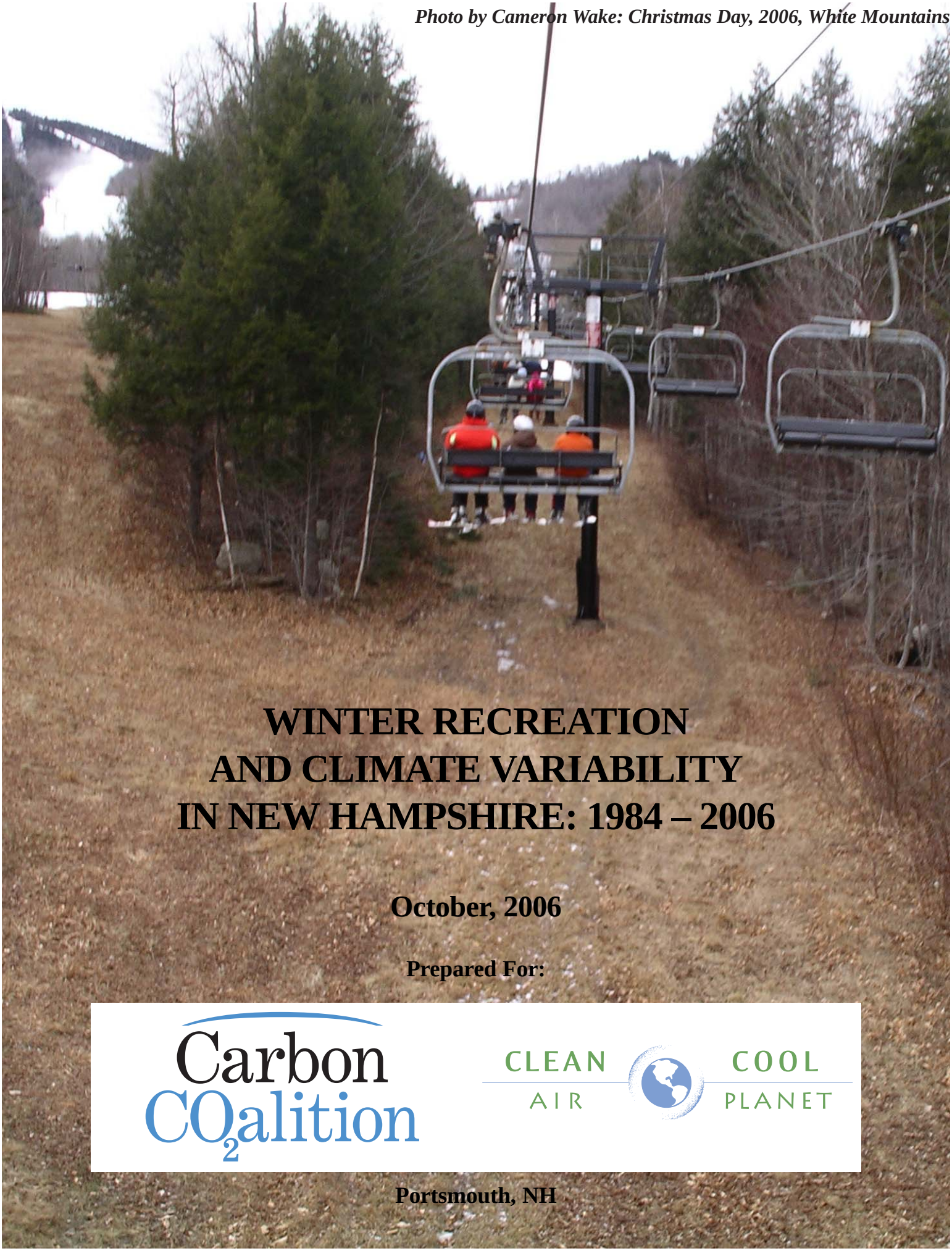


Photo by Cameron Wake: Christmas Day, 2006, White Mountains

WINTER RECREATION AND CLIMATE VARIABILITY IN NEW HAMPSHIRE: 1984 – 2006

October, 2006

Prepared For:

Carbon CO2alition

CLEAN AIR COOL PLANET

Portsmouth, NH

WINTER RECREATION AND CLIMATE VARIABILITY IN NEW HAMPSHIRE: 1984 – 2006

by

Cameron Wake and Elizabeth Burakowski
Climate Change Research Center, Institute for the Study of Earth, Oceans and Space
University of New Hampshire

and

Laurence Goss
Department of Geography, Salem State College

Prepared For:

The Carbon Coalition
and
Clean Air – Cool Planet
Portsmouth, NH

October, 2006

Executive Summary

WINTER RECREATION, GLOBAL WARMING AND NEW HAMPSHIRE[1]

We've always had a hunch that cold, snowy winters produce more North Country tourist dollars than warm, slushier ones. Now, in this report, the authors have analyzed historical climate data and several winter recreation economic indicators to prove the hunch and put hard numbers on the differences.

To summarize the findings:

Outdoor winter recreation is a critical economic driver for New Hampshire's four northern counties and is vital to the entire state.

- During the winter quarter (December through March) almost 40 percent of our state's total visitor spending goes to the North Country. Almost 80 percent of that is spent on snow- and cold-dependent outdoor recreation: skiing, ice fishing and snowmobiling.
- The Rooms & Meals Tax is the state's second largest revenue source. During the winter quarter, the North Country generates one-third of visitor Rooms & Meals tax revenues.
- Winter visitors spend almost 20 percent more per visitor day than the average.

Cold, snowy winters bring more visitors and generate more economic activity than warm, slushier winters.

- Warm, slushy winters mean 3,000 fewer jobs, a loss of 4 percent of North Country winter employment.
- 33 percent fewer skiers visit New Hampshire in low versus high snow years. Alpine ski ticket sales are lower by 15 percent, or almost $12 million dollars. Nordic ski ticket sales drop by almost 30 percent, or $650,000.
- Snowmobile registration license fees are lower by almost 30 percent, a loss of nearly one million dollars.
- Total ski ticket, fishing license and snowmobile registration fees decline by 14 percent, a loss of over $13 million dollars in warm, slushier winters.

Energy policy choices today will impact the winter economy in the coming decades.

- This 2006 climate-tourism study shows that an overall increase of 5 degrees F marks the difference between a relatively good and relatively poor year for winter recreation.
- A recent study published by the Union of Concerned Scientists projects that, if we continue to burn fossil fuels at present rates, atmospheric concentrations of heat-trapping greenhouse gasses will continue to increase.
- By the middle of this century, winter temperatures in New Hampshire would increase by about 6 F, cutting winter snow cover days in the White Mountains by about 20 percent. By the end of the century, winter temperatures would increase by 10 F and White Mountains snow cover days would drop by one-third. Unless we change energy policy to limit greenhouse gas emissions, the relatively warm and snowless winter of 2006 will become the "normal" winter of 2050.

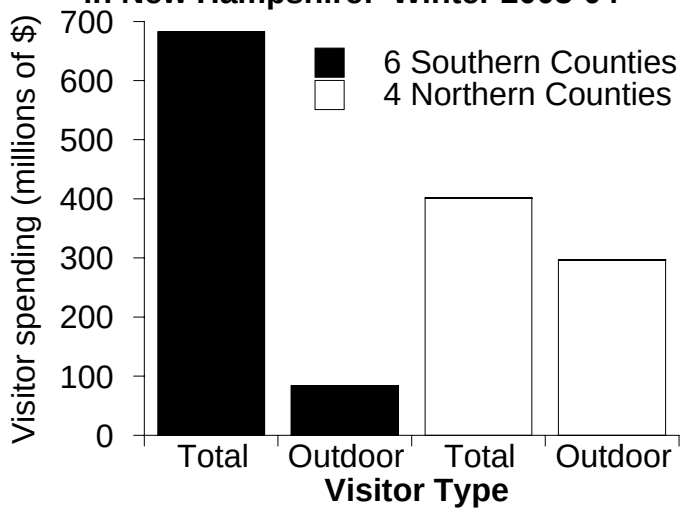
The Good News.

- We can reduce these projected impacts by about half and protect the North Country winter economy … if we seek aggressive efficiencies and begin to replace fossil fuel combustion with non-polluting energy sources, such as wind, biomass, solar, geothermal and other technologies.
- The energy path we choose today will largely determine whether or not New Hampshire's climate becomes remarkably similar to that of the U.S. south.

Notes:
Over the past two decades, the North Country continued to attract visitors during warmer winters. While warmer-winter visitors spent similar sums of money on rooms and meals, they engaged in activities that do not rely on cold, snowy conditions: shopping, scenic driving, walking and hiking**. It is not clear that visitors will continue** to travel to the region and spend their dollars on rooms and meals if warmer, slushier winters become more frequent and make the prospect of quality outdoor recreation experiences too uncertain.

Most of the jobs gained or lost as a result of winter climate variation are seasonal full-time and part-time positions at ski areas and stores which rent, sell and repair ski and snowmobiling equipment, and are generally held by people who also depend on seasonal jobs in the region during the rest of the year, such as farmers, forest workers, and landscape and nursery workers.

Total and Outdoor Recreation Visitor Spending in New Hampshire: Winter 2003-04



78 percent of outdoor winter recreation activity spending statewide took place in the northern four counties of New Hampshire, where visitors make up 37 percent of the total spending by all visitors statewide during the four winter months of 2003-4. **Spending by those engaged in outdoor winter recreation activities is a far more important activity in the northern four counties** than it is in the balance of the state.

Study Authors:

- Laurence Goss is a professor in the Department of Geography at Salem State College. For the past 16 years, he has been an adjunct professor for tourism research at the Institute for New Hampshire Studies at Plymouth State University.
- Cameron Wake researches global climate and environmental change from the University of New Hampshire Climate Change Research Center.
- Elizabeth Burakowski is a master's candidate at the University of New Hampshire, working in the Climate Change Research Center researching changes in winter time climate in the Northeast.

Table 7.3. Estimated ticket sales and license fees in 2006 dollars for cold, snowy winters vs. warm, less snowy winters.

Ticket sales and license fees are also compared between cold, snowy winters and the winter of 2006, which science indicates is likely an "analogue" – or typical – for winters in NH for the next 50 years.[1]

Winter Recreation Indicator		Cold Snowy Winters	Warm Less Snowy Winters	Difference	Percent Decrease	"Analogue" winter of 2006	Decrease from cold, snowy winters
Alpine Skier Days							
	North	$55,812,157	$49,284,664	$6,527,494	12%	$47,858,240	14%
	South	$28,582,319	$23,605,970	$4,976,349	17%	$28,020,210	2%
	Total	$84,394,496	$72,890,634	$11,503,862	14%	$75,878,450	10%
Nordic Skier Days							
	North	$1,721,088	$1,334,928	$386,160	22%	$1,067,584	38%
	South	$526,736	$260,834	$265,902	50%	$141,946	73%
	Total	$2,247,824	$1,595,762	$652,062	29%	$1,209,530	46%
Fishing Licenses		$1,678,545	$1,605,340	$73,205	4%	$1,299,400	23%
Snowmobile Regis.		$3,534,583	$2,588,736	$946,207	27%	$3,160,989	11%
Revenue (reg. & lic.)		$5,213,128	$4,194,076	$1,019,052	20%	$4,460,389	14%
Total		**$91,855,448**	**$78,580,477**	**$13,174,976**	**14%**	**$81,548,369**	**11%**

[1] Cameron Wake, Elizabeth Burakowski and Larry Goss. 2006. "Winter Recreation and Climate Variability in New Hampshire: 1984 – 2006". Commissioned by Clean Air-Cool Planet.

