CLIMATE CHANGE AND THE SKI INDUSTRY IN EASTERN NORTH AMERICA: A REASSESSMENT

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ABSTRACT

The ski industry and winter tourism more generally has been repeatedly identified as vulnerable to global climate change. An important limitation of previous climate change impact assessments of the ski industry is their incomplete consideration of snowmaking as a climate adaptation strategy. This limitation is particularly problematic in areas of eastern North America, where snowmaking has been an integral component of the ski industry for more than 20 years. This study examined how current snowmaking capacity affects the climate change vulnerability of ski areas in six locations in Ontario, Quebec, Vermont and Michigan where previous climate change assessments did not incorporate snowmaking. The study used a model developed and previously applied in areas of Ontario and Quebec (Canada) to project the length of ski seasons under a range of climate change scenarios. The findings suggest that in the 2020s, even the high impact climate change scenario poses only a minor risk to ski areas at five of the six study areas. The reassessment for the 2050s period with snowmaking found that the impacts of climate change were not as severe as projected in earlier studies. The low impact climate change scenario would pose a challenging business environment for ski areas, but would not pose a serious risk to their economic sustainability. Conversely if the high impact climate change scenario was realized the reduction in the length of the ski season, combined with projected increases in snowmaking requirements, could jeopardise ski operations in some ski areas (southern Michigan and Ontario) by the 2050s. However, this high impact scenario for the 2050s did not pose a threat to the regional ski industry. Instead, certain ski areas will likely benefit economically from reduced competition brought about by climate change induced contraction in the industry.

KEYWORDS: *Climate change, Ski industry, Tourism, Recreation, Canada, United States*

INTRODUCTION

The winter tourism industry, in particular alpine skiing, has been repeatedly identified as highly vulnerable to climate change. Studies (1) indicate that the Swiss tourism industry has not fully recovered from low snowfall years during the late 1980s and project that climate change could jeopardise the industry by reducing the number of 'snow reliable' ski resorts from 85% to between 44%-63%. In Austria, changes in snow cover could put several major low elevation resorts at risk, resulting in winter tourism revenue losses of 10% (2). An assessment of the Japanese ski industry (61 ski areas) estimated that increased winter temperatures of 3°C would reduce skier visitation by 30% (3). The impact of climate change on Australia's snowfields and its three main ski areas is also expected to be substantial, with the average ski season reduced by 54-81% (4).

The earliest studies on the potential impact of climate change on the ski industry were completed in the Great Lakes and New England regions of North America (5, 6, 7, 8). Although snowmaking has been an integral component of the ski industry in eastern North America for more than 20 years, an important limitation of these first generation climate change impact assessments of the ski industry was the omission of snowmaking.

Scott et al. (9) were the first to fully integrate snowmaking as an adaptation strategy to climate change. They found substantially lower climate change impacts relative to previous assessments of the ski industry in central Ontario that did not incorporate snowmaking. The authors subsequently recommended that similar reassessments be completed in areas of eastern North America where previous, and widely cited, climate change studies projected very large impacts on the ski season. Building on this recommendation and the methods developed by Scott et al. (10), this study examined the impact of projected climate change on six ski areas in eastern North America where previous climate change impact studies had been completed without consideration of snowmaking.

METHODS

The ski areas examined in the study are located in the provinces of Ontario and Quebec (Canada), and the states of Michigan and Vermont (USA). The selection of the climate stations for this study was based on two considerations: proximity of the station to the ski area of interest and the quality of the climate record (minimally 1961-1990). For each location a complete record of daily temperature and precipitation was obtained for the 1961-1990 period. The results of this analysis are only valid for the climate station location and surrounding areas that exhibit similar climatological characteristics. The ski area(s) in the vicinity are usually several kilometres away and may have microclimatic features that enhance or reduce its natural snowfall or suitability for snowmaking.

The climate change scenarios used in this analysis were obtained from the Canadian Climate Impact Scenarios project and were constructed in accordance with the methodological recommendations of the United Nations Intergovernmental Panel on Climate Change (IPCC) Task Group on Scenarios for Climate Impact Assessment. A total of 25 possible scenarios from global climate models (GCMs) were considered for this analysis. In order to limit the number of scenarios to a manageable number, while still considering the full range of potential climate futures, five scenarios representing the upper and lower bounds of change in mean temperature and precipitation, for December-January-February (DJF), were analysed. For concise presentation only the results of two scenarios, a low impact scenario (least change in climate - NCARPCM-B2) and high impact scenario (greatest change in climate - CCSRNIES-A1), are reported. Changes are relative to the 1970s baseline (average 1961-90). Results for the 2020s are of greatest relevance to ski area operators due to the smaller range in uncertainty of climate change projections, and because they are within the lifetime of existing infrastructure and long-term business and investment planning horizons.

