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Thirty years of assessing the impacts of climate change on outdoor recreation and tourism in Canada

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ABSTRACT

This paper reviews 30 peer-reviewed academic journals articles (1986–2016) that assess the impacts of climate change on outdoor recreation and tourism in Canada. The review follows a sector-based approach, covering the various activities that have been assessed within a Canadian context. In general, climate change is expected to present increased risks for cold-weather activities in Canada, while there may be increased opportunities for warm-weather activities. A series of knowledge gaps are identified and recommendations for future research in the field are made. Emphasis is placed on overcoming limitations associated with reliance on out-dated climate science, climate models and climate change scenarios; addressing the uneven geographic distribution of existing assessments and filling the gap regarding regions that are currently underrepresented; as well as exploring the weather sensitivity and potential climate change impacts for outdoor recreation and tourism activities that have not yet been assessed.

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1. Introduction

The important relationship between weather and climate with recreation and tourism has been well-documented within the academic literature across the international scientific community. Furthermore, this acknowledgment has sparked numerous climate change impact assessments for outdoor recreation and tourism across the globe. Given the rapidly growing body of literature on climate change impacts for tourism, there have been several recent literature reviews in the field. Scott, Gössling, and Hall (2012) reviewed the projected impact of climate change on international tourism, outlining the complex interrelationships between climate change and the multiple components of the international tourism system, while taking a sector-based approach and discussing studies in numerous tourism contexts across the globe. Gössling, Scott, Hall, Ceron, and Dubois (2012) reviewed the current state of understanding and remaining uncertainty among the academic community concerning the perceptions and responses of tourists to global climate change and the implications for projected declines or increases in specific tourism markets. Becken (2013) reviewed 459 English-language academic publications from 1986 to 2012 and concluded that the multi-dimensional literature on tourism and climate change is an evolving knowledge domain, identifying key contributors in the field as well as academic debates that have materialised over time. Kaján and Saarinen (2013) methodically analysed 35 peer-reviewed academic journal articles from 2006 to 2011, looked specifically at more recent studies in the field that have begun to incorporate climate change adaptation for tourism into the assessment and discussion. Rosselló-Nadal (2014) reviewed the most common approaches to quantitative climate change impact assessment for tourism, but from a Euro-centric perspective that almost excludes entirely the vast body of literature from North America, that was been written on the subject. More recently, Njoroge (2015) re-conducted another review of studies considering climate change adaptation for tourism, identifying a newly emerging theme within the literature, namely sustainable adaptation. Earlier, Dawson and Scott (2010) reviewed the existing literature (including university papers, unpublished graduate theses, government reports, industry reports and book chapters) regarding the impacts of climate change on tourism in the Great Lakes region of North America (encompassing southern regions of Canada as well as northern regions of the United States).

From a national perspective, Canada can be viewed as an example of best practice within the international field of climate change impact assessment for tourism. It has been acknowledged by Dawson and Scott (2010) as well as Kaján and Saarinen (2013) that the first climate change impact assessment for tourism ever conducted was completed in Canada (Wall, Harrison, Kinnaird, McBoyle, & Quinlan, 1986). Furthermore, based on several quantitative measurements (number of publications, degree of connectedness with other authors and power or influence over the field of study) it was recognised by Becken (2013) that the leader in the field of climate change and tourism research operates out of Canada (Professor Daniel J. Scott). Additionally, many of Professor Scott's former graduate students have continued to publish in the field within a Canadian context as they embark on their own academic and professional careers (Dr. Brenda Scott, Dr. Jackie Dawson, Dr. Christopher Lemieux, Dr. Michelle Rutty, Dr. Micah Hewer, Dr. Mark Groulx). Including, but not limited to Professor Scott's legacy of promising graduate students that have now become young academics, within Becken's (2013) list of the most influential authors in the field of climate change and tourism research, 6 out of 19 academics listed (32%) are based in Canadian research institutions (Dr. Daniel Scott, Dr. Jackie Dawson, Dr. Geoffrey Wall, Dr. Geoff McBoyle, Dr. Brenda Jones, Dr. Rachel Dodds). Nonetheless, no study to date has produced a formal synthesis of the academic community's current understanding regarding the impacts of projected climate change on ORT in Canada.

The purpose of this article is to review all the available peer-reviewed academic journal articles that assess the impacts of climate change on ORT in Canada. There have been numerous working papers published by Canadian universities as well as several industry and government reports concerning the impact of climate change on ORT in Canada. However, these collections were not subject to the rigorous peer-review process that academic journal articles go through and are also seldom referenced by the international scientific community. For these reasons, reports published by university departments, industry organizations and government agencies were not included in this review. However, the value of this review has utility for university researchers, industry stakeholders as well as government agencies. Not only will this review illustrate the evolution of our current understanding on the issue, it will also create a clearer picture for national tourism policy-makers as well as destination managers and planners about the potential impacts of climate change on tourism in the country. Furthermore, this review of Canadian scholarship will provide the international academic community with a national example of best practice in the field of climate change and tourism impact assessment. Finally, this review will also provide national academics in the field with a current appreciation of the prevailing research inadequacies, existing knowledge gaps, the geographic imbalance of current assessments, as well as generate additional ideas for potential areas of future research.

The materials for this review were collected in a series of different ways to ensure the ability of this paper to present a collection of all the peer-reviewed academic journal articles that assess the impact of climate change on ORT in Canada. Initially, the collection of papers was compiled through various searches for numerous research projects in the field, using scholarly databases at university libraries, over the course of the lead author's academic career. Additionally, papers discovered this way then acted as useful cross reference tools and directed the authors to other papers that had been published since they were being referenced by related publications. Finally, to ensure the comprehensive nature of this review, the lead author personally contacted several notable scholars in the field (see Acknowledgements) to confirm the list of relevant publications that had already been compiled and request copies of any papers that may have been overlooked. The final stage did not yield many new papers but was helpful in gaining access to papers that had been discovered through the cross-referencing process but were not indexed in the host universities' scholarly databases.

2. Climate change impacts on outdoor recreation and tourism in Canada: a sector-based review

2.1. Alpine ski industry

2.1.1. Season length

Due to the dependence of skiing as a recreational activity on snow as a climatic resource, considering the implications of temperature fluctuations for snow fall, snow depth and snow-making, the ski industry is highly sensitive to weather and climate variability. The impact of climate change on the ski industry has received significant and warranted attention within the academic community worldwide and within a Canadian context as well. However, early studies attempting to assess the impact of climate change of the ski industry in Canada most likely overestimated the impact of climate change on ski season length. Table 1 displays the first studies conducted in an effort to assess the impact of climate change on ski season length in Canada. These studies were limited to the available climate change models which involved only a doubled carbon dioxide concentration emissions scenario (approximately equal to future climatic conditions in the 2050s). However, the greatest limitation associated with these early assessments was their failure to take into consideration snow-making as a supply side adaptation to climate change.

The first study looking at the impact of climate change on the ski industry in Canada that effectively accounted for snow-making as a

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Table 1
Early assessments of the impact of climate change on ski season length in Canada.

Source	Location	Season length
McBoyle, Wall, Harrison, Kinnaird, and Quinlan (1986)	Northern Ontario	−30 to −40%
McBoyle et al. (1986)	Central Ontario	−40 to −100%
McBoyle and Wall (1987, 1992)	Southern Quebec	−40 to-89%
Lamothe & Periard (1998)	Southern Quebec	−42 to −87%
McBoyle and Wall (1992)	Central Ontario	−40 to −100%

Table 3
The impact of climate change on the ski industry in Ontario and Quebec.
Source: Scott et al. (2006).

Location	Baseline (1961–1990)	2020s	2050s
Ski season length		(% Δ)	
Orillia, ON	149 days	−3 to −19	−8 to −46
Quebec City, QC	160 days	−1 to −13	−5 to −34
Ste. Agathe-des-Monts, QC	163 days	0 to −13	−4 to −32
Thunder Bay, ON	163 days	−2 to −17	−4 to −36
Snow-making requirements		(% Δ)	
Orillia, ON	105 cm	47 to 66	62 to 151
Quebec City, QC	77 cm	8 to 24	18 to 116
Ste. Agathe-des-Monts, QC	78 cm	11 to 45	27 to 150
Thunder Bay, ON	92 cm	28 to 52	40 to 161
Snow-making costs	US$ (millions)		
Orillia, ON	1.0 to 1.9	1.5 to 3.0	1.6 to 4.4
Quebec City, QC	0.8 to 1.4	0.9 to 1.7	1.0 to 3.0
Ste. Agathe-des-Monts, QC	0.7 to 1.4	0.8 to 2.0	1.0 to 3.3
Thunder Bay, ON	0.9 to 1.6	1.1 to 2.4	1.2 to 4.0

supply-side adaptation strategy was conducted by Scott, McBoyle, and Mills (2003). This case study was limited to only one ski resort (Horseshoe Valley), located in central Ontario. The assessment was based on Global Climate Model (GCM) projections, including both a least and greatest change emissions scenario, across the course of the 21st century (2020s, 2050s & 2080s). The climate change projections were then statistically downscaled to a local climate station using the Long Ashton Research Station stochastic Weather Generator (LARS-WG). Table 2 conveys the results of this climate change impact assessment (CCIA) on ski season length and snow-making requirements in central Ontario. Based on the results of this reassessment, it became clear that snow-making was a critical adaptation strategy for this region, demonstrating that the impact of climate change was significantly less than was earlier predicted, without the consideration of snow-making. According to Scott et al. (2003), ski season length in Ontario was only expected to decline by 7–32% during the 2050s, based on current snow-making techniques, which is considerably less than the 40–100% decline suggested by McBoyle et al. (1986) and McBoyle and Wall (1992). Nonetheless, the 161–342% increase in snow-making requirements for this same time period projected by Scott et al. (2003) raised concerns about the sustainability of the ski industry in this region and sparked a wave of new studies that took into account snow-making as an adaptation strategy when assessing the impact of climate change on ski tourism.