Table of Contents

Acknowledgements

This report was prepared for the Carbon Coalition and Clean Air-Cool Planet of Portsmouth, New Hampshire.

This study would not have been possible without the socio-economic data provided by: Ski New Hampshire, Inc., the New Hampshire Snowmobile Association, the New Hampshire Department of Revenue Administration, the New Hampshire Fish and Game Department, the New Hampshire Division of Travel and Tourism Development, and the Institute for New Hampshire Studies at Plymouth State University.

We obtained the meteorological data from the NOAA - National Climatic Data Center (http://www.ncdc.noaa.gov).

Roger Stephenson, of Clean Air-Cool Planet and Jim Rubens, Union of Concerned Scientists, jointly managed the project on behalf of the Carbon Coalition with the intent that the information be shared with businesses that rely directly and indirectly upon winter tourism.

1. Introduction

Many assessments of the impacts of climate change on our society have been based on future climate derived from the output from Global Climate Models (GCM)(1). However, recent analyses of climate change in the northeast United States (2) have clearly shown that the region has experienced significant climate change over the past three decades. For example, average winter temperatures have increased on average 4.4^{o}F over the last 30 years (Figure 1.1), which means that Boston's wintertime climate is now equivalent to that of Philadelphia thirty years ago. In addition, the winter warming has been relatively consistent across the entire northeast (Figure 1.2). Over the same time period, snowfall in northern New England and northern New York state has decreased, snow-on-ground days have decreased, ice-out dates on lakes occurs one to two weeks earlier, and bloom dates for lilacs and grapes are 4 to 8 days earlier (3) (Figure 1.3). We expect that there have been significant impacts of this climate change on the region's economy, especially in northern New Hampshire, but to date these impacts have not been quantified.

Outdoor recreation is a very important component of the winter economy in New Hampshire. On an annual basis, data from the Travel Industry Association of America, which is the nation's largest tourism research organization, has shown that tourists in New Hampshire are twice as likely to engage in outdoor recreation as those nationally. Because of the states location and climate, outdoor recreation during the winter months in New Hampshire includes skiing, snowmobiling, and ice fishing.

This study was undertaken with two questions in mind. First, to what extent do the year-to-year changes in New Hampshire's winter climate over the past two decades affect the number of individuals who participate in outdoor recreation activities? Second, to what extent do year-to-year changes in winter climate impact rooms and meals spending (and resultant tax revenue) in the northern region of the state?

Importance of Winter Tourism in Northern New Hampshire

Tourism was a $4 billion industry in New Hampshire in terms of estimated direct visitor spending during state fiscal year 2004, the most recent year for which detailed tourist spending and visitation data is available (5). This spending was about 7.9 percent of the "gross state product" for New Hampshire for state fiscal year 2004, which ended in June of 2004. For the four month period of December to March, which is used to describe the winter season for most of the information presented in this report, total visitor spending for the winter of 2003-4 was estimated at $1,085,000 statewide, or about 27.1 percent of total annual spending by visitors during state fiscal year 2004. It is estimated that there were 11.7 million visitor days spent in the state during the four winter months (December through March), which was about 22.8 percent of the annual total of visitor days for fiscal year 2004. Thus, the number of visitors and visitor spending during the winter months is below 33.3 percent which would be the case if visitation and spending were equally spread across the months of the year. However, winter visitors spent almost 19 percent more money per visitor day than the average tourist in the state during the year, reflecting the relatively expensive nature of both alpine skiing and snowmobiling, which are important winter tourist activities in the northern part of the state and the importance of

business travel during the winter in the southern part of the state. Research has shown that alpine skiers and business travelers on overnight trips spend far more money per day than any other kind of tourist (5).

The data presented later in this report will show that the weather during the winter of 2003-4 was an average winter, so that participation in winter outdoor recreation activities, and the resultant spending, was also close to the long term average when spending is adjusted for inflation. About 14 percent more skiers came to New Hampshire during the cold, snowy winter of 2000-1 than in 2003-04. About 19 percent fewer skiers were in New Hampshire during the very low snowfall and warm winter of 1994-5 compared to 2003-4. That low snowfall winter led to the closure of two medium-sized alpine ski areas in the state and major investments by other alpine ski areas in snowmaking equipment, as will be reviewed later in this report.

This report focuses on the state's four northern counties of Belknap, Carroll, Coos, and Grafton. It is in these four counties that visitors are most likely to engage in winter outdoor recreational activities and less likely to be on a winter vacation trip for some other reason. In reviewing the alpine and Nordic skiing information, about 75 percent of all skier days during the winter of 2003-4 were at ski areas in these four northern counties. Snowmobiling and ice fishing are also concentrated in these four counties.

Based on state tax data and visitor surveys, it is estimated that total spending by visitors in the four northern counties was about $402 million during the December 2003 to March 2004 period, or about 37 percent of total statewide visitor spending during these months. Members of skiing, snowmobiling, and ice fishing travel parties spent an estimated $297 million, or 78 percent, of the total amount of $381 million spent by tourists in these four counties during this four month period (Figure 1.4).

There were an estimated 3.3 million visitor days in the four northern counties by people who were in travel parties where at least some of the party members were engaged in skiing, snowmobiling, or ice fishing. Out of this 3.3 million, there were 2.0 million visitor days by people who were in skiing parties. Seventy five percent of the 2 millions visitor days be people who were in skiing parties (or 1.6 million days) were spent skiing in these four counties during 2003-4. There were an estimated total of 4.4 million visitor days in the four northern counties during the four winter months, which was 38 percent of total statewide visitor days (Figure 1.5).

In the other six counties of the state, there were 1.1 million visitor days representing people in skiing, snowmobiling or ice fishing travel parties. This was out of as total of 7.3 million visitor days spent in the southern six counties, or 15 percent of total visitor days. Travel parties engaged in winter outdoor recreation activities are estimated to have spent $84 million, or 12 percent of $683 million spent by all travel parties in the six southern counties. These data show that winter outdoor recreation activities are both concentrated in the four northern counties and also make up a very large share of total visitor spending (74 percent) and of all activities (75 percent) within those counties (Figures 1.4 and 1.5).

An analysis done for Ski New Hampshire, Inc., estimated that about ten percent of the 115,000 jobs during the winter in the four northern counties are based on spending by travelers engaged

in alpine and Nordic skiing. An estimated additional 4 percent of the employment is due to trip spending by snowmobilers and ice fishers. During a cold and snowy winter it is estimated that this employment increases by about 1,500 jobs over an average winter, including the multiplier impact of this increased spending by outdoor recreation travel parties. Conversely, a warm and less snowy winter will have about 1,500 fewer jobs than during an average winter. This is a swing of about 3,000 jobs or almost 3 percent of total employment during the winter months in these four northern counties. Most of the jobs gained or lost are seasonal full-time and part-time positions at ski areas and at stores which rent, sell and repair ski and snowmobiling equipment, and are generally held by people who also depend on seasonal jobs in the region during the rest of the year, such as farmers, forest workers, and landscape and nursery workers. There is virtually no change in employment at restaurants, lodging establishments and other kinds of retail stores.

Figure 1.1 Regional average winter temperature trend 1900-2000. Average temperature for winter (DJF) for the northeast (New England, New York, NJ, and Pennsylvania) determined from a regionally weighted average of data from 56 USHCN meteorological stations. Note the rapid warming of 4.4 ^{o}F over the 30 year period from 1970 to 2000.