To produce daily data for the two climate change time series, (2010-2039 and 2040-2069), monthly climate change scenarios from the two GCM scenarios were downscaled using the LARS stochastic weather generator. The weather generator was parameterized to the climate station at each location using climate data from the baseline period 1961-1990.

Daily temperature and precipitation data downscaled with the LARS weather generator were used to drive a locally calibrated snow depth model that was based largely on methods used to develop the *Canadian Daily Snow Depth Database* and *Water Balance Tabulations for Canadian Climate Stations*. This technique involved estimating three parameters: 1) amount of precipitation that falls as snow and rain, 2) snow accumulation, and 3) snowmelt. Historical precipitation data was analyzed for each station to determine the minimum, maximum and/or mean daily temperature thresholds that best-predicted observed snowfall amounts over a 30-year period. Snowfall was added to the snow pack assuming a constant density of $400 kgm^{-3}$. A US Army Corps of Engineers equation was used for daily snowmelt calculations. The snow model was evaluated by comparing the predicted and observed number of days with snow, and days when snow depth met or exceeded the assumed operational requirement (30cm) over the baseline period.

To complete the modelling of snow conditions at each ski area, a snowmaking module was integrated with the natural snow cover model. The estimated technical capacities and decision rules were derived from communications with ski industry stakeholders.

The climatic criteria for a skiable day were adopted from Scott et al. (10), which were derived from an examination of 20 years of daily observed ski operations data from ski areas in the province of Ontario, and communications with ski industry stakeholders. Ski areas were assumed to close if any of the following climatic conditions occurred: snow depth less than 30cm, maximum temperature greater than 15°C for two consecutive days and accompanied by measurable liquid precipitation, or when the two-day liquid precipitation exceeded 20 mm. It is acknowledged that these criteria may differ slightly in the other ski regions, but data were not available to make regional adjustments.

In order to compare the relative impact of projected climate change at the six locations in this study, it was decided to model the impact of climate change on a single hypothetical ski area (identical in skiable terrain and snowmaking capacity) at each study area. This approach isolates the importance of climate and projected climate change at each location, rather than the advantages of the snowmaking systems in place at each ski area.

RESULTS

Table 1 presents the modelled baseline ski season (in days) at the six study areas as well as the projected impact of climate change in the 2020s and 2050s. The modelled average baseline ski season was the longest at more northerly (Quebec City =160, Ste. Agathe-des-Monts and Thunder Bay = 163 days) locations, while the most southerly and lower elevation study area had the shortest average baseline ski season (Brighton = 114 days).

The projected impact of climate change on average ski season length differed substantially among the high and low impact scenarios and among the six study areas (Table1). Unlike earlier climate change impact studies, which could only examine doubled-carbon dioxide conditions (~2050s), this analysis was able to examine the impact of climate change scenarios for the early decades of this century, which are the most relevant to business planning and investment time frames. The 2020s low impact climate change scenario produced minor impacts on the length of the average ski season (less than -10% at all locations). Under the much warmer high impact scenario more serious impacts were realized at Brighton (-28%) and Rutland (-25%) relative to other locations where projected season losses ranged from 13-19%.

The range of projected impacts on the average ski season length increased substantially in the 2050s, portraying two distinct operational futures for the six ski areas examined. Once again, the low impact scenario projected only minor impacts on the average ski season length (<10% reduction) at four of the six study areas. Only the southern Michigan and low elevation Vermont locations had losses of greater than 10%. Notably the range of season losses projected under the 2050s low impact scenario were less than the high impact scenario for the 2020s, indicating the importance of uncertainty related to climate change scenarios. The 2050s high impact climate change scenario presented a much more challenging scenario for the ski industry. Substantial season losses (32-65%) were projected for the six study areas. It is questionable whether ski operations at some of these locations would be sustainable under the high impact climate change scenario of the 2050s. The two Quebec locations appeared to be the least vulnerable to climate change.