Based on the earlier case study by Scott et al. (2003), a multi-regional reassessment of the impact of climate change on ski tourism, incorporating snowmaking as a supply-side adaptation strategy, was conducted by Scott, McBoyle, Minogue, and Mills (2006). This study incorporated the same methods established by Scott et al. (2003) but widened the geographic scope of the study to include 6 different study areas, 4 of which were located in Canada (2 in Ontario and 2 in Quebec). In addition to modelled ski season length and snow-making requirements, this study also tried to quantify the cost associated with increased snow-making requirements. In their reassessment, Scott et al. (2006) also limited the temporal scope to only the 2020s and 2050s, as these were the time frames of greatest relevance to the ski industry. Table 3 displays the results of the CCIA by Scott et al. (2006) on 4 different ski areas located in Ontario and Quebec. Although the impact of climate change on ski season length by the middle of the 21st century was not as severe as earlier studies had suggested, on average, ski season length was expected to decline by 5–37%, increasing snow-making requirements by 37–145% and causing operating costs to rise by 1–4 million US$. Based on these results, the ski industry in central Ontario is likely to be the most negatively impacted by projected climate change, recording the greatest season length reduction and highest estimated increase in operating costs, likely due to its more southern location and lower elevation.

Table 2
The impact of climate change on ski season length and snow-making requirements in central Ontario.
Source: Scott et al., 2003.

Snow-making technology	Baseline (1961–1990)	2020s (% Δ)	2050s (% Δ)	2080s (% Δ)
Ski season length				
Current	123 days	0 to −16	−7 to −32	−11 to −50
Advanced		+5 to −8	−1 to −21	−4 to −39
Snow-making requirements				
Current	56 cm	136 to 244	161 to 342	191 to 401
Advanced		148 to 287	185 to 421	230 to 542

A very similar study was conducted soon after by Scott, McBoyle, and Minogue (2007a), focusing this time on the province of Quebec alone, using two of the same locations and presenting the same results as the multi-regional assessment by Scott et al. (2006); however, the new study included an additional ski area in Quebec (Sherbrooke). Results remained consistent with that of Scott et al. (2006), showing that the impact of climate change on ski tourism in Quebec will likely cause an increase in snow-making requirements, water consumption and energy costs; with smaller, lower lying and more southern locations being most severely impacted by such changes. Overall, Scott et al. (2007a) concluded that climate change does not pose an immediate threat to the sustainability of the Quebec ski industry; however, significant increases in energy and water requirements, as well as escalating operating costs associated with increased snow-making requirements are expected.

2.1.2. Demand response

Most recently, Rutty et al. (2015a) used an in-situ survey-based approach to assess demand response to non-reliable snow conditions resulting in resort closures among skiers at Ontario ski resorts. Although this study itself cannot be considered a climate change impact assessment, the results certainly have implications for the impact of climate change on ski tourism demand in Ontario. The results of this study were derived from the responses to 2448 surveys collected from 10 different ski resorts across Ontario. The main point of inquiry was exploring substitution behaviours among skiers in response to non-reliable snow conditions, including temporal, spatial and activity substitution. When asking skiers how they would respond if the resort they were currently visiting had been closed for the day, 70% responded by stating they simply would not ski that day (temporal substitution), while the other 30% indicated they would travel to another resort so that they could ski that day (spatial substitution). When asked how they would respond if the resort was closed until mid-January, 48% stated they would go elsewhere, while 43% would wait till mid-January (the remaining 9% indicated they didn't ski till after January anyways). When asked, what they would do if the resort they were currently visiting was closed permanently: 61% stated they would go elsewhere, 36% would ski less and 3% wouldn't ski anymore.

In a follow up study, based on the same surveys, collected from the same resorts across Ontario, Rutty et al. (2015b) explored the geography of spatial substitution among demand responses to non-reliable

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snow conditions resulting in resort closures. Again, this was not a climate change impact assessment, but the survey results have clear implications for the altered competitive relationship among ski resorts in Ontario due to the impact of snow scarcity under projected climate change. Based on the surveys collected from across 10 different ski resorts in Ontario, when respondents indicated they would travel to another ski resort if the one they were currently visiting was closed for the day: 27% stated they would go to Blue Mountain Resort (BMR), 14% stated they would visit Mount Saint Louie Moonstone (MSLM) and 11% would leave Ontario and travel to a resort in Quebec. When respondents indicated, they would travel to another resort if the one they were currently visiting was closed until mid-January: 28% stated they would go to BMR, 15% would travel to Quebec and 11% would visit MSLM. Finally, when respondents indicated they would travel to another resort if the one they were currently visiting was permanently closed: 28% would go to BMR, 12% would travel to Quebec and 10% would visit MSLM. The results of this study clearly indicated that if less-reliable snow conditions were experienced under projected climate change, the two largest and most advanced ski resort in the province (BMR & MSLM) would experience increased skier demand due to spatial substitution, while ski resorts in Quebec would also be likely to benefit from less-reliable snow conditions in Ontario.

2.2. Parks and protected areas

2.2.1. Seasonality and visitation

Nature-based tourism has been identified as a highly weather sensitive tourism activity and park visitation forms a significant portion of nature-based tourism in Canada. In an early assessment on the impact of climate change for nature-based tourism in Ontario, based on a doubled carbon dioxide concentration climate change scenario (~2050s), Wall et al. (1986) predicted that the camping season in 8 of Ontario's Provincial Parks would be expanded beyond the current operating season by as long as 40 days in some parks. More recently, an assessment of the impact of climate change on park visitation in Ontario was conducted by Jones and Scott (2006a) who looked specifically at provincial parks. Jones and Scott (2006a) selected six provincial parks, one from each of Ontario's six park regions, thereby presenting a system-wide assessment. Through a series of regression analyses, including multiple climate variables and monthly visitation data, it was determined that daily maximum temperature (T_{max}) was the greatest predictor of park visitation in Ontario. The shoulder seasons (spring and fall) and peak season (summer) were modelled separately to account for natural and institutional seasonality. Climate change projections were based on GCMs; including both best and worst-case emissions scenarios for the 2020s, 2050s and 2080s. Climate change projections were then statistically downscaled to a local climate station near each of the six study parks using LARS-WG. Table 4 conveys the results of the CCIA on visitation to Ontario's provincial parks by Jones and Scott (2006a). The results of this study suggest substantial increases to park visitation under projected climate change, even as early as the 2020s (an increase of 11–27% beyond current visitation numbers for total visitation, combining all parks in Ontario). Interestingly, the northeast and southeast park regions were expected to experience the greatest increase in park visitation under climate change. It is uncertain whether this is related to greater climate change impacts in these regions or due to greater sensitivity to climate variability, among parks in these regions.

Table 4
The impact of climate change on visitation to Ontario's provincial parks.
Source: Jones and Scott (2006a).

Park region	Total visitors	2020s (% Δ)	2050s (% Δ)	2080s (% Δ)
Northwest	777,477	8.3–24.4	12.3–51.7	16.3–73.3
Northeast	816,572	22.2–57.4	30.7–97.0	37.4–103.1
Central	3,486,606	8.3–20.6	11.9–44.2	14.5–65.6
Algonquin	866,617	2.6–7.7	4.0–16.8	5.2–24.5
Southeast	1,951,717	17.2–40.1	23.1–91.8	29.7–146.3
Southwest	2,264,129	8.2–21.3	10.9–47.2	14.6–68.2
Ontario	10,182,118	10.6–26.7	14.7–56.4	18.6–81.7

In a similar assessment, this time of Canada's national parks, Jones and Scott (2006b) selected 15 of Canada's 39 national parks, representing 86% of total visitation to Canada's national parks and covering 4 of Canada's 5 geographic regions. T_{max} and T_{min} were determined to be the most influential climate variables for predicting park visitation (based on both linear and cubic regression models). Again, the shoulder and peak seasons were modelled separately to account for natural and institutional seasonality (seasonality varied across the country with 3 parks having their peak seasons in months other than July and August). Climate modelling and climate change projections followed the same methods established by Jones and Scott (2006a). This study focused on warm-weather visitation only, and therefore does not represent annual park visitation, especially not for parks that experience significant winter season visitation related to activities such as cross-country and downhill skiing (i.e. mountainous parks in British Columbia and Alberta). Table 5 presents the results of this CCIA on visitation to Canada's national parks by Jones and Scott (2006b). The results of this study, in comparison to that of Jones and Scott (2006a), show that on average, by the end of the 21st century, climate change will likely cause a greater increase in visitation to provincial parks in Ontario (+19 to +82% beyond current visitation levels) than to that of national parks across Canada (+10 to +40%). This is likely because the impacts of climate change on warm-weather park visitation are much more disparate among parks across Canada, with certain regions only being mildly impacted (such as western Canada), while other regions are expected to see greater increases in park visitation under climate change (i.e. Ontario and Eastern Canada, see Table 5).