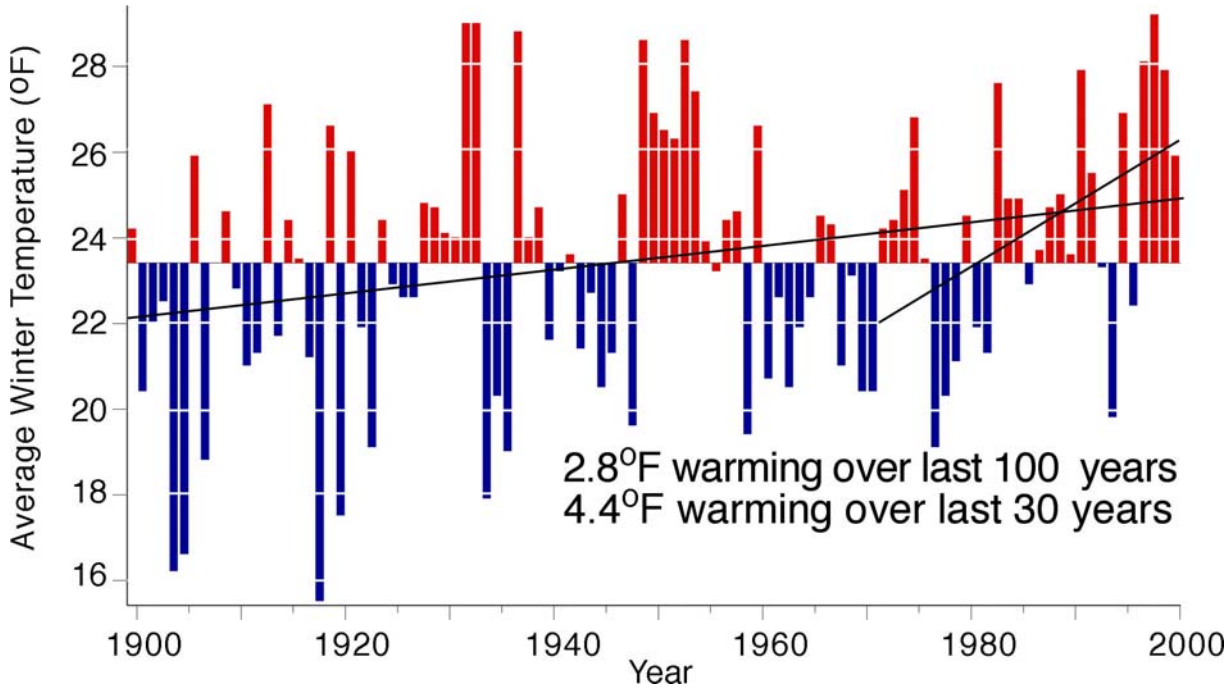
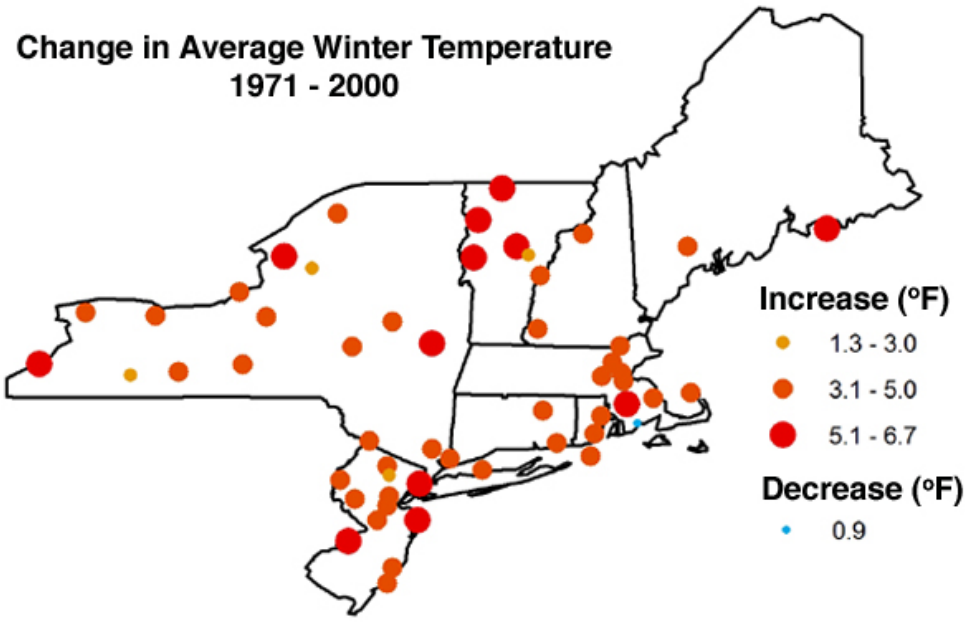
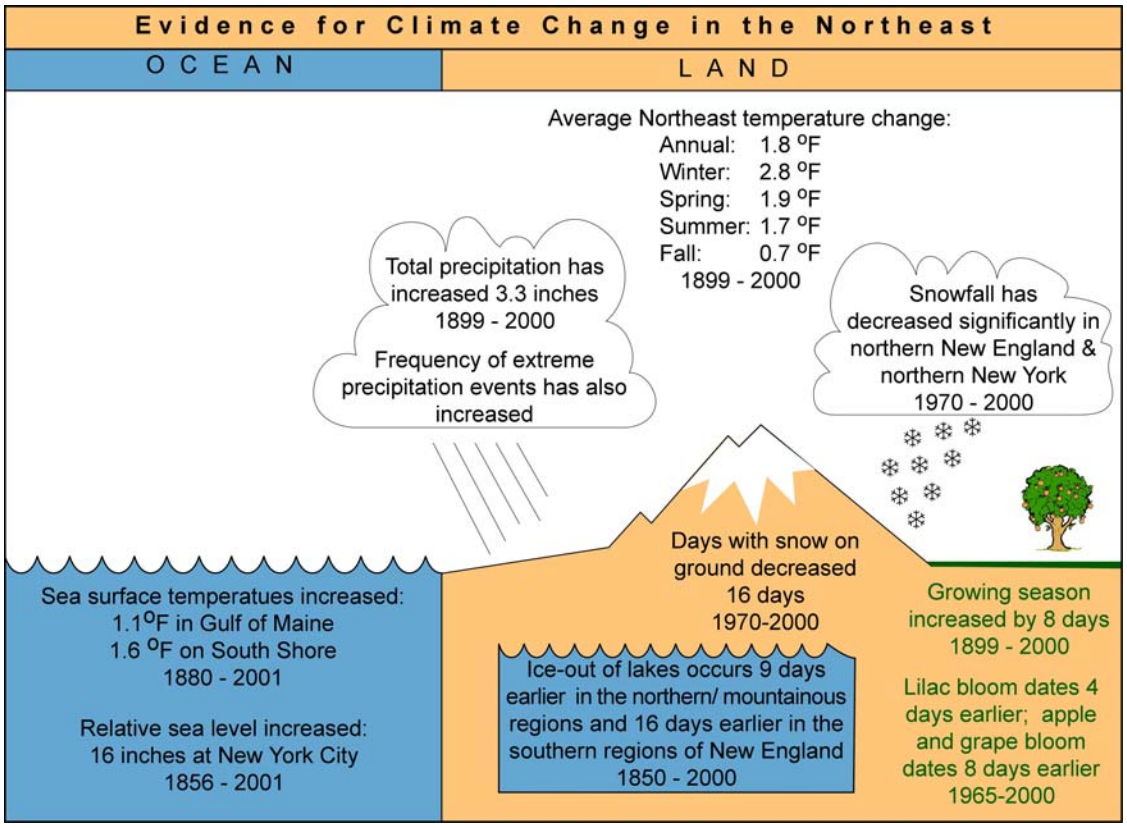


Figure 1.2 Spatial variation in winter temperature trends 1970-2000. The trend was calculated



from a linear regression for the winter (DJF) average temperature for each station. Note the entire region is experiencing significant winter warming.

Figure 1.3 Summary of climate change in the Northeast as summarized in a report on the *Indicators of Climate Change in the Northeast - 2005* (3).



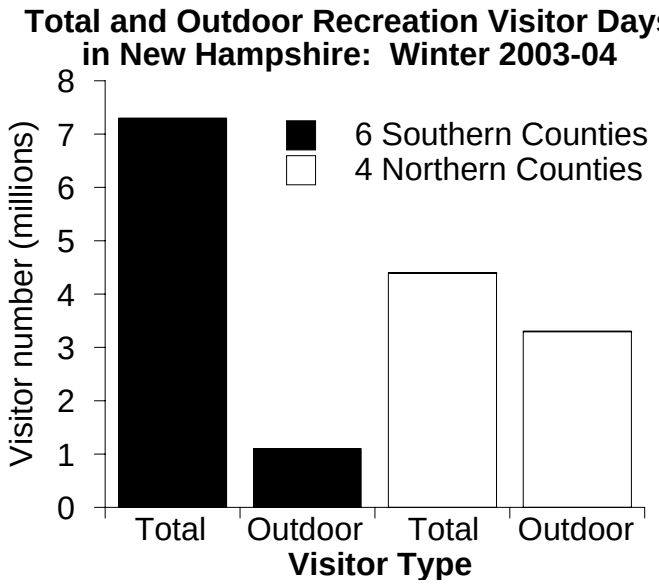


Figure 1.4 Three-fourths of travel parties engaged in outdoor winter recreation activities were in the northern four counties of New Hampshire, where they also made up 75 percent of the total number of visitor days during the four winter months of 2003-4. The share of all visitors to New Hampshire by the four northern counties was 38 percent. In the southern six counties, travel parties engaged in outdoor recreation activities made up only 15 percent of all visitor days spent in that part of the state. In contrast, the share of all visitors to New Hampshire by the six southern counties was 62 percent. Engaging in outdoor winter recreation activities is a far more important activity in the northern four counties than it is in the balance of the state.

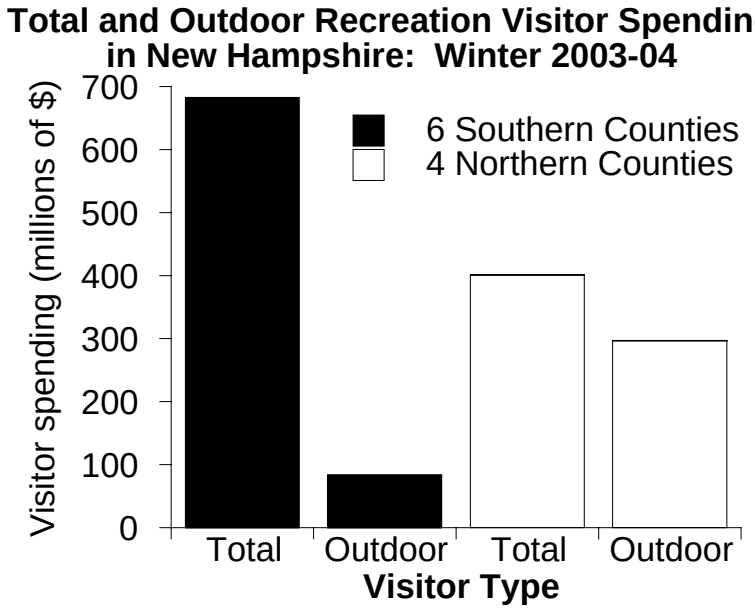


Figure 1.5 78 percent of outdoor winter recreation activity spending statewide took place in the northern four counties of New Hampshire, where visitors make up 37 percent of the total spending by all visitors statewide during the four winter months of 2003-4. In the southern six counties, travel parties engaged in outdoor recreation activities made up only 12 percent of all statewide spending by those engaged in outdoor recreation activities. However, the six southern counties had 63 percent of all statewide visitor spending. Spending by those engaged in outdoor winter recreation activities is a far more important activity in the northern four counties than it is in the balance of the state.

2. Year-to-Year Climate Variability

New Hampshire's climate displays considerable variability from year-to-year. Here, we use three meteorological variables to quantify the year-to-year variability in New Hampshire's winter climate: (1) mean temperature for the months December-January-February-March (DJFM); (2) amount of snowfall for the months December-January-February-March (DJFM); and (3) the number of days with snow on the ground for the entire winter. Originally we downloaded data for 31 meteorological stations in New Hampshire and eastern Massachusetts (See Figure 4.1) from the National Oceanographic and Atmospheric Administration (NOAA) – National Climatic Data Center (http://www.ncdc.noaa.gov/oa/climate/climatedata.html#daily).

For ease of presenting and interpreting the data, we have chosen three stations that have relatively complete records and that are representative of three different climate regions of interest. Pinkham Notch (2008 feet above sea level [asl]) represents the White Mountain region of northern NH; Concord, NH (346 feet asl) represents the central/southern region of the state, while Haverhill, MA (18 feet asl) represents northeastern Massachusetts. We have plotted the data using the winter year so that the winter 2006 data includes data from December 2005 and January, February, and March, 2006.

Figure 2.1 displays the mean winter (DJFM) temperature for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006. Note that the temperature (y axis) is plotted backwards so that warm winters can be directly related with less snowy winters in Figures 2.2 and 2.3. Note relatively cold winters in 1994, 1996, 2001, 2003 and the relatively warm winters 1995, 1997-2000, 2002, 2006. Also note similar trends from year to year among the sites.

Figure 2.2 shows winter (DJFM) snowfall for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006. Note relatively snowy winters in 1994, 1996, 2001, 2003 (except for Pinkham Notch), 2005 and the winters with much less snow in 1995, 1997-2000, 2002, 2006.

Figure 2.3 illustrates the number of days with snow on the ground for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006. For Concord and Haverhill, note the relatively high number of snow-on -days in 1994, 1996, 2001, 2003, 2005 and winters with relatively few snow-on-ground days in 1995, 1997-2000, 2002, 2006. Pinkham Notch shows relatively little variability form year to year.

In summary, looking at all three climate variables (temperature, snowfall, snow-on-ground days) the years 1994, 1996, 2001, 2003, and 2005 had climate that was good for skiing, snowmobiling, and ice fishing (i.e. cold and snowy), while the years 1995, 1997-2000, 2002, and 2006 were relatively poor years for skiing, snowmobiling, and ice fishing (warmer with less snow).

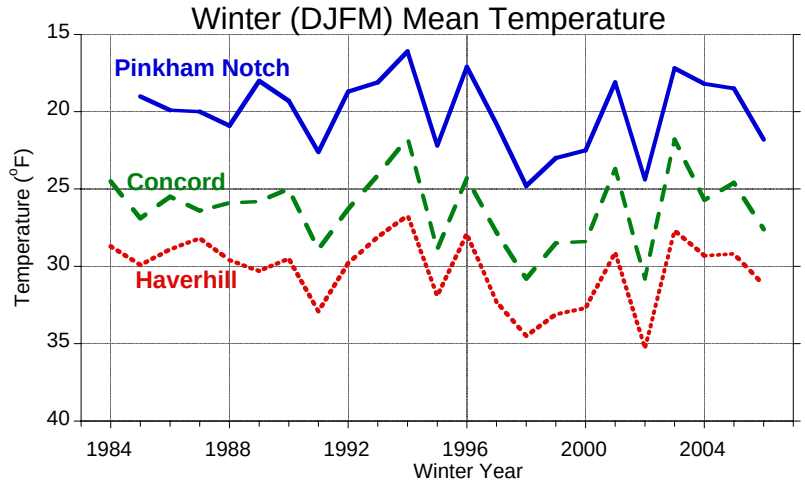


Figure 2.1 Mean winter (DJFM) temperature for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006. Note the temperature scale is plotted with warmer temperatures at the bottom so that warm winters can be directly related with less snowy winters in the two figures below.

