the winter tourism season, lasting from early December to late March even under the warmest scenario.

Banff — ski season

Of Banff's three ski areas, Mount Norquay experiences the shortest ski season (early December to mid-April). Mount Norquay's short season is partially a function of its comparatively low-elevation operations (Table 5).

Using the ski operations model[15,16,18] with Banff station data, the average modelled length of the ski season

Figure 12. Projected daily average snow depth at Banff in the 2020s (1,600 m)

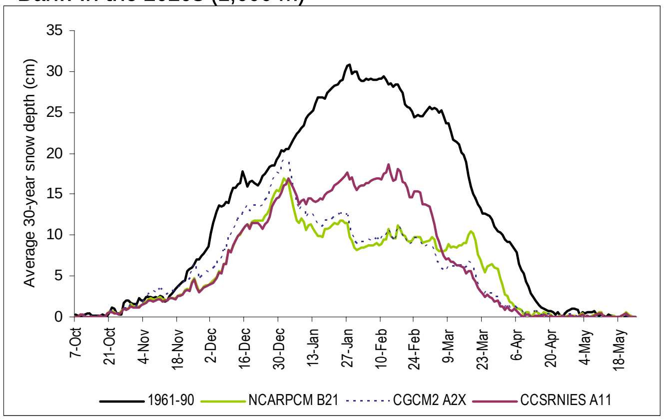


Figure 13. Projected daily average snow depth at Banff in the 2020s (2,600 m)

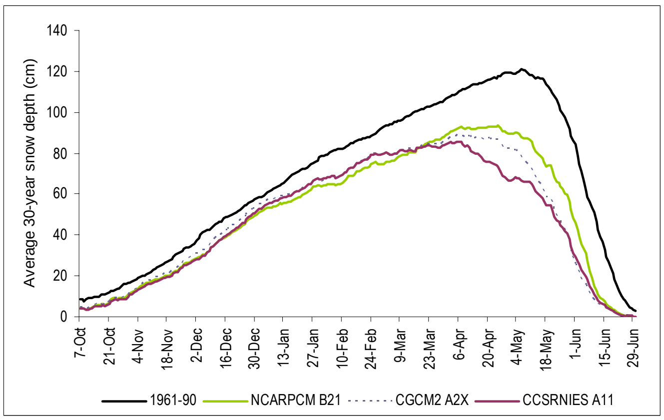


Figure 14. Projected daily average snow depth at Banff in the 2050s (1,600 m)

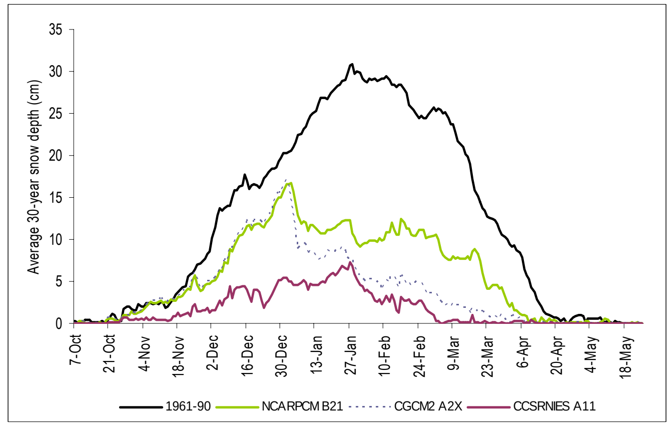
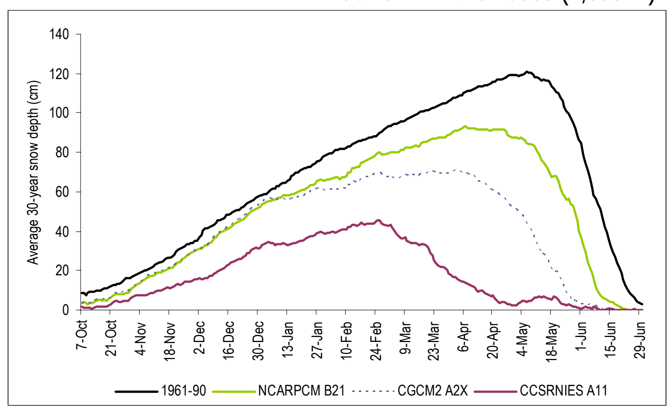


Figure 15. Projected daily average snow depth at Banff in the 2050s (2,600 m)



with natural snow conditions in Banff is approximately 76 days at the base of existing ski runs (~1,600 m) and 179 days near the summit (2,600 m) (Table 7). When only natural snow is available, the impact of projected climate change at base elevations (~1,600 m) is significant as early as the 2020s (Table 7). Under warmer climatic conditions, the average ski season is reduced to between 34 and 38 days (at least a 50% reduction) under both climate change scenarios. In the 2050s, where only natural snow was available, the average ski season at low elevations would be largely eliminated under the warmest climate change scenario.