Most recently, Hewer, Scott, and Fenech (2016) re-assessed the impact of projected climate change on park visitation in Ontario, based on a case study of Pinery Provincial Park. Unlike previous climate change impact assessments on park visitation (Jones & Scott, 2006a, 2006b; Scott, Jones, & Konopek, 2007b, 2008) that relied on crude monthly climate and visitation data, this study was based on daily data. Furthermore, previous assessments relied on climate change projections for the IPCC's (2001) TAR; whereas, this study was able to utilise more recent climate change projections from the IPCC's (2013) AR5. Hewer et al. (2016) analysed historical weather and visitation data in order to determine the statistical relationship and create a series of seasonal predictive multi-variable regression models. Climatic predictor variables included in the seasonal visitation models were temperature and precipitation. Control variables also included in the models included a temperature threshold variable, as well as the effect of weekends and holidays. Working with the Statistical Down-Scaling Model (SDSM), the authors generated local-daily climate change scenarios that

Table 5
The impact of climate change on visitation to Canada's national parks.
Source: Jones and Scott (2006b).

National park	Total visitors	2020s (% Δ)	2050s (% Δ)	2080s (% Δ)
Pacific Rim Reserve	537,282	7.6–9.8	13.2–37.2	15.6–49.4
Waterton Lakes	418,358	6.1–10.2	10.1–36.3	14.4–60.0
Prince Albert	203,376	6.7–14.6	10.4–35.7	11.7–55.1
Mt. Revelstoke & Glacier	462,448	8.8–26.1	14.8–56.0	17.1–78.7
Kootenay	1,628,373	5.7–8.1	9.8–31.5	11.6–52.4
Yoho	1,066,544	3.5–5.1	5.5–19.1	6.7–29.9
Banff	4,413,741	2.5–3.0	4.0–11.9	4.7–19.8
Jasper	1,879,078	3.5–3.9	6.1–18.5	7.1–31.0
Point Pelee	331,932	4.8–13.0	6.5–28.6	9.1–39.4
Pukaskwa	8367	12.2–22.6	14.2–40.2	16.4–58.8
La Maurice	171,710	5.5–15.7	8.8–35.2	10.9–54.3
Prince Edward Island	845,850	14.1–22.4	21.2–50.6	23.8–73.6
Kouchibouguac	229,055	5.1–5.2	7.9–22.4	9.8–33.3
Cape Breton Highlands	366,307	22.9–30.0	36.6–78.2	40.3–126.2
Terra Nova	239,736	3.4–3.9	5.8–9.3	7.0–12.7
Canada	12,802,157	5.5–8.2	8.6–28.7	10.2–40.1

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described a progressively warmer and wetter climate for the region over the course of the 21st century. The results of the study suggested that for each degree Celsius of warming modelled (+1 to +5) annual park visitation increased by 3.1% (~18,500 additional visitors each year). The vast majority of modelled increases in visitation under projected climate change were experienced during the shoulder seasons (spring and fall). The results of this re-assessment were much more conservative than the previous assessment for this same provincial park in Ontario. Jones and Scott (2006a) projected an 8.2 to 68.2% increase in annual visitors to Pinery Provincial Park based on projected warming ranging from 0.6 to 9.4 °C. Whereas, Hewer et al. (2016) projected a 3.1 to 15.4% increase in annual park visitation based on a warming of 1 to 5 °C. These discrepancies are likely explained by the inability of the crude monthly models to include the negative effect of precipitation as well as to identify and control for critical temperature thresholds. Furthermore, the shoulder season model of Jones and Scott (2006a) included all months in the year outside the peak season (from September to June). On the other hand, Hewer et al. (2016) created three seasonal models (off, shoulder and peak) and found that visitation only had a strong enough sensitivity to weather variability in order to effectively predict future visitation during the conventional shoulder seasons in Ontario (May–June & Sept–Oct), and therefore did not project the impact of climate change on off season park visitation (November to April).

2.2.2. Climate-induced environmental change

According to the Federal government agency responsible for the management of Canada's system of national parks (Parks Canada, 1994), spatial displacement of ecosystems into and out of the stationary boundaries of Canada's national parks will pose unparalleled challenge to Parks Canada's mandate of maintaining ecological integrity in a representative sample of the nation's ecosystems. The first study published in a peer-reviewed journal that attempted to assess the impacts of climate-induced environmental change on parks and protected areas in Canadian was conducted by Suffling and Scott (2002). Suffling and Scott (2002) employed the Canadian Centre for Climate Modelling and Analysis (CCCma) coupled model (CGCM1), including both a doubled and tripled CO_2 levels climate change scenario, and projected changes in temperature and precipitation for each on the 38 Canadian national parks in operation at the time of the study. Unfortunately, this is where the empirical nature of the study ceased and the paper transitioned into a review of existing literature and intellectual discussion concerning the implications of such climatic changes for environmental features at one particular national park in Canada that served as a case study (Bruce Peninsula National Park in Ontario). For this park in particular, climate-induced environmental changes included: lowered water levels and ecological succession from marshes and fens to more dryland plants; rising water temperatures and changing freeze-thaw cycles as well as altering biological diversity within the aquatic ecosystem; increased fire-weather index ratings and forest fire hazards; increased forest pests and disease outbreaks; shifting bird migration patterns; expansion of the active dune complex; as well as increased ecological stress due to rising visitor numbers (Suffling & Scott, 2002). In conclusion, Suffling and Scott (2002) produced a table that provided a summary of similar climate-induced environmental changes for parks in six different regions across Canada (Atlantic parks, Great Lakes parks, Prairie parks, Western Cordillera parks, Pacific parks and Arctic parks). However, this final portion of the review was a summary of a more detailed governmental report which the author's alluded to and was unfortunately not presented in a very credible form since there were no references to support the various impacts indicated.

A more rigorous assessment concerning the potential impact that climate change will have on biome representation in Canada's national park system was published soon after by Scott, Malcolm, and Lemieux (2002). Scott et al. (2002) employed BIOME3 and MAPSS equilibrium process-based global vegetation models (GVMs), run with 5 different doubled CO_2 climate change scenarios from the IPCC's (1990) First Assessment Report (FAR) as well as IPCC's (1995) Second Assessment Report (SAR), in order to model climate-induced vegetation change on 39 Canadian national parks using a geographic information system (GIS). Although the IPCC's (2001) TAR was not available for use with GVMs at the time, the authors recognised that the FAR climate change projections were most similar to TAR projections and elected to use a number of these older scenarios to better represent the most recent developments in climate science and overcome the underestimation associated with the SAR. The MAPSS-based scenarios all resulted in at least one new biome type appearing in the majority of national parks (55–61%); whereas, the BIOME3-based scenarios showed a new biome appearing in 39–50% of parks. Table 6 presents the modelled proportional distribution of biome types in Canada's national park system under current and future climate conditions. This assessment of the effects that climate-induced environmental change will have on Canada's national parks systems suggests that there will be a reduction in Tundra and Taiga biomes across parks, while Boreal and Temperate forest biomes are projected to increase (Scott et al., 2002). The greatest consequence for park managers and planners associated with the results of this study is that it is within the parks' mandate to protect representative ecosystems, yet climate-induced environmental change threatens to modify and/or relocate the very ecosystems these parks were established to represent and protect (Scott et al., 2002). Furthermore, altered landscapes and shifting ecosystem biomes may have considerable impacts on the expectations, satisfaction and behaviour of park visitors, with both supply and demand side implications ORT in Canada.

A few years later, a very similar study was conducted by Lemieux and Scott (2005), using nearly the exact same methods (with only one noted divergence, mentioned below), but this time broadening the scope of the assessment to include not only Canada's system of national parks (~40 sites) but also a wide range of other parks and protected areas in the country (2979 sites in total). Once again, 2 GVMs (MAPSS & BIOME3) were used in combination with output from 5 doubled CO_2 climate change scenarios associated with the IPCC's (1990) FAR and (1996) SAR, applied to 2979 sites within a GIS to assess the percentage of protected areas to change biome type and the percentage change in representations of biome type across protected areas in Canada. The only noted difference in methods between this study and the previous study was that Scott et al. (2002) used a nearest grid cell approach, whereas Lemieux and Scott (2005) used an interpolation approach to correlate the GVM output with represented protected areas in Canada, stating that the large number of study sites included in the analysis warranted this alternative approach. Table 7 conveys the percentage of protected areas in Canada by designation type to change biome type under projected climate change (doubled CO_2 scenarios).

Table 6
Proportional biome representation (km^2) in 36 Canadian national parks as projected under current and future ($2 \times CO_2$) climate conditions.
Source: Scott et al. (2002).

Biome type	MAPSS		BIOME3	
	Baseline (1961–1990)	2050s (2040–2069)	Baseline (1961–1990	2050s (2040–2069)
Tundra	35%	20–30%	37%	22–37%
Boreal + Taiga/Tundra	45%	43–48%	47%	39–49%
Taiga/Tundra	19%	13–18%	N/A	N/A
Boreal	27%	26–34%	N/A	N/A
Temperate Evergreen Forest	8%	7–19%	4%	1–4%
Temperate Mixed Forest	8%	12–16%	7%	7–26%
Savana/Woodland	2%	2–5%	4%	4–11%
Shrub/Woodland	0%	0–0%	1%	1–2%
Grassland	1%	0–1%	0%	0–0%
Arid Lands	0%	0–0%	0%	0–0%

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Table 7
Biome-change in Canada's protected area network (by designation) under projected climate change (2 × CO_2).
Source: Lemieux and Scott (2005).