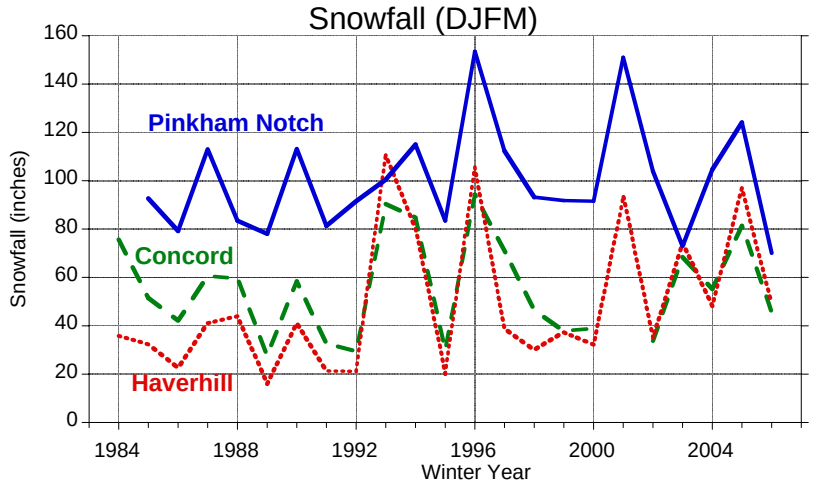


Figure 2.2 Winter (DJFM) snowfall for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006.

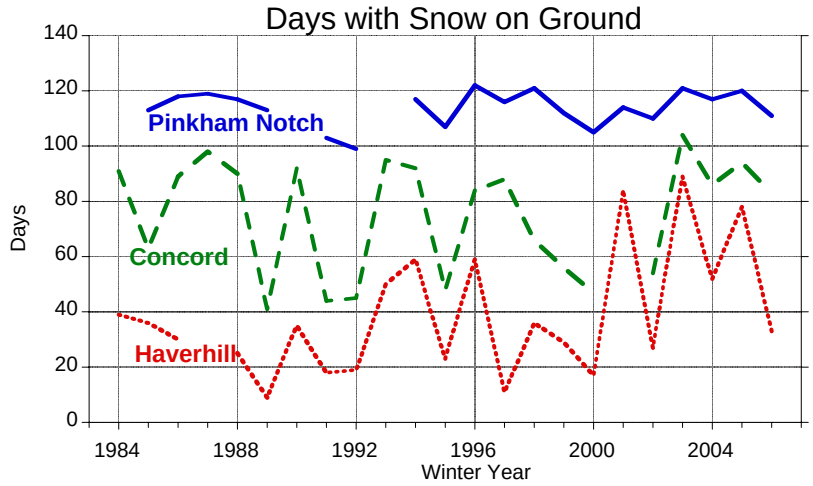


Figure 2.3 Days with snow-on-ground for Pinkham Notch, NH, Concord, NH and Haverhill, MA from 1984 – 2006.

3. Rooms and Meals Spending

The rooms and meals tax levied in New Hampshire are the state's second most important revenue source after the business enterprise and profits tax. Approximately 64 percent of the total rooms and meals taxes collected are paid by people who travel outside their community on non-commuting and non-shopping trips. Over 90 percent of this 64 percent in rooms and meals taxes is paid by people who live in other states or countries. During state fiscal year 2004, the state collected $170 million from this tax, which is 8 percent (the NH "rooms and meals tax") of more than $2.1 billion of spending for meals and accommodations. It is estimated that almost $109 million was paid by tourists and business travelers who spent over $1.36 billion on meals and accommodations. Of this amount, about $100 million was paid by residents of other states and countries who spent over $1.2 billion.

During the four winter months of 2003-4, the state collected almost $50 million from this tax based on spending of $625 million for meals and accommodations. It is estimated that the state collected $12.5 million from restaurants and accommodations located in the four northern counties, or 25 percent of total statewide rooms and meals tax revenues during this four month period. It is estimated that statewide, tourists paid about $29 million in these taxes. In the four northern counties, it is estimated that tourists paid $9.7 million in rooms and meals taxes or over $120 million, which was about one-third total statewide taxes and spending paid by tourists.

Figure 3.1 shows total rooms and meals sales for each of the four northern counties for the four winter months for the 1991 to 2006 period. The data has been converted to 2006 dollar values to account for inflation. The Institute for New Hampshire Studies uses a methodology to take monthly rooms and meals tax receipt data reported by county by the New Hampshire Department of Revenue Administration (DRA) to estimate total sales for each month by county. This methodology includes using 2002 U. S. Census of Business data for each county to reassign the DRA county data. Beginning in December 1997, the DRA assigned sales to counties based on corporate headquarter location as opposed to establishment location. DRA data is available for the 1991 to 2006 period for the winter months.

There has been an overall upward trend in rooms and meals spending in these four counties, even after inflation is considered. There are some flaws in these data that do need to be considered. First, it was during the winter months of 1997-1998 that the DRA transitioned from an establishment location to a headquarters location data reporting system. Thus, it is likely that the 1998 totals for Grafton and Carroll counties are too high in Figure 3.1. Also, the 2002 and 2003 data points for meals for Coos County are anomalously high, perhaps due to be a data entry problem at DRA which assigned sales to Coos County which should have been assigned to another county, probably Rockingham County. The 2002 and 2003 values have therefore been removed from the graphs for Coos County. Figure 3.1 shows significant growth in rooms and meals sales after the warm winter of 1994-5 for Grafton, Carroll, and Coos counties. There is a slower growth trend in Belknap County, which is the southernmost of these four counties and the one most likely to attract day trip skiers, rather than overnight ski trips. The growth in Coos County reflects the reopening of the Mountain View Hotel in Whitefield for the 2002-3 winter and the new winter season operation of the Mt. Washington Hotel (which began in 1998-99) at Bretton Woods, now one of the state's largest ski areas.

Figure 3.2 shows the trends for the 1991 to 2006 period for the four counties in terms of meals, or restaurant, sales made and Figure 3.3 shows these same data for rooms, or accommodations, receipts in 2006 dollars. The total of the data in Figures 3.2 and 3.3 will be slightly less than the total sales number given in Figure 3.1, as some rooms and meals sales are for prepared foods that are taxed by the state, but that are sold by grocery stores and other retail vendors. The room spending is a more reliable indicator of the level of overnight tourist trips. The winter season has the highest rate of the four seasons of overnight visitors who stay in the types of accommodations where they must pay a rooms tax. The growth of receipts in Coos County is significant because of its two very large hotels, which opened for the winter during this time period, even after discounting data entry errors for 2002 and 2003. The relative lack of overnight visitors during the winter months in Belknap County is also apparent in Figure 3.3.

Figures 3.4 shows the meals receipts data for the four counties for each of the four months in 2006 dollars. As noted above, the jump in meals receipts for December 1997 for Grafton County reflects the problem in shifting to a new geographic reporting system (Figure 3a) . The DRA data reporting problems for Coos County for February 2002 and 2003 are also apparent in Figure 3.4b. These two figures do show the importance of February as the winter month with the greatest sales, due to the two weeks on which New Hampshire, Maine, and Massachusetts have school vacations. Also, there is some variability in the monthly meals receipts patterns from year to year.

Figures 3.5 show the rooms receipts data for the four counties for each of the four months in 2006 dollars. As noted above, the jump in meals receipts for January 1998 for Grafton and Carroll counties reflects the problem in shifting to a new geographic reporting system that not all businesses shifted to immediately. The overall trend in rooms receipts in constant 2006 dollars is up in all counties except for Belknap. In recent years, Carroll County has drawn even with Grafton County in rooms receipts during the winter months.

Summary

Our analysis of rooms and meals spending for the four northern counties indicates that there is no statistical relationship between the weather and the level of spending during the four winter months. To say this a different way – the amount of rooms and meal revenue does not change much between cold snowy winters (e.g., 1994, 1996, 2001, 2003, 2005) and warm, less snowy winters (e.g., 1995, 1997-2000, 2002, 2006). We suspect that the primary reason for this is that if people are not able to ski, snowmobile, or ice fish because of the weather, they are still very likely to come and engage in other activities, such as shopping, scenic driving, walking, and hiking. During an average winter about 25 percent of all visitors to the four northern counties are not members of travel parties where people are skiing, snowmobiling, or ice fishing. Also, during an average winter about 16 percent of the people who are part of the travel parties who are engaged in skiing, snowmobiling or ice fishing are not themselves engaged in those activities. Thus, roughly 40 percent of all visitors to the four northern counties are not engaged in winter outdoor recreation. If snow and ice conditions are good for outdoor recreation, it appears that a larger share of those who visit engage in outdoor recreation. If snow and ice conditions are not good for winter recreation, people are more likely to engage in other activities. In fact, traffic

count data from the New Hampshire Department of Transportation was evaluated and compared with weather data as part of this study for the four northern counties. It appears that people are more likely to be out driving around this part of the state when there is less snow available for skiing and snowmobiling, likely because of the improved conditions for driving.

The lack of a strong correlation between winter climate and meals and rooms spending reflects the fact that even during warm, less snowy winters, people are still traveling to the northern New Hampshire and spending money on rooms and meals. However, it is not clear if people will continue to travel to the region if there is a series of poor winters, as they may consider visiting and spending money in other regions that provide them with activities that are not focused on outdoor winter recreation. With this in mind, ski area operators – and tourism-related businesses and local chambers of commerce – will want to continue what seems to be a move toward diversification of winter activities, including shopping and entertainment, as well as the on-resort availability of activities like swimming and working out. It is worth noting that the beginnings of this trend, with more ski areas becoming four-season resorts, appears to be a type of adaptation to climate change.

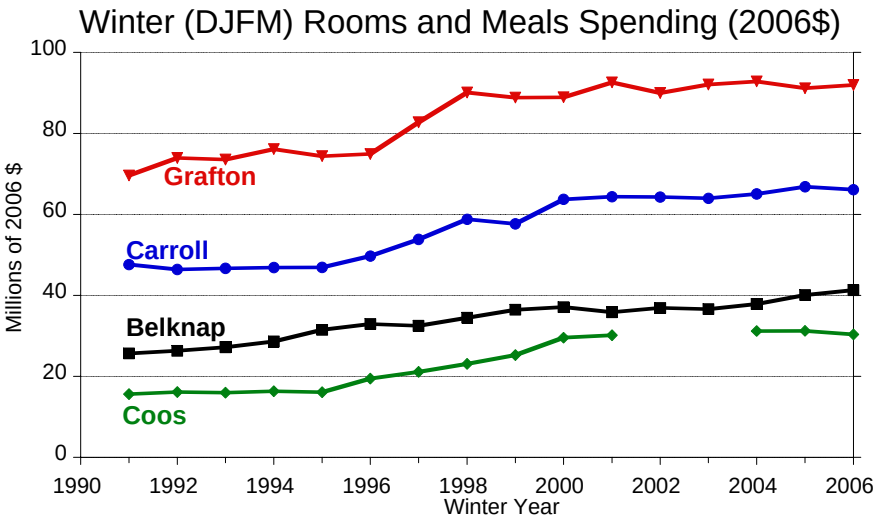


Figure 3.1 Rooms and meals spending in 2006$ for four counties during winter (December through March).