Snowmaking has become an integral component of the ski industry over the last 25 years and all three of the ski areas in the Banff region have invested in snowmaking systems. By incorporating snowmaking, the length of baseline ski seasons at base elevations is 167 days, on average. If it is assumed that no changes occur in current snowmaking technology (Table 2), average ski seasons at base elevations (1,600 m) are projected to be only 7% to 15% shorter in the 2020s. In the 2050s, the least-change scenario projects a minor reduction (-9%) in average ski seasons, while the warmest scenario projects a 43% reduction. Under both climate change scenarios, the probability of ski runs at base elevations being closed for the entire Christmas-New Year holiday in the 2020s and 2050s was almost zero. This indicates that the economic core of the ski season can be maintained with additional snowmaking even under the warmest scenario for the 2050s.

Ski areas at higher elevations are considerably less vulnerable to projected changes in the climate (Table 7). Areas near the top of existing ski runs in Banff (~2,600 m), where only natural snow is available, are projected to experience minimal change in average ski seasons (-7% to -9%) in the 2020s. In the 2050s, different futures emerge. Changes in the average ski season remained relatively minor (-13%) at the summit under the least-change scenario, but increased substantially (-59%) under the warmest scenario.

The implication of this analysis is that further investment in snowmaking at higher elevations may be required by ski areas in the Banff region. If snowmaking was in place, the impact of projected climatic changes on the length of average ski seasons at high elevations is estimated to be negligible under even the warmest climate change scenario for the 2050s (Table 7).

Table 7. Projected ski seasons at Banff

Elevation	Modelled (1961–90) (days)	Climate Change Scenarios			
		2020s (% Δ)		2050s(% Δ)	
		NCARPCM B21	CCSRNIES A11	NCARPCM B21	CCSRNIES A11
		With natural snow only			
1,600 m (base area)	76	-50%	-57%	-66%	-94%
2,600 m (summit)	179[a]	-7%	-13%	-9%	-59%
		With advanced snowmaking capacities			
1,600 m (base area)	167	-7%	-15%	-9%	-43%
2,600 m (summit)	211	No change	-1%	No change	-6%

[a] compares reasonably well with the average ski season of the two higher-elevation ski resorts in the region (~180 days) (Table 5).

Lake Louise — ski season

Compared to the Banff climate station, observed data from the Lake Louise station suggests that it naturally receives more snow, and on average, has a much greater snow depth throughout the winter season — approximately double the snow depth of Banff in December through February and triple the depth in March and April (Figure 11). Using the ski operations model[15,16,18] with Lake Louise station data, the average modelled length of the ski season with natural snow conditions at Lake Louise is much longer (153 days verses 76 days for Banff) than Banff at the base of existing runs (1,600 m) and about 20 days longer near the summit (2,600 m) (Tables 7 and 8). Differences in the availability of natural snow at the two locations explains the higher level of investment in snowmaking at Mount Norquay (90% coverage of ski terrain) than at Lake Louise's ski area (20% coverage of ski terrain).

Table 8. Projected ski seasons at Lake Louise

Elevation	Modelled (1961–90) (days)	Climate Change Scenarios			
		2020s (% Δ)		2050s (% Δ)	
		NCARPCM B21	CCSRNIES A11	NCARPCM B21	CCSRNIES A11
		With natural snow only			
1,600 m (base area)	153	-27%	-35%	-31%	-87%
2,600 m (summit)	197[a]	-2%	-3%	-2%	-19%
		With advanced snowmaking capacities			
1,600 m (base area)	178	No change	-1%	No change	-12%
2,600 m (summit)	208	+2%	+2%	+2%	No change

[a] compares reasonably well with the average ski season of the two higher-elevation ski resorts in the region (~180 days) (Table 5).

When only natural snow is available, the impact of projected climate changes on the length of ski seasons at base elevations (~1,600 m) is substantial (-27% to -35%) as early as the 2020s (Table 8). In the 2050s, warmer climatic conditions are projected to contribute to even greater reductions in the ski season at low elevations. Average ski seasons are projected to be reduced 31% to 87%, making ski operations at this elevation marginal without the use of snowmaking.