Protected area designation	Current number of protected areas	MAPSS	BIOME3
National parks	38	47–61%	39–42%
Wetlands of international importance	44	18–48%	34–34%
Migratory bird sanctuaries	66	17–50%	35–36%
National wildlife areas	40	15–45%	18–30%
Ecological reserves	464	34–52%	44–55%
Provincial parks	946	31–49%	54–71%
Wilderness areas	234	38–44%	31–56%
Total	2979	28–48%	37–48%

The range of percentage change associated with each GVM (Table 7) captures the range of uncertainty involved in the different GCM scenarios employed; where in general, GCMs associated with greater warming lead to higher degrees of biome-change (Lemieux & Scott, 2005). Depending on the GVM used, the percentage of protected areas in Canada projected to experience biome-change varied from 28 to 48% under MAPSS to a narrower range of 37–48% under BIOME3. Furthermore, the MAPSS projections suggested that national parks in Canada were the protected areas associated with the highest percentage of biome-change (47–61%); whereas, BIOME3 projected that provincial parks in Canada were associated with the highest percentage of biome-change (54–71%). Regardless of the GVM employed, the results suggested that out of all the different protected area designations in Canada, parks are likely to experience the greatest degree of biome-change under projected climate change. Beyond assessing the percentage of protected areas designations projected to experience a biome type change, Lemieux and Scott (2005) also modelled the percentage change in biome representations under current and projected climate conditions (Table 8). Under the MAPSS GVM, representation of the more northern biome classifications (tundra, tundra/taiga and boreal conifer forest) were all projected to decrease with considerable agreement across the four GCM scenarios. Generally, representations of the more southern biome classifications were projected to increase within Canada's network of protected areas, although there was greater uncertainty associated with these projections, as 1 out of the 4 scenarios tended to suggest change in the opposite direction than the other 3 for each biome classification. Under the BIOME3 GVM, the biome classification of temperature evergreen forest was added to the previously listed northern biomes all projected to experience a decline in representation. On the other hand, the more southern biome classifications were subject to greater uncertainty, with only 2 GCM scenarios and each suggesting a different direction of change, apart from temperature mixed forest which was associated with a marked increase in representation. Like the conclusions drawn by Scott et al. (2002), the modelled biome-change under future climate conditions by Lemieux and Scott (2005) calls into question the capacity of protected areas in Canada to continue representing and protecting the full range of ecological diversity within the country.

Using the same two GVMs and still relying on the doubled CO_2 climate change scenarios (IPCC's 1990 FAR & 1996 SAR), Scott and Lemieux (2007) published another study looking at the impact of climate change on biome-change, this time in Canada's boreal forest. Most the paper was a review of the existing literature from various disciplines and the skillful application of the results from the reviewed studies to identify and discuss climate-induced environmental change within Canada's boreal forest. The literature reviewed and the impacts discussed, as well as the actual modelling conducted was very similar to the work already done by Scott et al. (2002) for Canada's national parks as well as by Lemieux and Scott (2005) for Canada's protected areas, only the scope was narrowed to focus on only one biome this time (boreal). From a narrowly defined tourism perspective this paper added little to our current understanding of climate change impacts in Canada, but from a forestry and environmental management perspective, the paper had significant utility.

The first study that attempted to assess both the impact of climate-induced environmental change on park visitation as well as the modelled impact that direct climatic change would have on park visitation, was conducted by Scott et al. (2007b). Based on a case study of Waterton Lakes National Park in the Canadian Rocky Mountain region, Scott et al. (2007b) used a survey-based approach to assess the impact of climate-induced environmental change on park visitation over the course of the 21st century. The statistical model using linear and cubic regression to establish the relationship between T_{min} and monthly visitation projected an increase of + 6 to + 10% in the 2020s; + 10 to + 36% by the 2050s; and + 11 to + 60% by the 2080s. The survey results regarding the impact of climate-induced environmental change revealed that under 2020s conditions, 99% of respondents would still visit, while 10% would visit more often; under 2050s conditions, 97% would still visit, but 14% would visit less often; and under 2080s conditions, 19% would no longer visit with 37% indicating they would visit less often. Overall, the study revealed important findings suggesting that during the early and middle portion of the 21st century climate-induced environmental change is unlikely to impact park visitation. However, by the end of the 21st century, based on the survey based results of Scott et al. (2007b), environmental changes may cause a significant decline in park visitation which is contrary to the large increases for the end of the century projected by statistical models (Jones & Scott, 2006a, 2006b). However, these surveys are based on responses from individuals who have been “conditioned” by the era they are living in. Whereas, the 2080s people will have been conditioned differently so their preferences and behavioural responses are very difficult to ascertain, and therefore may not be accurately captured within this type of assessment.

Using the same survey instrument as Scott et al. (2007b), Scott et al. (2008) conducted a similar study, this time broadening the scope to develop a regional assessment of the impact of climate-induced environmental change on tourist decision-making and park visitation over the course of the 21st century within the Canadian Rocky Mountain region. The two national parks surveyed ($n = 809$) were Banff and Waterton (Scott et al., 2008). Results remained consistent with those from the earlier case study by Scott et al. (2007b). When visitors were asked to consider the environmental change scenarios projected for the 2020s, 88% indicated that their trip frequency would remain the same, 3% would visit less often, while 9% actually indicated that they would visit these two parks more often (Scott et al., 2008). Under the environmental change scenario depicted for the 2050s, 96% of all respondents indicated that they would still visit; however, 18% of total respondents indicated that they would visit less often (Scott et al., 2008). Finally, under the 2080s environmental change scenario, 25% of respondents indicated that they would no longer visit these national parks, and an additional 36% of respondents indicated they would visit the national parks less often. Scott et al. (2008) concluded that visitors travelling further distances and investing greater time and money were more sensitive to climate-induced environmental changes at these two rocky mountain national parks: reporting that approximately 34% of overseas visitors would not visit if environmental conditions in the 2080s scenario were realized, compared to only 17% of regional visitors and 24% of long-distance visitors from elsewhere in North America. Furthermore, the authors concluded that the impact of climate-induced environmental change, although insignificant at first, may begin to have a significantly negative impact on tourist decision-making and subsequent park visitation by the end of the 21st century.

2.3. Golf participation

The golf industry in Canada, as an ORT activity, is highly sensitive to weather and climate variability. Scott and Jones (2006) was the first

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Table 8
Biome representation in Canada's protected areas under current and projected climate conditions using two GVMs (MAPSS, BIOME3) and five GCMs scenarios (2 × CO_2).
Source: Lemieux and Scott (2005).

Biome	MAPSS		BIOME3	
	Protected areas in biome (1961–90)	%Δ under 2 × CO_2 (2040–69)	Protected areas in biome (1961–90)	%Δ under 2 × CO_2 (2040–69)
Tundra	39	−38 to −79	79	−67 to −72
Taiga-tundra	124	−81 to −87	161	−53 to −57
Boreal conifer forest	419	−22 to −75	797	−54 to −78
Temperature evergreen forest	684	−3 to +46	335	−34 to −73
Temperate mixed forest	1081	−29 to +31	1184	+47 to +93
Savanna/woodland	580	−32 to +90	346	−17 to +35
Shrub/woodland	24	−29 to +17	76	−43 to +9
Grassland	27	−15 to +141	1	−100 to −100
Arid lands	0	N/A	0	N/A

study to use a revealed climate preferences approach and establish a statistical relationship between historical climate information and actual golf participation data. In this initial case study attempting to assess the impact of climate change on golf participation in the Greater Toronto Area (GTA), only one golf course that was contacted by the researchers agreed to participate in the study and that golf course was only able to produce two years of daily golf participation data for the purpose of analysis (2002 − 2003). Multiple linear regression analysis (T_{max}, T_{min}, Daily Precipitation and Day of Week) was used to model the impact of climate change on future golf participation. Climate change projections were based on GCMs including both a best and worst case emissions scenario for the 2020s, 2050s and 2080s. GCM projections were downscaled to a local climate station (1961–1990) using LARS-WG. Table 9 presents the results of Scott and Jones' (2006) CCIA on golf participation in the GTA. From the results of the study it is apparent that climate change will likely cause an increase in rounds played within the GTA by as much as 10 to 28% come the end of the 21st century, even if the current season is not expanded beyond the present average of 214 days. However, if golf courses in the region adapt their operating seasons to take advantage of the newly suitable climatic conditions, especially in the shoulder seasons, it is likely that rounds played will increase by as much as 32–73% by the end of the 21st century.

To validate their model for predicting the impact of climate change on rounds played in the GTA, Scott and Jones (2006) used a spatial climate analogue approach. The spatial analogue required the detection of another golf course, located in a region that currently experiences climatic conditions similar to that which was projected for the GTA under future climate change. It was determined that the current climate in Columbus, Ohio is similar to that projected for the GTA by the end of the 21st century (2080s), under a high GHG emissions scenario. This spatial climate analogue was an effective tool for validating the predictive model used by Scott and Jones (2006) in that season length (323 and 333 days, respectively) and rounds played (46,720 and 47,600 rounds, respectively) were very similar between the modelled case study (Toronto, Ontario, Canada) and the observed analogue (Columbus, Ohio, USA).