Table 1: Modelled Ski Season Length

Study Area	Baseline Average (days)	Climate Change Scenario	% Change from 1970s Baseline 2020s	2050s	% Change in Earlier Studies (~2050s)
Brighton, Michigan	114				-59 to -100 (7)
		Low Impact	-5	-12	
		High Impact	-28	-65	
Orillia, Ontario	149				-40 to -100 (8)
		Low Impact	-3	-8	
		High Impact	-19	-46	
Quebec City, Quebec	160				-42 to -70 (6)
		Low Impact	-1	-5	
		High Impact	-13	-34	
Rutland, Vermont	119				-56 to –92 (5)
		Low Impact	-5	-14	
		High Impact	-25	-60	
Ste. Agathe-des-Monts, Quebec	163				-48 to -87 (6)
		Low Impact	-0	-4	
		High Impact	-13	-32	
Thunder Bay, Ontario	163				-30 to -40 (8)
		Low Impact	-2	-4	
		High Impact	-17	-36	

Consistent with Scott et al. (10) the range of season losses projected by this study in the 2050s were substantially lower than earlier studies that did not account for snowmaking (Table 1). In most cases the losses projected under the high impact 2050s scenario in this study ('high impact') approximated the low end of the impact range ('low impact') from earlier studies. This reinforces the importance of incorporating snowmaking in climate change impact assessments, particularly where snowmaking systems are already an integral component of ski operations.

DISCUSSION

This study reassessed the potential impact of projected climate change on the ski industry at six locations in eastern North America. A central conclusion of this study is that rather than 'crippling' the ski industry as some media reports have suggested, climate change will create winners and losers in the ski industry of eastern North America. The confluence of climatic changes and other factors (access to capital, demand trends, energy prices, water supply, etc.) will advantage certain ski areas and likely result in further contraction and consolidation in the industry. The findings suggest that in the 2020s even the high impact climate change scenario poses only a minor risk to ski areas examined, except southern Michigan, where a series of poor winters could pose a reasonable business risk to smaller, less diversified ski areas. Consistent with Scott et al. (2003), a major finding of the reassessment was that ski season losses to climate change in the 2050s were not as severe as projected in earlier studies that did not include snowmaking. Nonetheless, the projected average season length reductions in the high impact 2050s scenario were not insignificant. When reductions in the season length are combined with the projected increases in snowmaking costs, the sustainability of ski operations could be jeopardised by the 2050s if the high impact climate change scenario were realized. This scenario is currently thought to have a low probability however.

REFERENCES

1. Elsasser, H and Bürki, R. 2002. Climate change as a threat to tourism in the Alps. Clim Res. 20:253-257.
2. Breiling M., Charamza P., and Skage O. 1997. Klimasensibilitat Osterreichischer Bezirke mit besonderer Berucksichtigung des Wintertourismus. Report 97:1. Institute for Landscape Planning. (Alnarp, Austria).
3. Fukuskima, T., et al. 2003. Influences of air temperature change on leisure industries: case study on ski activities, Mit & Ad Strat. for Climate Change, 7:173-189.
4. Galloway RW. 1988. The potential impact of climate changes on Australian ski fields. Greenhouse: Planning for climatic change, edited by Pearman GI. (CSIRO, Melbourne, Australia), 428-437.
5. Badke, C. 1991. Climate change and tourism: the effect of global warming on Killington, Vermont. Senior Honours Thesis, Department of Geography, University of Waterloo, Waterloo, Ontario, Canada.
6. Lamothe and Periard. 1988. Implications of climate change for downhill skiing in Quebec. Climate Change Digest 88-03, Environment Canada, Ottawa, Canada.

7. Lipski, S. and McBoyle, G. 1991. The impact of global warming on downhill skiing in Michigan. East Lakes Geog. 26:37-51.

8. McBoyle, G., et al. 1986. Recreation and climate change: a Canadian case study, Ont Geog. 23:51-68.

9. Scott, D., et al. 2001. Assessing the sensitivity of the alpine skiing industry in Ontario, Canada to climate variability and change. Proc. of the First Int'l Workshop on Climate, Tourism and Recreation., edited by A. Matzarakis and C. de Frietas. (Int'l Soc. of Biomet. - Commission on Climate, Tourism and Recreation. 5-10 October 2001. Halkidiki, Greece), 153-170.

10. Scott, D., McBoyle, G., Mills, B. 2003. Climate change and the skiing industry in Southern Ontario (Canada): Exploring the importance of snowmaking as a as a technical adaptation. Clim Res, 23, 171-181.