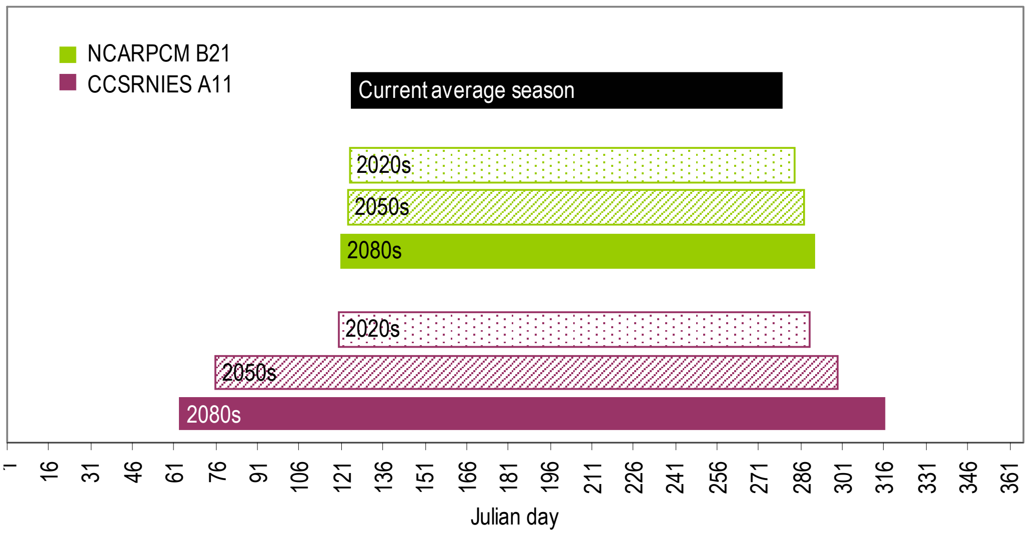
Projected changes in temperature regimes have minimal impact on the snow depth at higher elevations (2600 m) in the 2020s. As a result, changes to the average length of the ski season at higher elevations is negligible (-2% to -3%). In the 2050s, the least-change scenario also projects little change in the ski season (-2%). Only under the warmest scenario for the 2050s is there a substantial reduction in average ski season near the summit (-19%). Compared to the Banff station, the impact of projected climatic changes on natural snow conditions is much less at Lake Louise (Tables 7 and 8).

Although the Lake Louise ski area does not have the same snowmaking capacity as Mount Norquay (Table 5), it does have some snowmaking in place at lower elevations. When snowmaking is incorporated into the ski operation model, the length of the average modelled ski season near Lake Louise increases 25 days (to 178 days) at low elevations (1,600 m) and increases 11 days (to 208 days) at high elevations (2,600 m) (Table 8). Snowmaking does reduce the impact of projected climatic changes on average ski seasons at low elevations (1,600 m) in the 2020s and 2050s, except under the warmest scenario where there is a 12% reduction in season length in the 2050s. At high elevations (2,600 m), the addition of snowmaking has little impact on the length of the ski season, even under the warmest climate change scenario in the 2050s. With an equal investment in snowmaking, the impacts of climate change on skiing near Lake Louise could be far less than near Banff.

Golf Industry

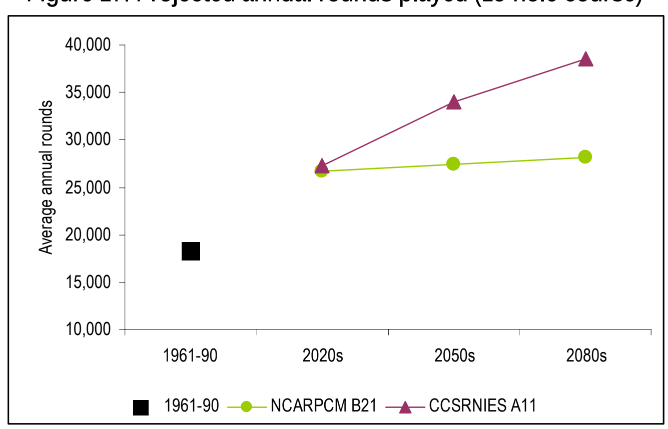
Golf is a popular recreational activity in the Banff area. The Fairmont Banff Springs Golf Course, with panoramic views of the Canadian Rocky Mountains, is among the most challenging championship-quality 18-hole golf courses in the world. Many nearby top-rated golf courses (e.g., Silver Tip, Stewart Creek, Mt. Kidd and the Springs at Radium) also attract visitors to the Banff area.

Figure 16. Projected golf season length



The golf season in Banff and nearby areas is climate-limited. Consequently, as the climate warms, the golf season is projected to become longer. Today, Banff's golf season is approximately 162 days, beginning in early May (~May 1; Julian day 121) and extending to mid-October (~October 10; Julian day 283). As the climate warms, there is little noticeable extension in the golf season under the least-change climate change scenario (Figure 16). Under the warmest climate change scenario, Banff's golf season is projected to be seven days (one week) longer in the 2020s and 61 days (~eight weeks) longer in the 2050s. In the 2080s, the golf season in Banff is projected to be 92 days (~12 weeks) longer under the warmest scenario, potentially beginning in mid-March and extending through to November.