Building on the framework established through the GTA case study (Scott & Jones, 2006); a regional CCIA on golf participation was conducted at the national level (Scott & Jones, 2007). This study included four golf courses located in four different regions across Canada (western Canada, southern and central Ontario, and eastern Canada). Again, the study was limited in regard to the availability of daily golf participation data for each course (only 2 to 5 years of data was available for analysis from each course). The methods set forth by Scott and Jones (2006) were used for establishing the relationship between climate and golf participation (multiple linear regression), as well as for projecting the impact of climate change (downscaled GCMs with best and worst case SRES for the 2020s, 2050s and 2080s). Table 10 presents the results of this CCIA on golf participation across Canada by Scott and Jones (2007). The impacts of climate change on rounds played and operating season length were disparate across the country. Western Canada experienced the lowest impact as it currently operates with a 365-day season and thus, there was no opportunity for season expansion, although warmer temperatures are still likely to cause more people to play more frequently. Whereas, eastern Canada, which currently has the shortest operating season, can expect to experience the greatest impact under climate change, with the potential for operating seasons to be lengthened by 39–85 days and rounds played to increase by 53–94%, come the end of the 21st century.

2.4. General tourism

Understanding that many forms of urban tourism are also highly weather-sensitive activities, it is expected that any changes in climate over time will have a significant effect on tourism seasonality and competitive relationships among tourism destinations, both domestically and internationally. Based on this premise, Scott, McBoyle, and Schwartzentruber (2004) conducted a CCIA on general tourism activities (such as shopping and sight-seeing) across North America. The study classified current climate (1961–1990) for tourism across the North American continent (Canada, USA & Mexico) using Mieczkowski's (1985) Tourism Climate Index (TCI) (a metric for evaluating climatic conditions for tourism, based on a combination of temperature, humidity, precipitation, sunshine and wind conditions). The study considered 143 urban cities (90 in the USA, 44 in Canada, 9 in

Table 9
The impact of climate change on golf participation in the GTA.
Source: Scott and Jones (2006).

Operating season	2020s		2050s		2080s	
	Rounds (+)	(% Δ)	Rounds (+)	(% Δ)	Rounds (+)	(% Δ)
Current average (1961–1990) 214 days 27,050 rounds	28,551–30,699	5.5–13.5	29,135–33,453	7.7–23.7	29,765–34,730	10.0–28.4
Climate adapted Max 365 days	33,384–37,084	23.0–37.1	34,257–43,417	26.6–60.6	35,570–46,720	31.5–72.7

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Table 10
The impact of climate change on golf season length and rounds played across Canada.
Source: Scott and Jones (2007).

Region	1961–1990		2020s		2050s		2080s	
	Rounds	Days	(% Δ) Rounds	(n Δ) Days	(% Δ) Rounds	(n Δ) Days	(% Δ) Rounds	(n Δ) Days
Western Canada	56,120	365	2–2	N/A	2–11	N/A	4–18	N/A
Southern Ontario	27,050	214	23–37	17–51	27–61	24–86	32–73	27–109
Central Ontario	25,309	192	21–35	10–16	25–59	10–37	30–74	18–68
Eastern Canada	23,269	168	40–48	28–45	49–74	28–56	53–94	39–85

Mexico), all being recognised as tourism attractions. GCMs were used to project changes in climate for the 2050s and 2080s; based on both best and worst case emissions scenarios. The TCI in combination with the GCM projections were then used to assess the suitability of climate for general tourism activities under future climate change. The climate for tourism in Canada is currently classified as a summer peak tourism climate (Scott & McBoyle, 2001). The results of the CCIA on the suitability of climate for general tourism activities across North America, by Scott et al. (2004), suggests that there will be evident shifts in tourism seasonality over the course of the 21st century, which in turn will alter competitive relationships between tourism destinations and create winners and losers within the industry. For example, climate in destinations such as Vancouver, a coastal city in southern British Columbia, Canada's most westerly province, is expected to benefit from projected climate change, whereas destinations such as Miami, in southern USA are expected to experience a negative impact on the suitability of climate for tourism. In general, it is expected that climate will become more suitable for tourism in Canada and northern USA, with regions in the southern parts of Canada potentially shifting from a summer peak tourism climate to a bi-modal tourism climate (peak visitation occurring in the spring and fall as temperatures become too warm during the summer months), as is currently experienced in warmer climatic regions within southern parts of the United States (i.e. Arizona).

A similar study was conducted by Amelung, Nicholls, and Viner (2007), following the approach of Scott et al. (2004), using Mieczkowski's (1985) TCI to assess the suitability of climate for tourism purposes, but this time on a global scale, taking a series of national perspectives. This study produced global maps showing the regions of the world that currently (1961–1990) have a climate which can be defined as suitable to general tourism activities (ratings of 70 or higher on the TCI). The study used GCMs in combination with two IPCC TAR (2001) SRES (B1A and A1F), to project the impact of climate change over the course of the 21st century (2020s, 2050s & 2080s). The main findings of this study suggested that the suitability of climate would shift poleward, with climate becoming more suitable for tourism as one moves away from the equator, while regions close to the equator have the potential of becoming too hot, especially during the peak summer seasons. In general, the results are in agreement with that of Scott et al. (2004), suggesting that conditions projected under climate change would likely result in a net benefit for general tourism activities in Canada (such as shopping and sightseeing), allowing for longer operating seasons and more attractive climatic conditions.

2.5. Polar tourism

2.5.1. Wildlife viewing

Similar expectations concerning the sensitivity of polar tourism to climatic variability that fuelled the numerous studies assessing the impact of climate change on ski tourism, most likely also sparked a number of empirical assessments concerning the impact of climate change on different forms of and locations for polar tourism. To begin, Dawson, Stewart, Lemelin, and Scott (2010) looked at carbon emissions and sea ice decline in relation to polar bear viewing as a form of last change tourism in Churchill, Manitoba. The paradox of this form of tourism pursuit was reported in the finding that tourists travelling to Churchill, Manitoba for polar bear viewing have a considerably high carbon footprint, which contributes to accelerated global warming and the melting of sea ice in the Hudson Bay region, an environmental feature essential to polar bear existence in the area and therefore the ability of tourists to see the bears when visiting the destination. Furthermore, since polar bear sightings are becoming less frequent, more tourists are travelling to the destination as it is gaining popularity as a form of last chance tourism, which in turn in further feeding the positive feedback cycle (more tourists, more emissions, less ice, less bears). Therefore, although climate change and declining sea ice could be accredited with an immediate boost in tourism to Churchill, Manitoba as the destination has shifted towards a form of last chance tourism, it is clear that climate change seriously threatens the sustainability of this form of polar tourism in the region.

2.5.2. Arctic cruises

Another form of polar tourism which has recently gained considerable attention from the academic community is cruise tourism. Initially, Stewart, Tivy, Howell, Dawson, and Draper (2010) analysed the impact that climate change has had on sea ice in the Canadian Hudson Bay region (1971–2007) and then assessed the indirect effect that declining sea ice has had on cruise tourism in the area (2006–2008). Based on an analysis of several indicators (total sea ice area, percentage of old ice, number of icebergs), the authors concluded that climate change has had a considerably detrimental impact on the prevalence of sea ice in the Hudson Bay region (almost rendering it non-existent), an environmental feature deemed very attractive by prospective cruise tourists to the destination. Therefore, declining sea ice has had a significantly negative effect on cruise tourism in the area.

A few years later, Stewart et al. (2013) shifted their focus further north into the Northern Passage of the Canadian arctic and reported different findings in relation to the impact that climate change and the effect declining sea ice has had on cruise tourism in the region. Although the impact of climate change is still causing a decline in sea ice within the Northern Passage, the effect has been positive in direction upon cruise tourism in the region, as vessels both for recreational and commercial purposes now enjoy greater mobility in the area. During the study period from 1968 to 2011, total sea ice area in the Northwest Passage has decreased by 11% per decade in the northern route and by 16% per decade in the southern route (Stewart et al., 2013). In conjunction with observed trends in declining sea ice, Stewart et al. (2013) found that from 2006 to 2010, the Northwest Passage had become the most popular cruise destination within the Canadian Arctic and that planned trips to the destination had increased by 70%. Therefore, climate change and declining sea ice had been shown to have disparate effect on cruising as a form of polar tourism in Canada, creating both winners and losers within the industry, based on the regional geography of destinations within the country. As the availability of sea ice and other environmental features associated with the tourism attraction continue to shift north under future climate change, a similar pattern can be observed as was seen with ski tourism in Canada, with southern destinations becoming less attractive to tourists and northern locations becoming more attractive to tourists. Paradoxically, as was the case with last

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chance polar bear viewing, this trend further increases the carbons emissions associated with this type of tourism and therefore increases its contribution to the acceleration of global warming and climate-induced environmental change.

2.5.3. Special events

Special events are defined by Ritchie (1984) as major one time or recurring events of limited duration. According to Getz (1991), special events include things such as festivals, fairs and major sporting events. Kim, Uysal, and Chen (2002) attest that special events are becoming an increasingly important form of tourism in Canada. When using a survey-based approach to explore the reasons for failure among special events, Getz (2002) found that weather was the most influential external factor (as ranked by respondents out of 8 different external factors). Furthermore, out of 30 factors in total contributing to the failure of special events, respondents ranked weather as the second most influential, only after a lack of corporate sponsorship (Getz, 2002).

