

USING AN ANOLOGUE APPROACH TO EXAMINE CLIMATE CHANGE VULNERABILITY OF THE NEW ENGLAND (USA) SKI TOURISM INDUSTRY

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ABSTRACT Climate change is projected to have a significant impact on winter recreation-tourism sector including the multi-billion dollar ski tourism industry. Detrimental effects for the industry have been projected in numerous studies throughout several continents including, Australia, Asia, Europe and North America. Modeling based studies have revealed shortened ski seasons and increased snowmaking requirements under warmer temperatures. This study uses a climate change analogue approach to examine how a wider range of ski area performance indicators were affected by anomalously warm winters in the New England region of the USA.

The record warm winter of 2001-02 is representative of projected future average winter climate conditions in the New England region under a high greenhouse gas emission scenario for the 2040-69 period and was used as one climate change analogue for this analysis. The 1998-99 ski season was also used as a climate change analogue as it represents the last of three consecutive warm winters that are representative of average winter conditions for the 2010-39 period. Ski area performance indicators for the 2001-02 and 1998-99 analogue years were compared to the climatically normal (for 1961-90) years of 2000-01 and 2004-05. The indicators examined include: ski season length, snowmaking (hours of operation and % fuel utilized as a proxy for fuel costs), total skier visits, visitation by time of year, average season passes sold, and operating profit (% of total gross revenue and % of total gross fixed assets). The revealed impact on ski season length during these climate change analogue years is also compared with modeled impacts for the region.

KEYWORDS: *Ski tourism, analogue, climate change, New England, USA*

INTRODUCTION

The impact of climate change on the highly climate-sensitive winter-tourism sector is expected to generate significant consequences for those not prepared for warming temperatures and changing precipitation patterns. Academic research in the field of climate change and winter-tourism has paid particular attention to the vulnerability within the multi-billion dollar international ski tourism industry (Australia, Austria, Canada, France, Germany,

Italy, Japan, Switzerland, United States). All of these international studies predict negative consequences for the ski industry to varying degrees and over varying timeframes.

The focus of climate change and ski tourism research in North America has been on modeling decreasing ski season lengths and increasing snowmaking requirements which compensate for significant reductions in natural snow availability (Scott et al., 2003; Scott et al., 2006, 2007). Limitations in the North American research have thus far included a lack of studies examining the impact of climate change on tourist demand patterns, as well as difficulty in determining the economic implications of climate change due to restrictions on proprietary financial information from ski area businesses. Ski area expenditures are however, expected to rise due to increased snowmaking requirements which will augment labor and power/fuel expenditures as well as water requirements. Expenses will be greater for lower elevation ski areas where more snowmaking will be required to compensate for warmer temperatures in comparison to ski areas located at cooler higher altitudes.

The U.S. New England ski region, which includes that states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont consist of over 150 ski areas ranging from 137 meters above sea level (masl) to 1353 masl. Although, mountains in this region represent some of the highest ski area elevation in Eastern North America many ski resorts in the area have base levels lower than 450 masl. These lower resorts are expected to be particularly vulnerable under warming trends because of a reduced season length and the aforementioned increase in costs due to increased snowmaking.

Skiing in New England is not only culturally important it is also economically significant. Individuals ski an average of 10 times per season in New England, which is the highest rate recorded in the country (National Sporting Goods Association, 2005). Of the ski regions in the U.S as defined by the National Ski Area Association [NSAA], New England consistently hosts the second highest total visitation rate (>13 million) across the United States, second only to the Rocky Mountain region (>19 million) (NSAA, 2005). Ski operations in Vermont and New Hampshire alone contribute in excess of US\$1.8 billion annually to state economies through direct and indirect spending.

This paper uses an analogue approach to examine some demand- and supply-side performance indicators that have not previously been assessed in a climate change context. Aggregated regional ski area information available from two annual NSAA reports (Kottke End of Season Survey and Economic Analysis of United States Ski Areas) provide operational performance information on New England ski areas for the past two decades. Performance indicators can be compared between climatically normal (average of 1961-90

period) versus anomalously warm winters to determine the impacts of warmer temperatures considered analogues for normal winter conditions under future climate change scenarios. The advantage of the analogue approach is that it uses observed data, not only abstracted model outputs, and captures the impacts when the full range of current supply- and demand-side adaptations occur.