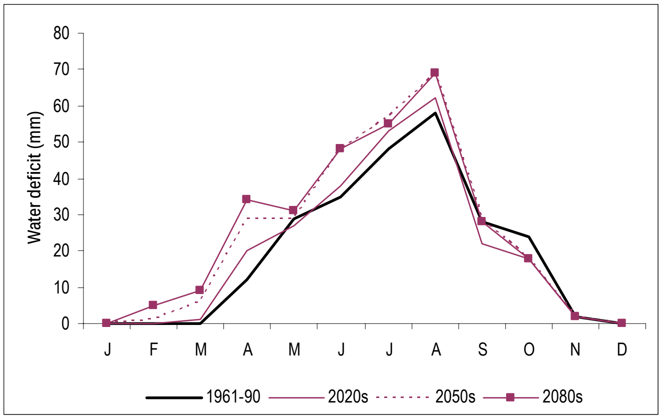
Figure 17. Projected annual rounds played (18-hole course)



Assuming current levels of demand for golf remain unchanged, both climate change scenarios suggest that more rounds of golf will be played as the season is extended and the climatic conditions for golf generally improve throughout the golf season, but particularly in shoulder seasons. The average number of annual rounds played is projected to increase between 46% and 49% over current conditions as early as the 2020s (Figure 17). In the 2050s, rounds played will increase, on average, between 50% and 86%. This increase represents an additional 9,200 to 15,800 rounds being played annually at the Fairmont Banff Springs golf course. Most of the increased demand will occur during the shoulder seasons, particularly in the spring (Figure 16). In the 2080s, the Fairmont Banff Springs golf course could experience an additional 54% to 111% more rounds per year. Golf courses in nearby areas could also experience similar increases in rounds played.

Although the golf industry in Banff and surrounding areas could benefit from projected changes in the climate, there could also be some important challenges in the decades to come, particularly under the warmest climate change scenario. As the climate warms, there is likely to be greater demand for irrigation to keep turf grass in optimal playing condition. The change in projected moisture deficits for the Calgary area supports this. During the summer, moisture deficits are projected to become more severe, increasing 7% to 10% in the 2020s and 19% to 37% in the 2050s, with little additional change by the end of the century (Figure 18). In addition, insect pests that currently have only one life cycle in many parts of Canada could begin to have two life cycles[48] under warmer conditions, and turf grass diseases and pests currently limited to latitudes that are more southerly latitudes could expand northward and require management interventions. It is uncertain how changes in irrigation and turf grass disease/insect management would affect the ability of Banff-area golf course to take advantage of opportunities for a longer and more intensive golf season under climate change.

Figure 18. Projected moisture deficits[a]



[a] Based on bio-climate profile for Calgary (data not available for Banff)[49]
Water deficit: Amount by which available moisture fails to meet water demand; calculated by subtracting potential evapotranspiration from actual evapotranspiration



Environmental Change

The natural environment is Banff's central attraction and the primary reason for its existence. Mountains, glaciers, turquoise-coloured lakes and wildlife are important attractions[1].

Banff has a rich ecological foundation (Table 9), and accordingly is designated an UNESCO World Heritage Site (along with Jasper, Yoho and Kootenay national parks). Policies established by Parks Canada are intended to protect and preserve Banff National Park's natural resources and ecological integrity for future generations; municipal policies established by the Town of Banff are also intended to maintain ecological integrity.

Table 9. Examples of Banff's natural resources[1]

Environment	3 zones - 40% alpine; 57% sub-alpine; 3% montane
Plants	193 species, including 8 species of orchids
Fish	Mountain whitefish, bull trout, lake trout
Large birds	Bald eagle, osprey
Mammals	Small: 29 species (e.g., beavers, muskrats) Ungulates: 8 species (e.g., deer, woodland caribou, moose, mountain goats, big-horn sheep) Carnivores: 4 families (weasel; dog — coyote, wolf; cat — lynx, mountain lion; bear — black and grizzly)
Glaciers	1,000+ (Athabasca, Victoria, Peyto)
Lakes	Vermillion, Minnewanka, Morraine, Bow, Peyto, Johnson, Two Jack, Hector, Louise
Springs and canyons	Bow Falls, Cave & Basin Hot Springs, Johnston Canyon

CLIMATE CHANGE AND PROTECTED AREAS

The international community has recognized the significance of global climate change for biodiversity conservation and protected areas management. In a recent study, it was stated that, "Despite the uncertainties… the overall conclusions … establish that anthropogenic climate warming at least ranks alongside other recognized threats to global biodiversity [and] contrary to previous projections it is likely to be the greatest threat in many if not most regions"[50]. Indeed, a growing body of scientific research indicates that physical and biological systems are already responding to the changing climate of the 20th century [33, 51–53].