2.5.4. Outdoor festivals and events

The first climate change impact assessment on special event tourism within the peer-reviewed academic literature across the international scientific community was based on a case study within the National Capital Region (NCR) of Canada, conducted by Jones, Scott, and Khaled (2006). The NCR includes the City of Ottawa in the Canadian province of Ontario as well as the City of Gatineau within the Canadian province of Quebec. Jones et al. (2006) conducted a climate change impact assessment on the three most popular special events in the NCR: Winterlude in the month of February, the Canadian Tulip Festival in the month of May and the Canada Day celebration in the month of July. Climate change projections employed by Jones et al. (2006) were based on GCM outputs from IPCC's (2001) TAR; including least, mid-range and greatest change emissions scenarios for the course of the 21st century (2020s, 2050s, & 2080s). Coarse regional-monthly GCM data was downscaled to local-daily climate change scenarios using LARS-WG (Jones et al., 2006). Each special event essentially required separate CCIAs as each activity was assessed using a different exposure unit. For Winterlude, Jones et al. (2006) used regression analysis involving temperature and precipitation variables to model the opening date and season length of the Rideau Canal Skateway, the primary attraction for the festival. For the Canadian Tulip Festival, Jones et al. (2006) used Growing Degree Days (GDD) in combination with predetermined thresholds for tulip emergence (20 GDD) and peak bloom (120 GDD) to assess the impacts of climate change for tulip phenology and festival timing. For the Canada Day celebration, Jones et al. (2006) used the predetermined thermal threshold of 30 °C (86 °F) to indicate a heat emergency and modelled the probability of a heat emergency occurring within the two-week period surrounding the Canada day celebration on July 1st each year. Table 11 conveys the potential impacts of projected climate change on a number of key elements for each of these special events within Canada's NCR. Jones et al. (2006) concluded that the special event which required the earliest adaptation from managers and planners was the Canadian Tulip Festival (with climate change causing peak bloom to occur before the festival begins as early as the 2020s). However, it was the Winterlude festival that was determined to be at greatest risk to climate change due to the low level of adaptive capacity and potential loss of the main attraction (Jones et al., 2006).

2.5.5. Mega sporting events

Recently, Scott, Steiger, Rutty, and Johnson (2014) conducted a global assessment of the impact of projected climate change on the suitability of climatic conditions for the Olympic Winter Games (OWG). The authors assessed the suitability of climate under baseline conditions (1981–2010) as well as under projected climate change (2050s, 2080s), for each of the 19 previous host cities of the OWG. The critical climatic requirements for reliable conditions as identified through a review of the relevant literature and then analysed by Scott et al. (2014) were the probability of minimum temperatures being below freezing and the probability of snow depth with the assistance of artificial snowmaking being >30 cm. Scott et al. (2014) based their climate change projections on an full ensemble of the 24 GCM outputs available from the IPCC's (2013) AR5, including both a least change (RCP2.6) and greatest change (RCP8.5) emissions scenario. Although this was an international study, out of the 19 cities assessed, 2 of the previous host cities were Canadian locations (the games were held in Calgary, Alberta during 1988 and in Vancouver, British Columbia during 2010). Table 12 displays the results of the study by Scott et al. (2014) that are relevant to this review of the projected impacts of climate change on tourism in Canada, specifically the suitability of climate in two different Canadian cities with regards to their ability to re-host the OWG. The qualitative designation of reliable climatic conditions is defined as the ability of a location to exceed a 90% probability that both temperature and snow depth will meet the minimum requirements (Scott et al., 2014). Whereas, the marginal (or high risk) designation indicates that either one indicator had a 90% or greater probability of being achieved and the other indicator had only a 75–89% probability of being achieved, or both indicators had a 75–89% probability of being achieved. Finally, the non-reliable designation indicates that there was less than a 75% probability that one or both indicators were achieved.

2.6. Snowmobiling

Although snow-making has proved to be a very effective climate change adaptation strategy for alpine skiing, it is not a realistic option for the snowmobiling industry (Dawson & Scott, 2010). As explained by Dawson and Scott (2010), in comparison to alpine skiing, snowmobiling takes place over a much larger area (making the production of artificial snow more difficult and highly inefficient), while also taking place at lower elevations (where temperatures are warmer and precipitation falling as rain is more common). The first and only known empirical study published in a peer-reviewed academic journal, assessing the potential impact of projected climate change on the suitability of climate for snowmobiling, was based on a Canadian case study by McBoyle, Scott, and Jones (2007). Using the conservative snow depth threshold of 15 cm to open and operate snowmobile trails (although a minimum of 30 cm is required for trails with rough surface terrain), McBoyle et al. (2007) modelled the impact of projected climate change on snowmobile season length across Canada's non-mountainous regions. The study sites selected for the assessment included 4 locations in the Prairies (2 in Saskatchewan and 2 in Manitoba); 4 in Ontario; 3

Table 11
The impact of projected climate change on special events in Canada's NCR (including both a least and greatest change emissions scenario).
Source: Jones et al. (2006).

Event	Key element	2020s	2050s	2080s
Winterlude	Rideau Canal Skateway opening by Feb 1st	100–100%	100–87%	100–53%
	Skateway season length (baseline: 61 days)	52–43 days	49–20 days	42–7 days
Canadian Tulip Festival	Tulips reaching peak bloom after May 1st	70–7%	53–0%	27–0%
	Earlier tulip full bloom (baseline: May 9th)	5–16 days	7–31 days	11–40 days
Canada Day Celebration	Occurrence of a heat emergency on July 1st	21–28%	21–57%	28–71%
	June 24th to July 7th heat emergencies (baseline: 2 days)	3–4 days	3–8 days	4–10 days

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Table 12
Climatic suitability of Canadian cities that previously hosted the OWG based on baseline conditions and future conditions under projected climate change.
Source: Scott et al. (2014).

Time frame			2050s (2041–2070)		2080s (2021 − 2100)	
Host City	Measurement	Baseline (1981–2010)	RCP2.6 (low)	RCP8.5 (high)	RCP2.6 (low)	RCP8.5 (high)
Calgary	Tmin <0 °C	100%	>90%	>90%	>90%	>90%
Vancouver		>90%	80%	65%	70%	45%
Calgary	Snow Depth >30 cm	100%	100%	100%	100%	100%
Vancouver		100%	100%	100%	100%	20%
Calgary	Climatic suitability	Reliable	Reliable	Reliable	Reliable	Reliable
Vancouver		Reliable	Marginal	Non-reliable	Non-reliable	Non-reliable

in Quebec; and 4 in the Maritimes (2 in Nova Scotia and 2 in Newfoundland). Climate change projections were based on GCM outputs from the IPCC's TAR (2001), following both a least and greatest change emissions scenario for the future time frames of the 2020s and 2050s; downscaled to local point scenarios using LARS-WG. Table 13 records the results of the climate change impact assessment by McBoyle et al. (2007) on snowmobile season length across Canada's non-mountainous regions. The results of the assessment suggest projected climate change poses the greatest risk for snowmobiling in the prairies and then the Maritime Provinces (McBoyle et al., 2007). However, under the greatest change emissions scenario, climate change poses a severe risk for the sustainability of the snowmobiling industry in non-mountainous regions of Canada, where McBoyle et al., 2007 suggest all four regions will experience more than a 90% reduction in season length. Even in the most resilient regions, this translates into a projected season length of only mere days rather than weeks or months.

Due to the mountainous nature of snowmobiling in British Columbia as well Alberta, and the perceived resilience of the suitability of climate for snowmobiling due to elevation in these areas, McBoyle et al. (2007) did not include any sites from these Canadian provinces in their assessment (despite comparable figures to the two represented prairie provinces in regard to the length of trails as well as the number of clubs and registered snowmobiles). Furthermore, the Canadian territories of the Yukon, the Northwest Territories and Nunavut as well as the maritime provinces of New Brunswick and Prince Edward Island were also not represented in this assessment. According to McBoyle et al. (2007), the exclusion of the Canadian territories was due to the nature of snowmobile use in the Canadian north (being primarily for transportation not recreation). In the Maritime provinces, it is assumed that Prince Edward Island was excluded due to it very low levels of snowmobile participation; whereas, the justification for not representing New Brunswick remains unclear.

2.7. Zoo attendance

After the weather sensitivity of zoo attendance as a ORT activity was acknowledged by the academic community (Hewer & Gough, 2016a; Perkins, 2016; Perkins & Debbage, 2016), the first formal climate change impact assessment on zoo attendance was based on a Canadian case study (Hewer & Gough, 2016b). This climate change impact assessment used a modelling approach, based on a statistical analysis of daily weather and attendance data from 1999 to 2013. Hewer and Gough (2016b) created three predictive seasonal multi-variable regression models (off, shoulder & peak) for predicting future attendance. GCM data from the IPCC's (2013) AR5 was ranked and selected using the Gough-Fenech Confidence Index (GFCI) to create a selective ensemble of seasonal climate change projections for the region. Regional-monthly GCM output was downscaled to local-daily climate change scenarios using SDSM. Under the low radiative forcing, least change scenario (RCP2.6), a warming of 1.4 to 2.0 °C over the course of the 21st century, caused annual zoo attendance to increase by 7.6 to 18.3% (~95,000 to 230,300 visitors). Under the high radiative forcing, greatest change scenario (RCP8.5), a warming of 1.6 to 5.9 °C over the course of the 21st century, caused annual zoo attendance to increase by 7.8 to 33.9% (~98,000 to 430,000 visitors). The vast majority of modelled increases in zoo attendance were experienced during the shoulder seasons (spring & fall); with only moderate increases during the off season (winter) and potential decreases during the peak season (summer), especially once warming exceeded 3 °C. The modelled impact of projected climate change on the seasonality of zoo attendance in Ontario (Hewer & Gough, 2016b), was in agreement with the general tourism study by Scott et al. (2004) that suggested tourism seasonality in southern parts of Canada may shift from the current summer peak tourism climate to a bi-modal tourism climate (with tourism peaking in the spring and fall rather than the summer).