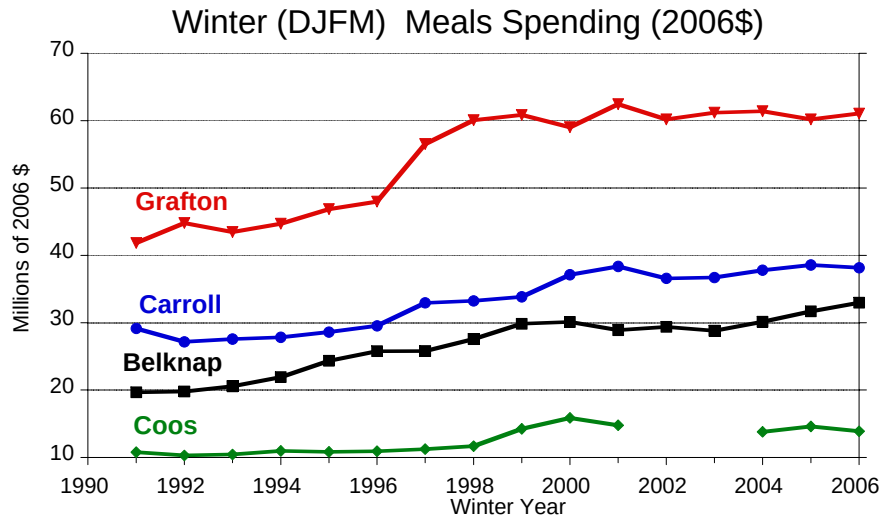


Figure 3.2 Meals spending in 2006$ for four NH counties during winter (December through March).

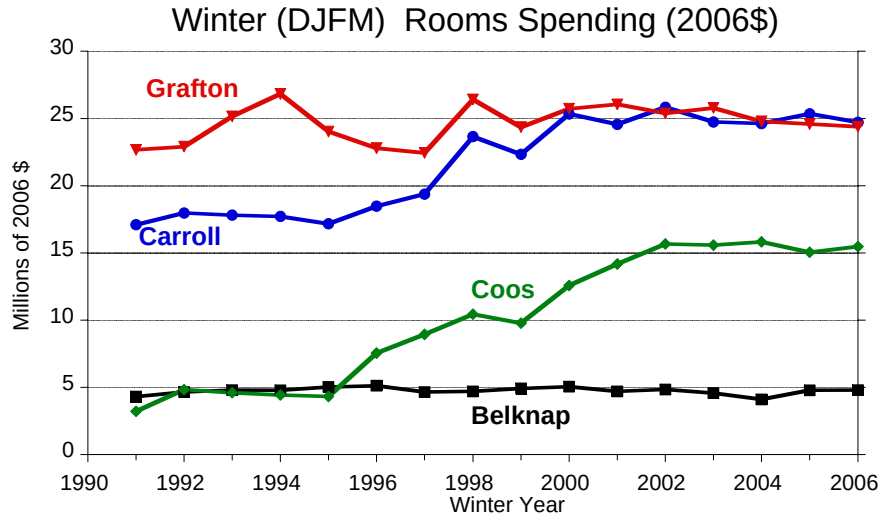


Figure 3.3 Rooms spending in 2006$ for four counties during winter (December through March).

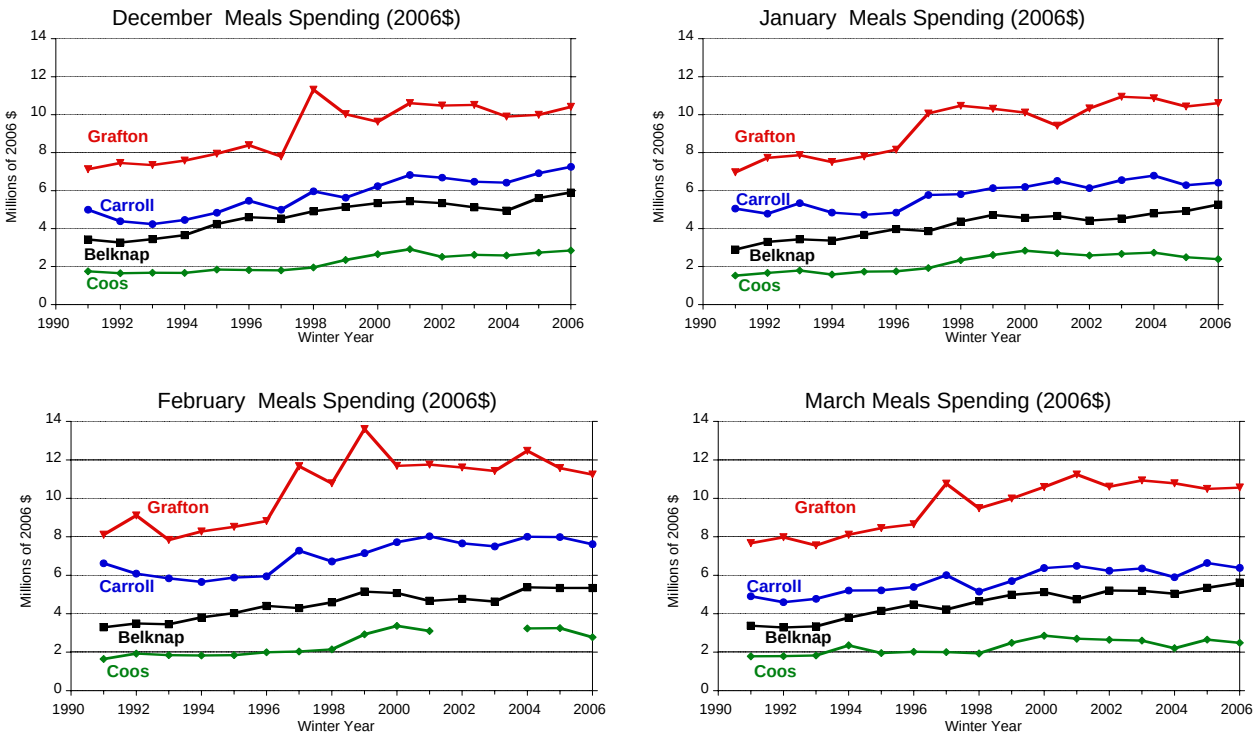


Figure 3.4 Meals spending in 2006$ for four NH counties for December, January, February, and March.

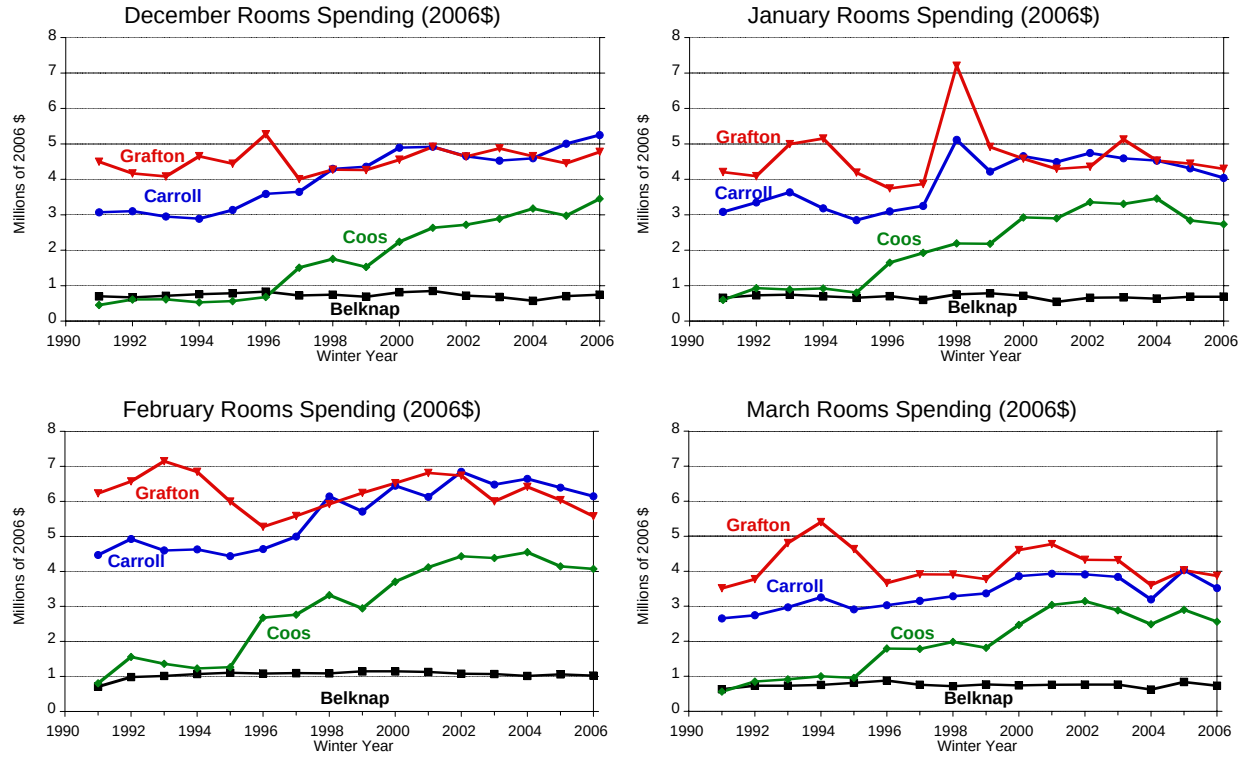


Figure 3.5 Rooms spending in 2006$ for four NH counties for December, January, February, and March.

4. Ski Areas in Operation and Snowmaking

Ski areas are found in all of the counties of the state, except for Rockingham and Strafford near the Seacoast (Figure 4.1). The largest number of alpine and Nordic ski areas is found in the three northern counties of the state: Grafton, Carroll, and Coos. When a line is drawn across the state from Hanover to Campton and on to Center Conway village at the Maine border, one finds that the ten alpine ski areas to the north of that line (identified with blue triangles in Figure 4.1) have remained continually in business since 1984 and before. To the south of that line, the number of alpine ski areas has varied for most years and some ski areas have closed permanently (Figure 4.3). Only five of the alpine ski areas to the south of the line across the state have remained in continuous operation from before the 1983-4 season up to the present.

Figure 4.1 shows the location of the alpine and Nordic ski areas as of 2004, as well as the location of all the stations for which we have meteorological data, and the location of the three meteorological stations we focus on in this report (Pinkham Notch, Concord, and Haverhill). Table 4.1 provides a list of the alpine and Nordic areas that existed between 1984 and 2004 that are to the north or south of the line across the state. In addition, there are seven alpine ski areas for which we have monthly attendance data for the 1993-4 to 2005-6 seasons (Attitash, Bretton Woods, Cannon, Gunstock, Loon, Pats Peak, Waterville Valley).

Table 4.1. List of alpine and Nordic ski areas in NH North verses South. The numbers in brackets beside the ski area names refer to their location in Figure 4.1. This list is accurate for the 1984 to 2004 period and includes areas that were active and then closed permanently (indicated by a strikethrough) during that time period.