The Consortium for Integrated Climate Research in Western North American Mountains (CIRMOUNT) was recently established with the goal of measuring and understanding climate-driven changes in the western North American mountain ranges and the implications for society and resource management in the region. Researchers at the CIRMOUNT meeting in Lake Tahoe in May 2004 were startled by the pace of environmental change already observed in several US studies[54].

For over a decade, climate change has been identified as an important strategic planning issue for park agencies in Canada. The policy and planning implications for Parks Canada have been discussed in detail elsewhere and readers are referred to these publications for additional information and specific case studies[28, 55–57].

In Canada's 1997 The State of the National Parks report[35], climate change was identified as a stressor causing significant ecological impacts in seven national parks. To understand better the implications of climate change for Canada's national parks, Parks Canada collaborated with the University of Waterloo to conduct a screening level climate impact assessment[28]. This section draws on this assessment and more recent studies from the Rocky Mountain region to highlight the major climate change-induced environmental changes anticipated for the Banff region.

ENVIRONMENTAL CHANGES

Flora and fauna

Vegetation modelling studies focusing on biomes suggest that the southern Canadian Rocky Mountains could experience a decline in temperate evergreen tree species and an increase in boreal coniferous and temperate mixed species[(55)]. Major elevation shifts in ecological communities are also projected to occur under projected climate change[(55)] and will vary at the micro-scale based on elevation and aspect[(58)]. Site-level studies in Banff National Park have already documented vegetation response at the upper tree line to climate change in the 20th century[(12,59)]. Projected shifts in vegetation zones over the course of the 21st century could result in the loss of some high alpine species of flora and fauna, as well as the disappearance of some sub-boreal and montane species[(55)].

Forest fires

Banff's mountain ecosystem depends on fire for regeneration, and as the climate warms, the park's natural fire regime is expected to change. Studies of vegetation and fire behavior modelling suggest that the frequency, severity and intensity of forest fires in the mountainous region of western Canada is projected to increase[(59–62)]. As summers become drier in the mountainous region of western Canada, the frequency of fires that burn more than 1,000 hectares is projected to increase as early as the 2050s, as is the geographic area designated 'extreme' for fire danger. Changes in the natural fire regime have important implications for vegetation and tourism (forest aesthetics). It also has implications for fire management policy, as decades of fire suppression may create dangerous wildfire conditions.

Glaciers

Similar to glaciers around the world, Banff National Park's glaciers have been retreating over the past century. Glacier coverage in the southern Canadian Rocky Mountains is estimated to have decreased 25% in the 20th century[(12,63)]. The terminus of the Athabasca Glacier for example, the main attraction at the Columbia Icefield, has retreated 1,200 metres since 1900[(64,65)]. As warmer springs and autumns extend the melting season, the snowline will increase in elevation and many of Banff's glaciers are expected to continue retreating. Lower elevation glaciers (e.g., Peyto), particularly those less than 100 metres thick, are projected to disappear in the next 30 to 40 years[(29)]. If such glacier retreat occurs, the Columbia Icefield could lose much of the tourist resource that is currently accessible.

An array of organic pollutants (e.g., organochlorines, pesticides) and suspended sediment is stored in glacial ice. Accelerated glacial retreat is projected to increase summer runoff until the glaciers have largely been depleted[(63)]. This would contribute to the release of increased amounts of pollutants and sediments into Banff's glacial-fed lakes and streams, altering water quality and turbidity levels in many popular recreational water resources.

Lakes and streams

Among the first ecosystems expected to respond to global climate change are alpine ponds[(66)]. These small water bodies are known to be highly responsive to changes in temperature and precipitation. A recent study in Banff National Park[(66)] projected that thousands of temporary alpine ponds in the Canadian Rocky Mountains may dry up; permanent ponds in the region may become temporary under a changed climate. The impact of these changes on some aquatic species could be substantive.

Rivers that originate in the Rocky Mountains are kept cold by melting glacial ice. As glaciers retreat, river volumes will decrease over time, which will allow water temperatures in rivers and associated water bodies to increase. As lakes, rivers and streams warm, temperature-induced habitat loss and range shifts are projected to occur for some aquatic species, contributing to losses in recreationally valued fish populations. A study of the thermal habitat of salmonid species in the US Rocky Mountains found that a projected 4°C in summer warming (in Banff, summer temperatures projected to increase 2.3°C to 6.3°C) would reduce habitat area by 62%[(67)]. Increases in lake and river temperatures could place pressure on cold-water fish species in Banff National Park, providing opportunities for the geographic expansion of cool-water and warm-water species that have higher temperature tolerances.