Hewer and Gough (2016c) used a multi-year temporal climate analogue approach, to re-assess the modelled impact of projected climate change on visitor attendance to the Toronto Zoo in Ontario. Statistical analysis of the effect that seasonal climatic anomalies (temperature and precipitation) had on zoo attendance from 1999 to 2015 was performed by the authors. Potential confounding variables were identified and controlled for, including the Toronto SARS outbreak in 2003, the opening of the Dinosaurs Alive! zoo exhibit in 2007, and the arrival of the Giant Pandas in 2013. GCM data from IPCC's (2013) AR5 was ranked and selected using the GFCI to create a selective ensemble of seasonal climate change projections for the region. Anomalously warm winters and springs resulted in significantly higher seasonal zoo attendance; whereas, anomalously warm summers resulted in significantly lower attendance levels (Hewer & Gough, 2016c). However, the authors found that anomalously wet seasons did not result in statistically significant changes in seasonal zoo attendance, except for during the spring when extreme precipitation caused attendance to decline. Seasonal temperature anomalies served as temporal climate analogues for the 2050s under projected climate change, suggesting that an average annual warming of 2.9 °C may cause annual zoo attendance to increase by 23% (~290,000 visitors). In comparison to the modelling approach of Hewer and Gough (2016b), where a projected warming of 2 to 3.5 °C resulted in a 14 to 17% increase for annual zoo visitation, the temporal climate analogue approach of Hewer and Gough (2016c) suggested a more pronounced impact of seasonal climatic variability under projected climate change on annual zoo visitation in the region.

Table 13
Average baseline snowmobile season lengths (in days) by region and potential reductions under projected climate change (least and greatest change emissions scenarios).
Source: McBoyle et al. (2007).

Region	Baseline (1961–90)	2020s (2010–2039)	2050s (2040–2069)
Prairies (SK, MB)	49	−69% to −80%	−69% to −98%
Ontario	78	−29% to −56%	−40% to −95%
Quebec	69	−29% to −53%	−37% to −95%
Maritimes (NS, NF)	30	−45% to −49%	−75% to −93%

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Nonetheless, the results of the analogue approach confirmed that the results of the modelling approach were certainly plausible, although potentially conservative in nature.

2.8. Knowledge gaps and future research

Scott et al. (2012) identified several critical knowledge gaps within the existing international literature from which a series of broad recommendations for future research were generated. The authors called for more wide-spread application of tourism climate analogues; further validation and calibration of tourism climate indices for specific tourism contexts; more adequate assessment of the impact that key species loss may have on tourism attractions and travel patterns; as well as an improved understanding of the adaptive capacity of tourists (Scott et al., 2012). Still from an international perspective, but looking more specifically at tourism demand and tourist behaviour, Gössling et al. (2012) identified several important gaps in our current understanding of the relationship between climate change and tourism. For example, there is a lack of knowledge pertaining to tourist's perceptions of climate change and the implications for tourist behaviour. In addition, little is known about the impact that climate-related media communication may have on tourist decision-making, although this has been assessed within a European context (Rutty & Scott, 2010). Finally, there has been a lack of studies aimed at assessing the impact of severe weather events on tourist behaviour and tourism demand in general, although this too has been recently assessed within a European context (Gössling, Abegg, & Steiger, 2016). These observations from reviews of the academic literature available within the international scientific community relating to tourism and climate change scholarship hold true within the Canadian context as well.

Based on this review of the current peer-reviewed academic literature assessing the impact of climate change on ORT in Canada, there have been a total of 30 papers published which examine 8 different industry sectors (Table 14). Looking at the geographic focus of the papers published, 13 out of the 30 papers published (43%) focus exclusively on the Canadian province of Ontario. The province to receive the next greatest amount of research attention was Quebec, but with only 5 papers exclusive to that province (17%). A total of 9 papers took a national perspective (30%), but only 6 of them represented the whole of the country while the other 3 drew on case studies from across the country selected from only a limited number of provinces/territories (see Table 14). The Atlantic Provinces (New Brunswick, Nova Scotia, Prince Edward Island as well as Newfoundland and Labrador) are under-represented in climate change impact assessments for tourism, only being captured in some of the national assessments. Tourism is an important economic aspect for the Atlantic Provinces and future research should be designed and conducted to address this geographic imbalance and knowledge gap within the climate change impacts and tourism literature for Canada. Furthermore, tourism is fast growing and very lucrative aspect of the regional economy in British Columbia, yet this province has also received very little attention from the academic community (Parks: Jones & Scott, 2006b, Scott et al., 2008; Golf: Scott & Jones, 2007; Special Events: Scott et al., 2014). The Prairie Provinces (Alberta, Saskatchewan and Manitoba) are also underrepresented, with only a few studies assessing the impact of climate change on ORT in this region of Canada (Parks: Jones & Scott, 2006b, Scott et al., 2007b, Scott et al., 2008; Snowmobiling: McBoyle et al., 2007; Polar bear viewing: Dawson et al., 2010; Special Events: Scott et al., 2014).

Certain ORT activities have begun to be assessed within a Canadian context, but there would be value in future research that explored the impact of climate change on these activities across different geographic contexts within Canada. For example, outdoor events and festivals have only been assessed in the geographic context of Ontario and Quebec (Jones et al., 2006), but not in any other regions across Canada (i.e. the Calgary Stampede in Alberta). Furthermore, out of the 30 papers reviewed, the 8 papers devoted to assessing the impact of climate

Table 14

Research on the impact of climate change for outdoor recreation and tourism in Canada (1986–2016) by tourism context, geographic focus and nature of assessment.

Study	Context	Geographic focus	Assessment
McBoyle et al. (1986)	Skiing	Ontario	Season length
McBoyle and Wall (1987)	Skiing	Quebec	Season length
McBoyle and Wall (1992)	Skiing	Ontario, Quebec	Season length
Scott et al. (2003)	Skiing	Ontario	Season length, snow-making requirements
Scott et al. (2006)	Skiing	Ontario, Quebec	Season length, snow-making requirements, snow-making costs
Scott et al. (2007a)	Skiing	Quebec	Season length, snow-making requirements, snow-making costs
Rutty et al. (2015a)	Skiing	Ontario	Demand response, behavioural adaptation
Rutty et al. (2015b)	Skiing	Ontario	Demand response, behavioural adaptation
Wall et al. (1986)	Parks	Ontario	Season length
Suffling and Scott (2002)	Parks	Canada[a]	Climate-induced environmental change
Scott et al. (2002)	Parks	Canada[a]	Climate-induced environmental change
Lemieux and Scott (2005)	Parks	Canada[a]	Climate-induced environmental change
Scott and Lemieux (2007)	Parks	Canada[a]	Climate-induced environmental change
Jones and Scott (2006a)	Parks	Ontario	Seasonality, visitation
Jones and Scott (2006b)	Parks	Canada[b] (BC, AB, SK, ON, QC, NB, NS, PE, NL)	Seasonality, visitation
Scott et al. (2007b)	Parks	Alberta	Seasonality, visitation, visitor response to environmental change
Scott et al. (2008)	Parks	Alberta, British Columbia	Seasonality, visitation, visitor response to environmental change
Hewer et al. (2016)	Parks	Ontario	Seasonality, visitation, temperature thresholds
Scott and Jones (2006)	Golf	Ontario	Season length, rounds played
Scott and Jones (2007)	Golf	Canada[b] (BC, ON, NS)	Season length, rounds played
Scott et al. (2004)	General	Canada[a] (North America)	Suitability of tourism climate
Amelung et al. (2007)	General	Canada[a] (Global)	Suitability of tourism climate
Jones et al. (2006)	Events	Ontario, Quebec	Suitability of climate for event attractions
Scott et al. (2014)	Events	Alberta, British Columbia	Suitability of climate for winter tourism
McBoyle et al. (2007)	Snowmobiling	Canada[b] (SK, MN, ON, QC, NS, NL)	Snow depth, season length
Dawson et al. (2010)	Polar	Manitoba	Sea ice, polar bear sightings
Stewart et al. (2010)	Polar	Nunavut	Sea ice, cruise ship trips
Stewart et al. (2013)	Polar	Nunavut	Sea ice, cruise ship trips
Hewer and Gough (2016b)	Zoos	Ontario	Seasonality, attendance, temperature thresholds
Hewer and Gough (2016c)	Zoos	Ontario	Seasonality. attendance

*Postal abbreviations for Canadian Provinces (10) and Territories (3): British Columbia (BC), Alberta (AB), Saskatchewan (SK), Manitoba (MB), Ontario (ON), Quebec (QC), New Brunswick (NB), Nova Scotia (NS), Prince Edward Island (PE), Newfoundland and Labrador (NL), Nunavut (NU), Northwest Territories (NT), Yukon (YT).

[a] Study focused on Canada and all Canadian regions are represented.

[b] Study focused on Canada but not all Canadian regions are represented (provinces and territories represented listed in abbreviated form*).