METHODS

In 2001-02 the New England region experienced a record warm winter season that is representative of projected future average winter climate conditions under a high greenhouse gas emission scenario for the 2040-2069 time period. Regional ski area information including ski season length, snowmaking requirements, visitation, and operating profits from this analogue year are compared with reported ski area information from the 2000-01 and 2004-05 seasons, which are representative of climatically average years for the 1961-90 baseline period. The 1998-99 ski season is also used as a second analogue as it represents the last of three consecutively warm winters that are representative of average winter conditions for the 2010-2039 time period. The examination of the 1998-99 ski season as an analogue for 2010-2039 allows conclusions to be made regarding the impact that several consecutively warm seasons may have on ski area operations versus the impact that may be experienced in a single marginal year (i.e. 2001-02). It is possible that a ski area may be able to more easily rebound financially after experiencing one marginal snow season amongst a series of average or above average seasons. However, it is likely more difficult to recover after experiencing two and three poor seasons consecutively (Scott and McBoyle, 2006).

The climatic average (2000-01 and 2004-05) seasons used in this study were chosen from winter climate data from the past 12 years which best represent the 1961-90 climatic average winter seasons (NOAA, 2007). The absolute best climatologically average year actually occurred 20 years ago in 1987, prior to the large-scale expansion of snowmaking in the region which was not relatively complete until the mid-late 1990's. Because snowmaking is an integral part of ski area operations today, the climatically normal year, 1987 was not used in this study as it would not be directly comparable to currently standard operations. In addition, post mid 1990's ski area business models have stayed reasonably consistent therefore allowing for a more reliable comparison between marginal and average ski area performance in this timeframe (i.e. heavy real estate development, diversified revenue sources, establishment of conglomerates).

The climatic ‘analogue’ seasons (2001-02 and 1998-99) chosen for this study both fall within the past twelve years and are representative of the most marginal seasons ever experienced within the past 112 years. The 2001-02 climatic analogue is representative of the warmest winter season on record (NOAA, 2007) and the 1998-99 season represents the highest average temperature recorded for the third of three consecutively above average seasons.

Ski area performance indicators for the 2001-02 and 1998-99 analogue years were compared with indicators for the climatically normal (for 1961-90) years of 2000-01 and 2004-05. The indicators examined include: ski season length in days, snowmaking (hours of operation and % power utilized), total skier visits, and operating profit (% of total gross revenue and % of total gross fixed assets). The revealed impact during the climate change analogue years (1998-99 representative of 2010-2039 and 2001-02 representative of 2040-2069) were also compared with previously modeled season length data for the 2010-2039 and 2040-2069 time periods in the New England region (modeled data found in Scott and Dawson (2007) at this conference).

RESULTS

Comparison between past ski seasons experiencing either average or marginal climatic conditions reveal significant differences between season lengths, snowmaking requirements, visitation, and profits. This section is divided into three segments outlining the physical indicators (snowfall, season length, and snowmaking requirements), demand indicators (visitation) and economic indicators (operational profit) examined in this study.

Physical Indicators

Four physical indicators were examined including, natural snow fall, snowmaking hours, percentage of power utilized for snowmaking, and ski season length. During the climatically normal years of 2000-01 and 2004-05, 199 and 153 inches of natural snow fell on the New England region. During the climatically marginal seasons of 1998-99 (analogue for 2010-2039) and 2001-02 (analogue for 2040-2069) just 108 and 107 inches of natural snow fell leaving ski areas with almost 40 % less natural snow on the hills than during climatically average seasons. Less natural snow fall during these years forced ski areas to rely more heavily on snowmaking to make up for poor snow coverage particularly early in the season. Snowmaking hours increased by 75.8 % and 11.4 % in the 1998-99 and 2001-02 analogue seasons in comparison to the climatically average years. During marginal ski seasons, the amount of power utilized for the purpose of creating snow was almost 35 % higher than

during average ski seasons. Increased snowmaking requirements inevitably increases operational costs to cover power/fuel, labor and machine maintenance particularly during warmer temperatures. The limited natural snow cover and increased snowmaking that occurred during the 1998-99 and 2001-02 New England ski seasons also had an effect on average ski season length. Season lengths were 3.4 % (1998-99) and 10.9 % (2001-02) shorter during the marginal seasons than during average seasons totaling an average season reduction by almost two full weeks (Tab. 1).

Table 1: Physical Indicators

Indicators	Climatically Normal Years		Climate Change Analogue Years		Average Normal	%change 1998-99*	%change 2001-02**
	2000-01	2004-05	1998-99	2001-02			
natural snowfall (inches)	199	153	108	107	176	-38.64	-39.20
snowmaking (hours operated)	820	1040	1635	1036	930	+75.81	+11.40
snowmaking % power utilized	33	46	54	52	40	36.71	31.35
season length (days)	137	129	128	118	132.5	-3.40	-10.94

* three season analogue for 2010-2039

** one season analogue for 2040-2069

Scott and Dawson (2007) modeled ski season lengths in the New England region for the 2010-2039 and 2040-2069 time periods using six climate change scenarios composed of three Global Climate Models (HadCM3, PCM, GFLD) each run under two IPCC-SRES emission scenarios, representing a high emissions future (A1Fi - 970 ppm) and a low emissions future (B1 – 550 ppm). The regionally averaged 1961-90 baseline ski season length was 132 days, which compares well to 133 days observed for the two climatically average years in Table 1. Ski season were projected to decline to 118 days in the 2010-2039 time period (average of B1 and A1fi scenarios), which is a greater reduction than observed in the 2010-39 analogue (1998-99) of 128 days. In the 2040-2069 time period, the ski season was projected to decline to 103 days under a high emission scenario (A1fi), which again was more than observed in the 2040-69 analogue (2001-02), where the season was 118 days.