INDIRECT IMPACT OF ENVIRONMENTAL CHANGES ON VISITATION

Nature-based tourism market research[(68)] in British Columbia found that natural settings were critical in determining a quality tourism product. Tourism market research in the Rocky Mountain TDR[(69)] clearly indicates that nature, specifically mountains, glaciers, turquoise-coloured lakes and wildlife, are Banff's key attractions.

The quality of Banff National Park's natural environment is critical to its success as a tourism destination, and park and town officials work diligently to ensure that tourism and other development does not diminish the state of the natural environment. Banff's environment is projected to be impacted by climate change and any environmental changes that diminish its much-loved and world-famous landscape could have negative implications for tourism.

Based on the scientific literature described in this section, scenarios of environmental change were developed for Banff National Park. Visitors were then surveyed to ascertain if and how these environmental change scenarios would affect their intention to visit Banff National Park. Of the 382 respondents, 7% were local, 22% were from elsewhere in Canada, 16% were from the United States and 55% were from overseas. As such, the sample does not reflect the normal distribution of visitors to Banff National Park (82% Canadian, 10% US, 8% international[1]; Parks Canada[23] — 70% Canadian, 30% US/international), but is weighted more to long-haul travellers that are economically most important to Banff's tourism industry.

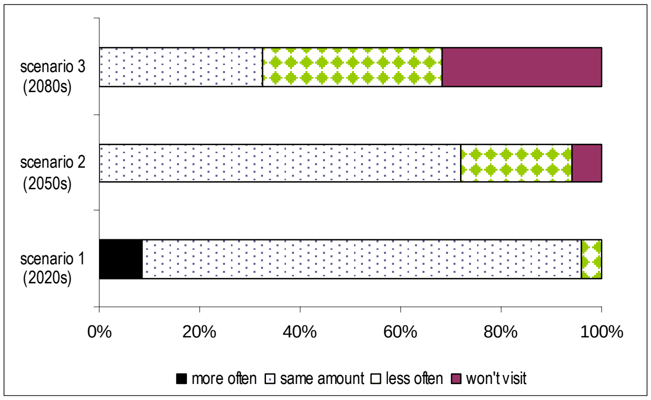
The results of the Banff visitor survey suggest that only long-term environmental changes could have a meaningful impact on future tourism. After considering the environmental changes outlined in scenario 1 (~2020s), all visitors (100%) indicated that they would still visit Banff National Park (Figure 19); 9% indicated that they would visit more often, while 4% would visit less often. Slightly fewer visitors (94%) stated that they would visit if the environmental changes in scenario 2 (~2050s) were realized, however, 22% of respondents indicated that they would visit less often.

For many current visitors to Banff National Park, the environmental changes in scenario 3 (~2080s) surpassed their threshold of acceptable change. If the environmental changes in scenario 3 (~2080s) were realized, 69% of visitors indicated they would still visit Banff, but 36% indicated they would visit less often. Approximately one-third of visitors (31%) indicated that they would no longer visit Banff. With most people indicating that they would not visit or would visit less often, it is possible that the considerable environmental changes projected to occur later this century may contribute to reduced annual visitation to Banff National Park.

Notably, the visitor segments most likely to be affected by potential climate-induced environmental change are those that travel a great distance to visit Banff National Park. When responding to scenario 3 for example, only 16% of local visitors stated they would no longer visit the park versus 33% of extra-regional visitors. These extra-regional visitors are economically the most important to Banff's tourism industry, as international visitors (overseas and US) and Canadians outside of Alberta represent 76% of the tourism spending in the Rocky Mountain TDR[24].

When visitors indicated that they intended to no longer visit Banff if the environmental changes in scenario 3 occurred, they were asked what single change was particularly important to them. The most common responses included — retreat of glaciers (32%), changes in wildlife populations (29%), the impact of forest fires (17%) and changes in vegetation (13%).

Figure 19. Environmental change scenarios and intentions to visit Banff National Park



In a recent Parks Canada survey of visitors to Canada's mountain national parks[70], nearly all respondents indicated that they were very satisfied with their natural environment experiences in Banff, Jasper, Yoho and Kootenay. The visitor survey developed for this climate change study suggested that environmental changes may adversely affect these experiences in the future. In order to clarify and provide a check on responses to scenario 3 (~2080s), an additional question was posed to visitors about their perceptions of Banff and potential impacts of climate change.

When visitors were asked about the future status of Banff as a world-class destination, most visitors (64%) felt that Banff would continue to be a world-class tourism destination regardless of the nature and magnitude of climate change-induced environmental changes projected for later this century. This is approximately an equal proportion (69%) to those that indicated they would visit Banff National Park under the high-impact environmental change scenario (scenario 3), thus providing increased confidence in these findings.