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change on alpine skiing in Canada all focused on either Ontario or Quebec, with no studies looking at the impacts on skiing in British Columbia, Alberta or any of the Atlantic provinces. Additionally, the impacts of climate change on zoo attendance have only been assessed in the context of Ontario, being even more geographically limited to only one case study in Toronto (Hewer & Gough, 2016b, 2016c). However, there are several other large zoos of regional and national significance in varying climate regions across the country that may provide additional insights (i.e. the Greater Vancouver Zoo in B.C.; the Calgary Zoo in Alberta; the Magnetic Hill Zoo in New Brunswick). Finally, the scope of assessment concerning the impact of climate change on cruise tourism in Canada could be expanded beyond the Hudson Bay Region (Stewart et al., 2010) and the Northwest Passage of the Canadian Arctic (Stewart et al., 2013), potentially looking at cruising on the pacific coast of British Columbia, the Atlantic coast or even above the Yukon.

There are also certain ORT activities in Canada that have yet to undergo a formal climate change impact assessment, or at least have not had any such assessment published in the peer-reviewed academic literature. For example, no studies have assessed the impact of climate change on wine tourism in British Columbia's Okanogan region or Ontario's Niagara region, where changing climate conditions may have important implications for growing seasons, grape diversity, wine quality as well as visitor satisfaction with and participation in winery tours. Furthermore, climate change may also have important implications for the volume and value of cottage sales, the geography of cottage real-estate as well as long weekend highway traffic conditions, but no formal climate change impact assessment has been conducted and published to date. The impact of climate change on attendance at amusements parks in Canada has also yet to be assessed and apart from Canada's Wonderland in Toronto (ON), studies focused on Playland in Vancouver (BC), Calaway Park in Calgary (AB) or La Ronde in Montreal (QC) would not only address this activity-based knowledge gap but also help to spread out the geographic focus of CCIAs for tourism in Canada. Finally, although beach tourism has received a considerable amount of attention within the international research on climate change and tourism (Moreno, 2010; Moreno & Amelung, 2009; Moreno & Becken, 2009), there is no peer-reviewed literature available on the impact of climate change for beach tourism in Canada. Future research assessing the impact of warmer weather projected under climate change for beach tourism on the pacific coast of British Columbia or among the Atlantic Provinces, as well as within the Great Lakes region, would be valuable contributions towards understanding the impacts of climate change on ORT in Canada. Future research designed to better understand the implications of sea level rise as well as the increasing frequency and intensity of extreme weather events for beach tourism, especially on Canada's ocean coasts, would also be useful.

Another area of future research that comes as a recommendation from this review is the need for current and on-going re-assessments. Out of the 30 papers reviewed, 7 of the earliest assessments (23%) relied on a simple doubled carbon dioxide concentration climate change scenarios. The most frequently applied climate change projections (14 papers, 47%) were guided by GCM data derived from the IPCC's (2001) Third Assessment Report (TAR) and the associated Special Report on Emission Scenarios (SRES). Oddly, there were no impact assessments that employed climate change projections from the IPCC's (2007) Fourth Assessment Report (AR4), which although based on more sophisticated and advanced GCMs, still relied on the same SRES as the TAR. Only 4 papers (13%) conducted climate change impact assessments (or re-assessments) on ORT in Canada taking advantage of the most up-to-date climate science and advancements in climate modelling, using GCM output from the IPCC's (2013) Fifth Assessment Report (AR5) and the newly devised climate change scenarios associated with the Representative Concentration Pathways (RCP). Beyond the widespread application of climate change scenarios that either precede the development and application of GCMs for CCIA (i.e. 2 × CO_2 scenarios) or are reliant of climate science and modelling that is now nearly two decades old (IPCC's 2001 TAR), 5 of the papers reviewed (17%), did not apply any climate change projections or make any impact modelling attempts at all, but only reported the observed impacts of historical climatic changes on recreation and tourism in Canada (Dawson et al., 2010; Stewart et al., 2010, 2013; Rutty et al., 2015a, 2015b). Therefore, whether it is a matter of previous assessments relying on out-dated climate science, climate models or climate change scenarios; or simply the fact that previous assessments did not take the next step of applying observed historical relationships to future impact models, further re-assessments are still an important area of future research within the study of climate change impacts for tourism in Canada.

Becken (2013) determined that after Canada, case studies from other western nations such as Australia, the United States, the United Kingdom and New Zealand have dominated the literature on climate change and tourism. However, there have been no attempts to synthesise these papers into a formal review of the impacts of climate change on tourism in any of these nations, as was done for Canada in this paper. Future research that replicates this somewhat unconventional literature review but focuses on the climate change impacts for tourism in another nation such as one of those listed above, which have all received considerable attention from the academic community, would be of considerable value and utility to government policy makers, destination planners, tourism managers and tourism scholars within the host nation.

Community-based impacts, vulnerabilities and adaptations to climate change has been identified as an important knowledge gap within the tourism literature (Kaján & Saarinen, 2013). To date, both globally and within a Canadian context, the tourism literature has been dominated by systems-based, economic (supply- and demand-side responses) climate change impact assessments. For example, studies which assess climate change impacts on the availability and seasonality of tourism-climate resources such as snow conditions (Scott et al., 2006) or comfortable temperatures (Hewer et al., 2016); or how tourism demand will respond under changed climatic (Scott et al., 2004) and environmental (Scott et al., 2007b) conditions. However, future research looking at how tourism communities will be affected by these climate-induced environmental and socio-economic changes remains an importance area of future research (Morrison & Pickering, 2013). For example, tourism product diversification has been identified as an effective industry adaptation in response to climate change, especially for winter resorts that are threatened by warming temperatures and unreliable snow conditions (Dubois & Ceron, 2006). However, no study to date has formally assessed how destination communities will be impacted by such changes, nor identified any further socio-economic adaptations that may ensue, as may be the case for the diversification of ski resorts into four-season resorts in many areas of southern Ontario. Nonetheless, this important knowledge gap has recently begun to gain attention from scholars within Canada, particularly for artic tourism (Stewart et al., 2013) and last chance tourism (Groulx, Lemieux, Dawson, Stewart, & Yudina, 2016).

Finally, the international literature on climate change and tourism suggests that climate in the region of origin may affect tourism flows. For example, Eugenio-Martín and Campos-Soria (2010) found that when climatic conditions improve within the region of origin, domestic travel increases and international travel decreases. Furthermore, Rosselló, Riera, and Cardenas (2011) reported that a 1 °C increase in average temperatures within the UK resulted in a 1.7% decrease in British out-bound tourism. No research to date has considered the implications of climate change in this regard for Canada's national tourism economy, nor the flows of domestic and international tourists, despite the suggestion that cold climate nations such as Canada stand to benefit from warming under projected climate change (Hamilton, Maddison, & Tol, 2005a, 2005b). Furthermore, European literature on climate change impacts for tourism is dominated by econometric modelling (Rosselló-Nadal, 2014), a research approach that is non-existent within the Canadian literature on climate change and tourism. Although many sound

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academic arguments have been developed which emphasise the importance of activity specific case studies (de Freitas, 2003; de Freitas, Scott, & McBoyle, 2008), which currently characterise the Canadian literature on climate change impacts for tourism, more general economic modelling may provide additional insights concerning the impact of climate change on tourism in Canada, especially from a national perspective.

3. Conclusion

Overall, climate change is expected to have a significant impact on seasonality and participation for ORT in Canada. Regarding warm-weather activities, climate change is expected to cause conditions in Canada to become more suitable for tourism, especially in regard to park visitation, golf participation, zoo attendance and more general tourism activities (such as sight-seeing and shopping). However, climate change is expected to have negative impacts on cold-weather activities, especially those dependent upon snow and ice as the main climatic resource such as alpine skiing, snowmobiling, winter festivals, polar bear sighting and glacier viewing. Some exceptions to this general trend involve concerns about thermal stress during the summer months for park visitation, zoo attendance and special events. Furthermore, although climate change generally presents risks for winter recreation and tourism in Canada, some new opportunities have been presented for arctic cruise tourism because of melting sea ice and increased ship mobility.

Although our understanding of climate change impacts and tourism in Canada has improved substantially, especially since the turn of the 21st century, there is still a great need for further research in this field, and more specifically within a Canadian context. Tourism activities in the provinces of Ontario and Quebec have received a disproportionate level of research attention, creating a need for future studies looking at weather and climate sensitive tourism activities in other regions of the country. In addition, many important tourism activities and attractions have yet to be assessed in relation to their respective weather sensitivity or the subsequent impacts of climate change. Finally, previous studies have been limited by out-dated climate science, climate models and climate change scenarios, with most assessments (70%) being based on either a simple doubling of pre-industrial carbon dioxide concentrations or GCM data from the IPCC's (2001) TAR. Future research looking at new and unstudied tourism activities as well as reassessments of previous studies are poised to take advantage of contemporary climate science, more advanced climate models and updated climate change scenarios from the IPCC's (2013) AR5. Climate change is very likely to present various risks and opportunities for the tourism industry in Canada. As a result, the on-going assessment and re-assessment of weather sensitivity and climate change impacts associated with recreation and tourism activities in Canada is an important area of future research.

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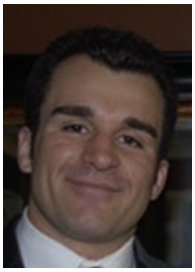

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