Alpine Areas		**Nordic Areas**	
North	South	North	South
Attitash (1)	Alpine Ridge (11)	Balsams (27)	Eastman (40)
Black (2)	Crotched Mtn (12)	Bear Notch (28)	Gunstock (41)
Bretton Woods (3)	~~Eastman~~ (13)	Bretton Woods (29)	King Pine (42)
Cannon (4)	Gunstock (14)	~~Cannon~~ (30)	Nordic (43)
Cranmore (5)	~~Highlands~~ (15)	~~Cranmore~~ (31)	Norsk (44)
Dartmouth (6)	King Pine (16)	Franconia (32)	~~Temple~~ (45)
Loon (7)	~~King Ridge~~ (17)	Great Glen (33)	Windblown (46)
Waterville (8)	McIntyre (18)	Jackson (34)	Woodbound (47)
Wildcat (9)	~~Moose~~ (19)	Loon (35)	
Balsams (10)	Pats Peak (20)	Mtn. View (36)	
	Ragged Mtn (21)	Mt. Washington Valley (37)	
	Mt. Sunapee (22)	Sunset Hill (38)	
	~~Temple~~ (23)	Waterville (39)	
	Tenney (24)		
	Whaleback (25)		
	~~Whittier~~ (26)		

Figure 4.2 shows the range of attendance data at the seven alpine ski areas between the months of November and April for 13 seasons (1994 to 2006). Attendance is so small during the months of November and April that skier days during these months have a negligible effect on total winter skier days. The months of December to March did show some meaningful patterns. February attracted the greatest number of skiers of these four months, just as the rooms and meals data suggested. However, February has the most consistent range of attendance numbers of the four months, followed by December. It is during these two months that families plan ski vacations (i.e. around Christmas vacation and spring breaks from grade school), and the year-to-year variability in skier days has only a limited relationship to weather data such as temperature and snowfall. The months of January and March show greater variability resulting from increased sensitivity of attendance at alpine ski areas to skiing conditions. As a result, the years with the higher numbers of skier days were years that had excellent skiing conditions during the months of January and March. The ski areas also provided their opening and closing dates. One year, Bretton Woods stayed open until early May. It was found that opening and closing dates had almost no relation to weather patterns.

Figure 4.3 provides a count of the number of alpine ski areas in New Hampshire to the north and south of the line drawn across the state from Hanover to Campton to Center Conway. As mentioned above, the same ten alpine areas have been in operation to the north of that line. To the south of that line, a number of ski areas have disappeared, especially after the warm winters of 1995 and 2002. Since 2002, two long-abandoned areas in the southern part of the state reopened: Granite Gorge and Crotched Mountain. Also reopening recently was Whaleback after a short closure. Other areas that have closed and reopened include Ragged Mountain and Tenney Mountain. Alpine areas that appear to have permanently disappeared are Alpine Ridge, Eastman, Highlands, King Ridge, Moose, Temple, and Whittier.

There is greater stability among the Nordic areas (Figure 4.4), probably because they require far less investment and have minimal operating costs. There has been a slight increase in the number of Nordic areas north of the line across the state, while there has been almost no change south of that line. This is in contrast with the pattern found for the alpine ski areas.

There are a variety of ways that alpine ski areas can try to modify the impacts of unfavorable weather and thereby adapt to changing climatic conditions. The most important of these are snow making and trail grooming. Figure 4.5 shows the number of acres and the cumulative investment in snowmaking as measured in 2006 dollars. Major investments are most likely to occur in the first and second summers after a warm winter. The relatively large investment between 1995 and 1996 in snowmaking does not show up very strongly in the total areas under snowmaking between those two years as two medium-sized ski areas that did have snowmaking went out of business and have since closed permanently. The drops in snowmaking acreage between 1998 and 1999 and between 2001 and 2002 reflect the recognition by ski area operators that not all trails need snowmaking in order for the ski areas to be successful. Some trails are too expensive to cover with snow versus the number of skiers who will use them. Where there is growth in snowmaking acreage in recent years, it has been due to the enlargement of existing ski areas in terms of numbers of trails and lifts. Before 1998 most of the growth in acreage was due to extending snowmaking to existing trails.

Over the past twenty years skiers have shown a small trend toward visiting ski areas in the northern part of the state instead of the southern part during typical winters. Reasons include improvements in highways, the increasing larger size of many of those areas in terms of lifts and trails, and the greater reliability of skiing conditions due to weather conditions there as well as snowmaking. Also, in comparison with Maine and Vermont, New Hampshire's ski areas are more accessible to the Boston market and offer a variety of off-slope activities. In fact, most of New Hampshire's alpine ski areas have become four season resorts offering a wide range of activities that can be undertaken even when snow conditions are not favorable. While New Hampshire has a large number of "lost" ski areas, most of them were small and relied on rope tows, J bars, T bars and Poma lifts. A large share of these areas were in the central and southern parts of the state and almost all of the alpine ski areas without chair lifts and snowmaking had disappeared by 1985 (6).

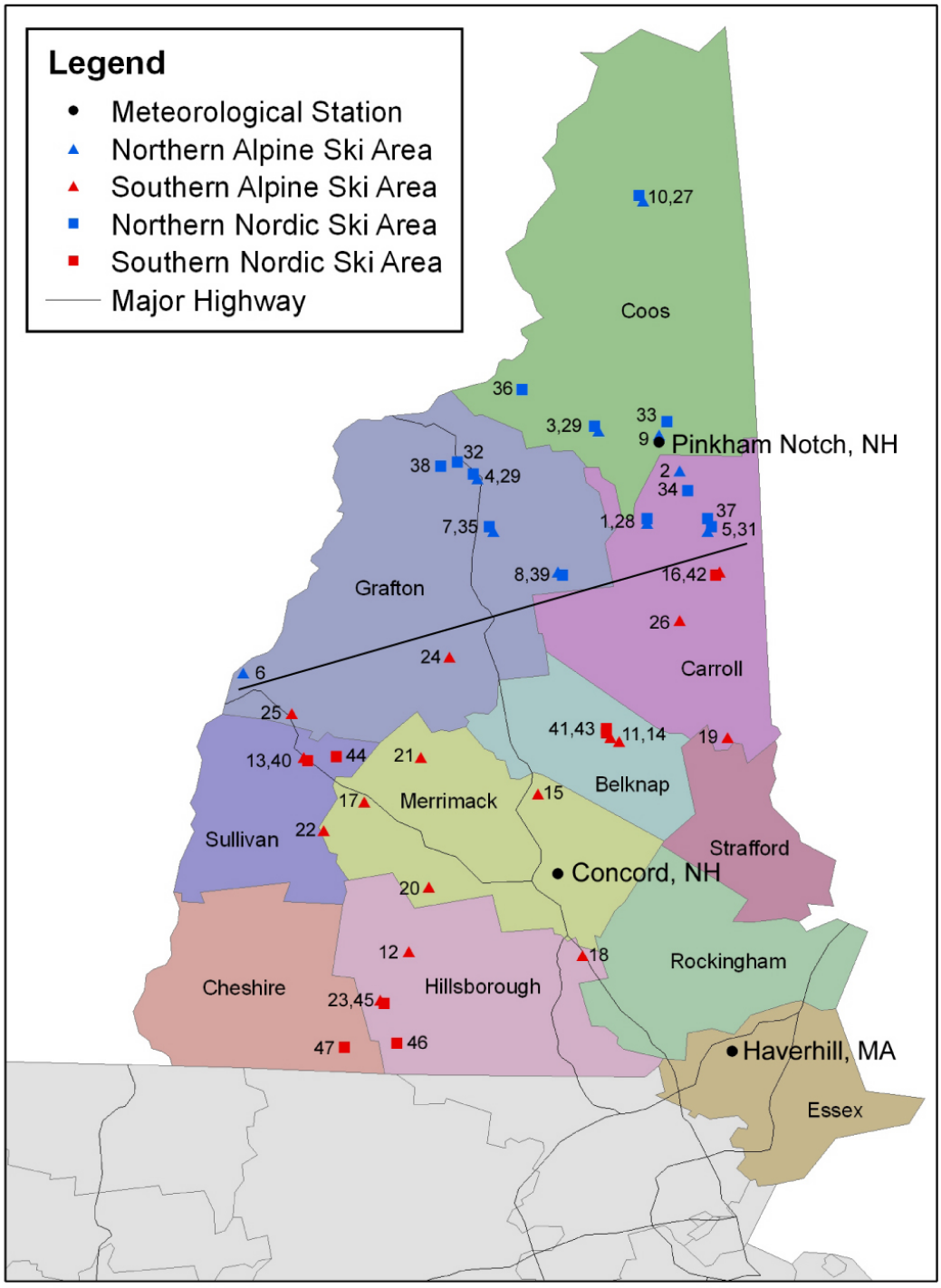


Figure 4.1 Location Map for ski areas in New Hampshire and the location of meteorological stations used in the report. The black diagonal line through the middle of the state of NH separates the northern and southern ski areas. The black line runs from Hanover, in southwestern Grafton County, through Campton in southeastern Grafton County to Center Conway village in the central part of Carroll County where it borders Maine.

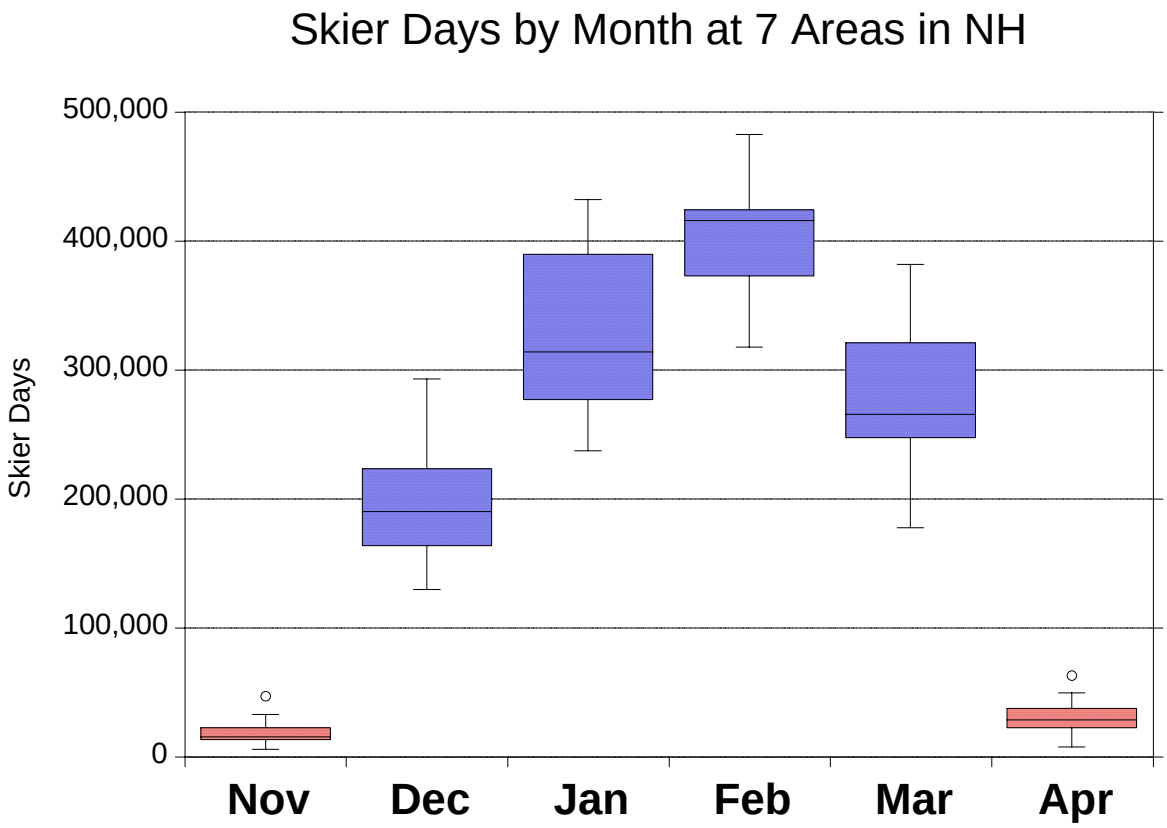


Figure 4.2 Alpine skier days per month at seven areas in NH for the 13 years of data (1993-4 to 2005-6 winter skiing seasons) showing the range of skier days for each month. The shaded areas represent the interquartile range (50 percent of the data around the median), while the bars represent the entire range of the data. November and April attract very few skiers on average. The greatest number of skier days occurs in February. Note that the shaded range is smallest for the months of December and February, indicating relatively low variability from year-to-year in skier days during these two months. This reflects the fact that these two months contain school vacation weeks and that travel parties are not particularly affected by the weather and snow conditions in their decision to ski. In contrast, there is relatively more variation in skier days during the months of January and March which do not have school vacation weeks and visitor decisions are more reflective of snow conditions.