Conclusions

Banff National Park is an internationally recognized world-class tourism destination, attracting millions of people annually to the Canadian Rocky Mountains. This executive summary has demonstrated that climate is important to Banff's tourism and recreation industry. It has also demonstrated that projected changes in the climate over the course of the next century will create new opportunities and challenges for park and tourism management in Banff.

SUMMARY OF FINDINGS

As the climate warms in the Canadian Rocky Mountains, visitors to Banff are projected to increase. Visitor increases of 3% are projected for the 2020s with increases of 4% to 12% by the 2050s. When demographic changes are factored in, visitor increases are projected to be even higher. Higher visitation levels could certainly exacerbate Banff's existing visitor pressures. Parks Canada is in the very early stages of developing a climate change adaptation framework[56]. Although the primary focus of climate change adaptation policy and planning to date has been the maintenance of ecological integrity, changes in visitor management strategies will also need to be a fundamental component of Parks Canada's adaptation framework[55,56]. As this study indicates, this is clearly the case for Banff National Park.

As for seasonal recreation, Banff's world-class ski industry is projected to be impacted negatively by climate change, particularly at the base of ski runs. By relying entirely on natural snow, 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 2002s; -2% to -19% in the 2050s) elevations are much less than at Banff. Snowmaking helps reduce the negative impact of less natural snow and will likely become an increasingly important climate adaptation for Banff's ski operations, particularly at low elevations.

The golf industry in Banff is projected to benefit from projected changes in the climate. Annual rounds played are projected to increase 46% to 49% in the 2020s and 50% to 86% in the 2050s. As the climate warms, the golf season is projected to be extended by one week in the 2020s and by as much as eight weeks in the 2050s, with most of the increase occurring in the spring shoulder season. While longer golf seasons will certainly benefit the Fairmont Banff Springs and other championship golf courses in nearby areas, increases in summer water deficits will increase the need for proactive golf course management to sustain world-class conditions.

Finally, Banff is projected to experience environmental change as the climate changes. The visitor survey found that it takes very substantial environmental change to potentially impact visitation. Based on available scientific knowledge, for scenario 3 in the survey to be realized would require the warmest climate change scenario to occur and decades of environmental change to manifest itself. Because we cannot predict the behaviour of visitors 80 years from now on the responses of contemporary visitors, this negative impact on visitation remains highly uncertain. Consequently, there is greater confidence in the positive impact of a longer and more climatically suitable warm-weather tourism season on visitation to Banff National Park. Thus, this is a management concern for the future.

MOVING FORWARD

Both the United Nations Intergovernmental Panel on Climate Change (IPCC) and the Government of Canada have indicated that despite efforts to reduce greenhouse gas (GHG) emissions some level of human-induced climate change will need to be realized in the 21st century. As a result, climate change adaptation is a necessary policy strategy.

Reductions in greenhouse gas emissions

An important conclusion from this scoping-level impact assessment is that of the climate change scenarios available and considered in this analysis, the least-change (low greenhouse gas emission) scenario is the least harmful to Banff's environmental resources and perhaps the most favourable to Banff's tourism industry (i.e., least impact on the current length of recreation seasons). While reducing GHG emissions worldwide can only be achieved though cooperation of the international community, Banff could demonstrate leadership amongst international tourism destinations and contribute to this global effort through locally appropriate GHG emission reduction initiatives.

The Town of Banff has completed a local action plan for community-wide energy management and GHG emissions as part of its Official Community Plan (1998). The Community Plan is being reviewed in 2005/06 and this study provides additional support for strengthening its GHG reduction strategy. Banff's ski industry may also want to take a leadership role in the Canadian ski industry and consider establishing the first Canadian chapter of the **'Keep Winter Cool'** campaign, an initiative begun by the National Ski Areas Association in the United States in 2003. The three objectives of the campaign are:

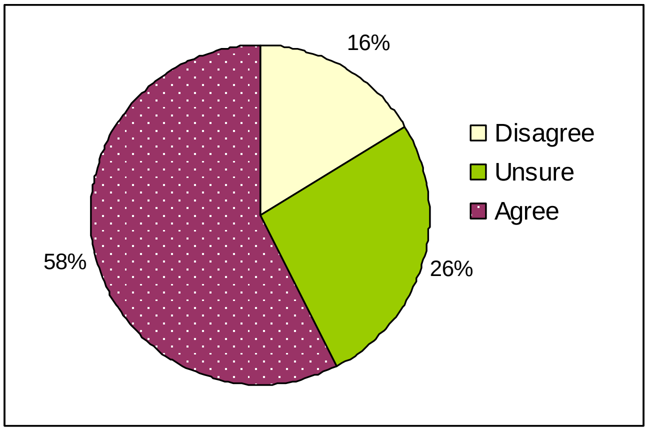
- Educate ski resort visitors about climate change and what they can do to reduce their GHG emissions,
- Initiate investment and showcase a range of energy efficiency and alternative energy projects implemented by ski areas to reduce their GHG emissions, and
- Develop a co-ordinated political lobby by the winter tourism industry to support policies to reduce GHG emissions.