Demand Indicators

Marginal ski conditions and shortened season lengths can have an impact on ski area visitation. During the 2000-01 and 2004-05 average ski seasons, New England ski areas drew more than 13.5 million visits. Visitation during the climate change analogue seasons of 1998-99 and 2001-02 drew 10.8 % and 11.6 % fewer visits respectively versus the two climatically normal winters (Tab. 2). It is acknowledged that other outside factors including the changing

cost of fuel and the state of the economy could play a role in inter-annual fluctuations in ski area visitation; however, these trends are minimized in the consecutive seasons analysis here.

Table 2: Demand Indicator

Indicators	Climatically Normal Years		Climate Change Analogue Years		Average Normal	% change 1998-99*	% change 2001-02**
number of visits	13917481	13660522	12299495	12187577	13789002	-10.8	-11.61

* three season analogue for 2010-2039

** one season analogue for 2040-2069

Economic Indicators

The combination of increased snowmaking costs, decreased season lengths, and lower visitation rates is likely to cause financial strain during marginal snow seasons. Examination of available economic data for the New England region shows that operating profit as a percent of gross revenue and as a percent of gross fixed assets display almost no change for the 1998-99 climatically marginal season (2010-39 analogue), and a very significant decrease during the 2001-02 climatically marginal season (2050s high emission analogue). The revenue per skier visit during the 1998-99 season was almost five dollars higher than seen in other years including the 2001-02 season (NSAA, 1998, 2001, 2004), which in part explains the slight increase in operating profit despite marginal climatic conditions. The 2001-02 season experienced average winter temperatures 8 °C higher than climatically normal temperatures for the 1961-90 baseline period greatly increasing the necessity of snowmaking and the cost of snowmaking. Operating profits for the 2001-02 season were between 19 and 32 % lower than during a climatically average season (Tab. 3). Importantly, while these represent substantial reductions in profits, in both climate change analogue seasons the ski industry in the region still operated in a profitable position.

Table 3: Economic Indicators

Indicators	Climatically Normal Years		Climate Change Analogue Years		Average Normal	% change 1998-99*	% change 2001-02**
Operating profit (%gross revenue)	21.70	19.90	20.90	16.80	21	0.48	-19.23
Operating profit (%gross fixed assets)	12.46	13.10	13.09	8.62	13	2.43	-32.55

* three season analogue for 2010-2039

** one season analogue for 2040-2069

DISCUSSION

This study used an analogue approach to examine a variety of physical, demand and economic impacts experienced by ski areas in the New England region during abnormally warm winter that are anticipated to be representative of average climatic conditions in the future. The 1998-99 season was chosen to represent an analogue for the 2010-2039s as an example of the third of three consecutively marginal ski seasons. The three seasons occurring between 1996/97 and 1998/99 all experienced average temperatures of at least 4.5 °C above the climatic average. Results indicate that during the third poor season (1998-99), ski areas experienced significant increases in snowmaking hours (+75 %) and costs (+36.7 % power required), a shortened ski season (-5 days), and a 10.8 % loss in visitation but still managed to produce a profit. In this example of consecutively marginal seasons, ski areas adapted well to warmer conditions. However, this may not be the case if temperatures experienced in the 2001-02 season (+8 °C) were to occur in successive seasons. During the 2001-02 analogue season ski areas were forced to increase snowmaking requirements by 31 % (power used), season lengths decreased by 15 days, visitation was down by almost 12 % and operating profits declined by 19 and 32 %.

The strength of an analogue approach is that the impacts of climate are based on actual occurrences and fully account for current adaptation practices. However, like other methods this approach can not account for future changes including advancing technology, changing demographics, increasing price of fuel (etc.). Further research in this area might include considering these factors and accounting for them in modeled projections. Future work could also incorporate a more detailed examination of ski area indicators beyond that which are considered here. For example, other indicators that could be examined also include, season pass sales, % visitation at different times of year (beginning, end, during important holiday seasons) and a more detailed summary of revenue sources (i.e. lessons, ticket sales, food and beverage, retail etc.). A more detailed analysis of indicators based on the size of ski resorts would be fruitful in determining which ski areas are more or less vulnerable to climate change and allow a determination of how the regional ski marketplace may evolve over time (i.e., where might the ski industry contract and which communities may need to prepare to adapt to this economic loss).

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