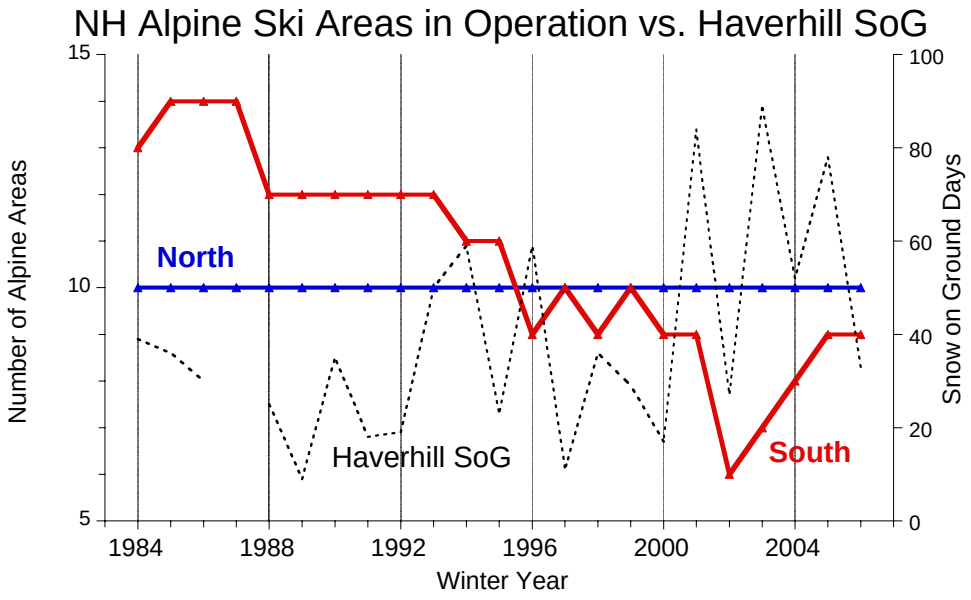


Figure 4.3 Alpine ski areas in operation in NH North vs. South 1984 – 2006 plotted verses Haverhill, MA snow-on-ground record. The ten alpine ski areas north of the line have consistently opened each winter. In the area to the south of the line across the state from Hanover to Center Conway there has been far more variability in operation and only five of the nine areas open during 2005-6 remained open for each season during the 1983-4 to 2005-6 time period. Note the number of alpine ski areas in operation in the south drops after the warm, less snowy winter of 1995 and 2002.

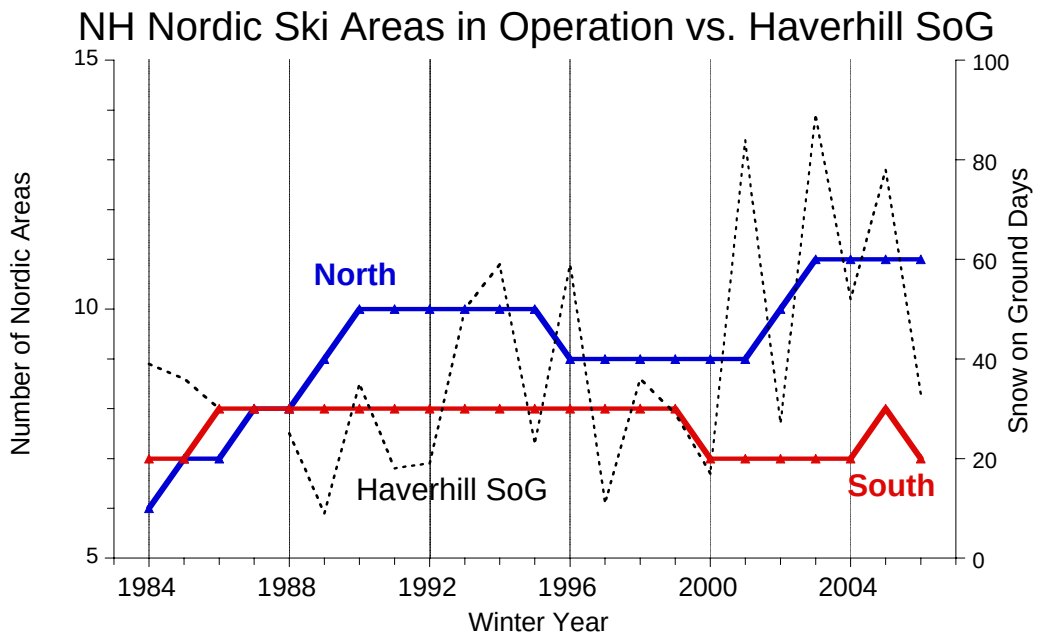


Figure 4.4 Nordic ski areas in operation in NH North vs. South 1984-2006 plotted verses Haverhill, MA snow-on-ground record. There is little relationship between climate and the number of Nordic ski areas in operation.

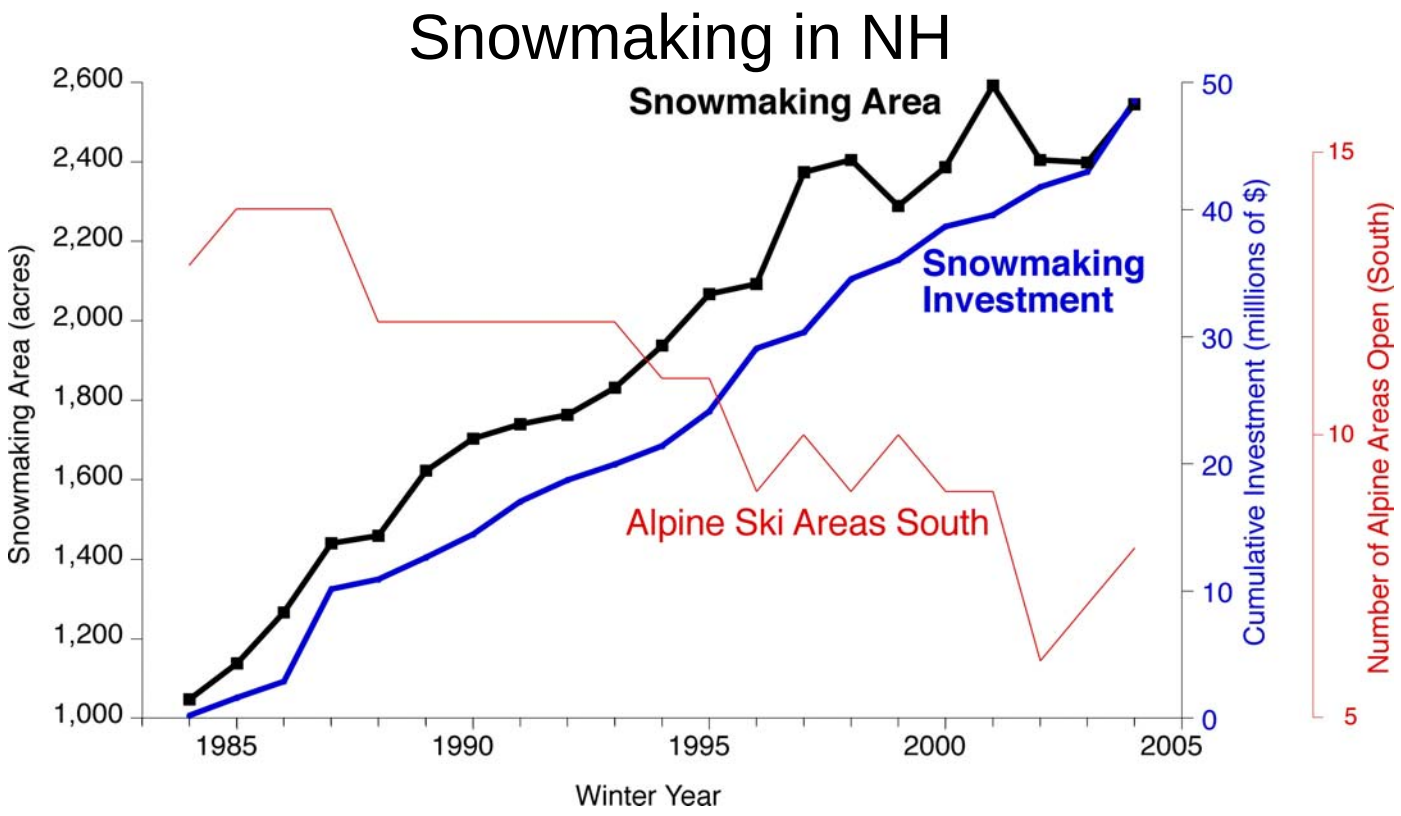


Figure 4.5 Snowmaking area and investment in NH alpine ski areas, 1984 –2004. The snowmaking investment line on Figure 4.4 is in cumulative 2006 dollars and includes ski areas that have closed and disappeared. The snowmaking area line shows the amount of area in acres for only those ski areas that operated during that winter. Thus, some of the losses in snowmaking area during recent years have been due to ski area closure. Also, between the warm winter of 1995 and the following season, there was a significant investment in snowmaking, but two areas closed and the shutdown of their snowmaking produced only a slight upward trend in additional acreage. Most areas are now at, or near, 100 percent coverage of their trails with snowmaking.

5. Alpine and Nordic Skier Days

New Hampshire's ski area operators have long observed anecdotally that when there is snow on the ground in northeastern Massachusetts and southern New Hampshire, attendance is much higher at ski areas in New Hampshire. The analysis of "snow-on-ground" data for several weather stations in Massachusetts and New Hampshire confirms this observation. For example, there is a significant correlation between alpine skier days and the number of days with snow on the ground at Haverhill, Massachusetts (Figure 5.1, Table 5.1). The correlation between Haverhill snow-on-ground is stronger for the alpine areas in the south (r=0.76) compared to areas in the north (r = 0.44). The correlation between Concord snow-on-ground is also strong for alpine area in the south (r=0.55) (Table 5.1). Total snowfall during the winter months at Haverhill was also a good predictor of alpine skier days attendance at alpine areas in the south (Figure 5.2).