Public education

The opportunities for public education on climate change extend beyond the ski industry. In Alaska, for example, climate change has become an important new interpretive and tourism marketing theme in Kanai Fjords National Park. The park has developed an interpretive display for its visitor centre called **'Glimpses of an Ice Age Past — Laboratory of Climate Change Today'** to explain the changing landscape in the park.

While the impacts of climate change are currently less evident in Banff than they are in Alaska, there is public interest in learning how climate change may affect Canada's mountain environment. The majority (58%) of Banff visitors surveyed in this study indicated that they would like to see interpretative programs that identify how climate change is affecting Banff National Park (both positively and negatively) (Figure 20). The **'Melting Mountains Awareness Program'**[(74)] was developed by the Alpine Club of Canada, the David Suzuki Foundation, the Government of Canada and Mountain Equipment Co-op over concerns that climate change will have a substantial impact on the country's recreational opportunities and mountain lifestyle. The Town of Banff, in cooperation with Banff National Park and other local tourism stakeholders could seize the opportunity to take a leadership role in public education on climate change and Canada's mountain environments.

Figure 20. Responses to a question about interest in climate change interpretative programs in Banff



[a] Survey question: I would be interested in interpretative programs to learn how climate change is affecting the environment in Banff

Future Research

Climate change is a very complex and rapidly evolving research and policy area. This scoping-level study, which focused on Banff, has identified a number of research areas that require further analysis.

1. As set out in the research objectives, this assessment focused exclusively on the potential impacts of climate change for recreation and tourism in Banff and did not examine these changes in the context of its competitors within regional and international tourism markets. An important dimension of future research would be to assess the potential impacts of climate change on Banff's regional and international competitors in order to

understand more fully the climate change implications for Banff.

2. At a recent presentation in Banff about the Canadian Rockies TDR[72], Aspen and Vail (Colorado), the Poconos (Pennsylvania), Whistler and Fermie (British Columbia) and Switzerland were identified as Banff's competition among mountain vacation destinations. An important dimension of future research would be to compare how climate change may impact these destination competitors and determine whether Banff's competitiveness among international mountain destinations could improve or diminish as a result of climate change.

3. To understand more fully the potential impact of climate change on winter tourism in Banff, it would be necessary to consider the impacts of climate change on snow conditions and the ski season in a regional context (and perhaps even the entire North America ski industry). For example, it has been speculated that Banff benefited from a transfer of skier visits during a recent winter (2004/05) when Whistler was experiencing poor snow conditions. Information on how climate change may affect other North American winter tourism destinations is available[43], but a comprehensive analysis was beyond the scope of this study.

4. Extremely warm summers, severe fire seasons, heavy precipitation events and warm winters with poor snow conditions have an impact on different aspects of the tourism industry. Analysis of the impact of these events (called 'climate analogues') on Banff's tourism industry should be undertaken to improve our understanding of the vulnerability of individual tourism and recreation sectors to climate variability and the effectiveness of response strategies.

5. Climate change will not be the only factor that affects Banff's tourism industry in the decades to come. Additional analysis is needed that examines how climate change may interact with these other factors (e.g., population growth, ageing society, travel costs, changing competition) to impact visitation. For example, the Canadian Ski Council[73] suggests that without interventions to retain the aging 'Baby Boomer' market and attract the ethnically diverse market of new Canadians, national ski/rider visits could decline to 15.5 million by 2018/19 from 19.1 million at present (2003/04). In Alberta, skier/rider visits are projected to decline from 2.8 million in 2003/04 to 2.4 million in 2018/19.

6. Adaptation strategies will be required to reduce the risks (i.e., shorter ski seasons) and to successfully take advantage of opportunities (i.e., increased visitation in current shoulder seasons) brought about by changes in climate. An important follow-up study to this research presented here would be to begin to identify a portfolio of potential adaptation strategies, and to assess the benefits and costs of priority responses and barriers to implementation. Integrating climate change adaptation with sustainable development is an important long-term planning strategy being undertaken by several Canadian municipalities.

FINAL THOUGHTS

Banff's diverse natural environment and range of recreational amenities attract millions of people annually, making it one of the most important tourism destinations in Canada. This study has demonstrated that projected climatic changes over the course of the 21st century could have important implications for Banff National Park and the tourism industry. Climate change will need to be further considered in strategic planning so that Banff can realize opportunities of a changed climate, and confront the challenges posed by a changing climate, in a sustainable manner. Importantly, future progress on understanding Banff's potential vulnerability to climate change will require collaboration from the community and the tourism industry.

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