The highest correlations for both Haverhill, Massachusetts, and Concord, New Hampshire, for the number of days with snow on the ground during the winter was for total ski area attendance at both alpine and Nordic ski areas located south of the line across the (Figures 5.1 and 5.3). Concord snowfall data was not a very good predictor for alpine and Nordic ski area attendance in the northern part of the state. In terms of average temperature during the winter months, Haverhill had a significant inverse correlation with Nordic skiing attendance in southern New Hampshire as shown in Table 5.1 and Figure 5.6. Concord had a significant inverse correlation with both alpine and Nordic skiing in the southern part of the state. As it is almost always cold at Pinkham Notch, temperature did not have a strong relationship with numbers of skiers.

As the Nordic areas do not make snow, they have greater variability in attendance than do the alpine ski areas. Also, the impact of warmer versus colder weather during the winter has a greater impact on ski areas south of the line across the state than on ski areas to the north of that line. Alpine areas to the north of the line had a 25 percent variation between low year skier days and high year skier days since 1990. For the Nordic areas north of the line, attendance varied by 30 percent. South of the line across the state the alpine ski areas had a 36 percent range between the high and low years and the Nordic areas had a 69 percent variation. Thus, attendance during the highest year was almost three times the number as during the lowest year for the southern Nordic ski areas.

Table 5.1 Correlation coefficients (R) among Skier Days and Climate Variables 1984 – 2006 (n=23).

Met Station	Alpine Ski Areas		Nordic Ski Areas	
	North	South	North	South
Snow-on-Ground Days				
Pinkham Notch	0.28	0.35	**0.40**	**<u>0.65</u>**
Concord	0.24	**0.55**	0.17	**<u>0.63</u>**
Haverhill	**0.44**	**<u>0.76</u>**	0.25	**<u>0.64</u>**
Snowfall				
Pinkham Notch	**0.47**	0.29	0.36	0.33
Concord	0.23	0.36	0.05	**0.42**
Haverhill	**0.48**	**<u>0.63</u>**	0.15	**0.43**
Winter Temperature (mean)				
Pinkham Notch	-0.28	-0.32	-0.22	-0.36
Concord	-0.27	**-0.43**	-0.14	**-0.50**
Haverhill	-0.17	-0.32	-0.05	**-0.45**

Bold: Significant at 90% confidence interval
<u>Underlined and Bold:</u> Significant at 95% confidence interval

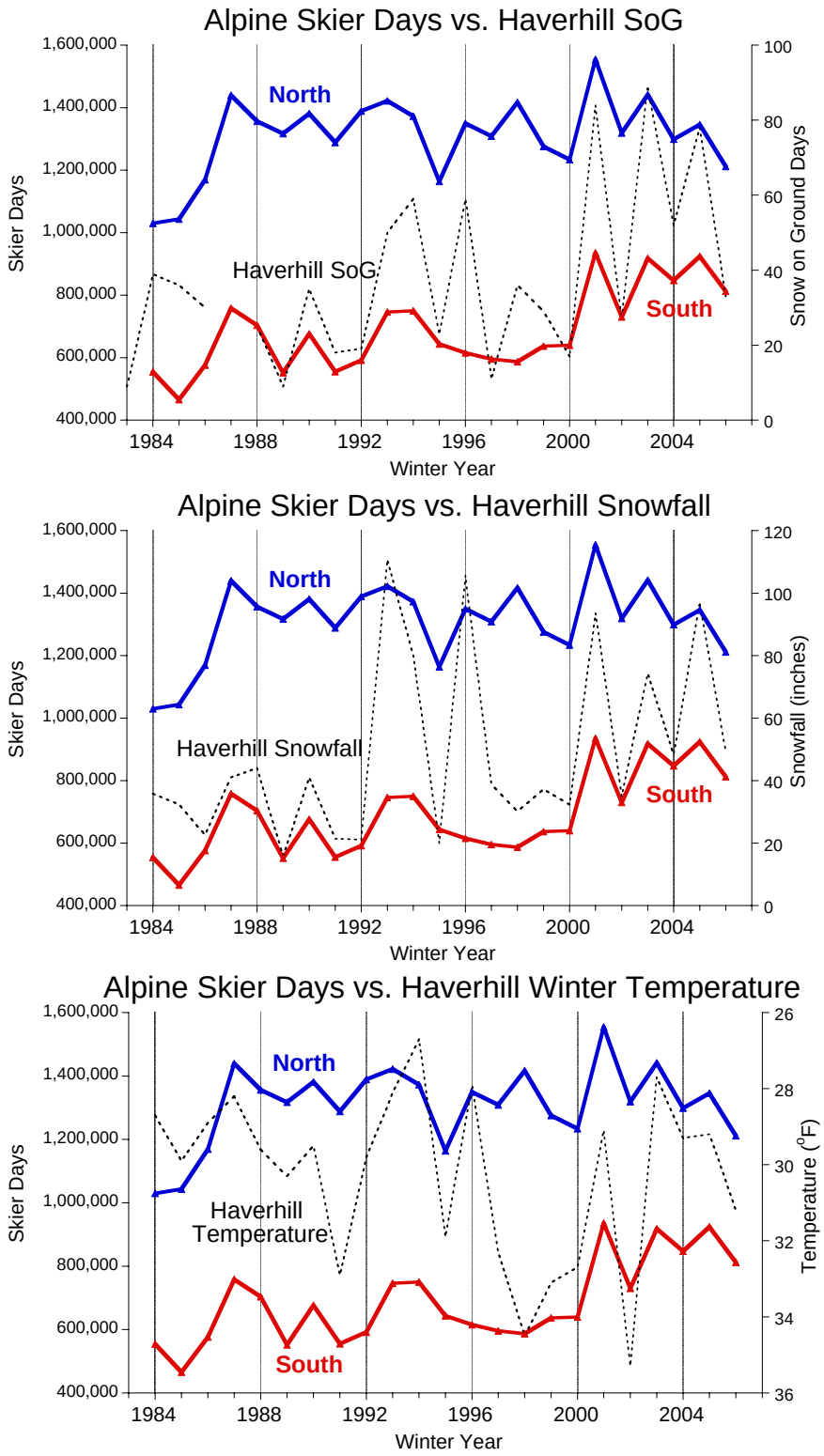


Figure 5.1 Alpine Skier Days vs. Haverhill, MA snow-on-ground days, snowfall, and mean temperature from 1984 – 2006. This figure shows that there is a relationship between snow on the ground and snowfall in Haverhill, Massachusetts, and the number of skier days. There is a stronger impact of the number of days that snow is visible on the ground in Haverhill on the attendance at ski areas in the southern part of the state than for the northern part of New Hampshire (See Table 5.1). The relationship with temperature and skier days is not as strong. Evidently, cold weather by itself does not get people thinking about going skiing.

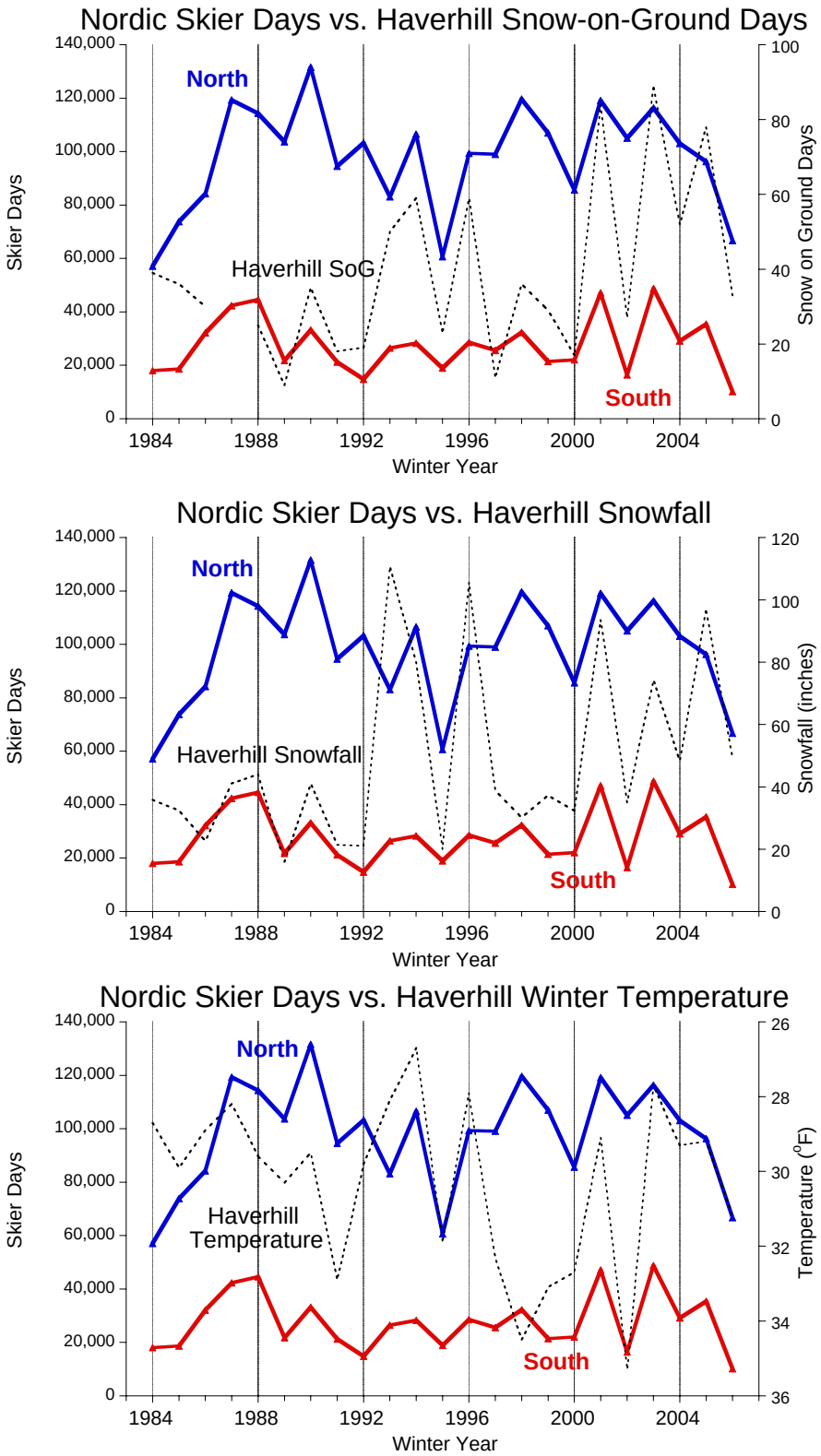


Figure 5.2 Nordic Skier Days vs. Haverhill, MA snow-on-ground days, snowfall, and temperature, 1984 – 2006. There is a strong correlation between snow on the ground in Haverhill and Nordic ski area attendance in southern New Hampshire (Table 5.1). A somewhat similar pattern is seen for snowfall total as for snow-on-ground days, except that total snowfall is not as strong. The relationship between the average temperature for the winter at Haverhill and ski area attendance at Nordic ski areas is fairly similar to the two previous figures. While there is a significant relationship between colder weather at Haverhill and the number of Nordic skiers in southern New Hampshire, there is no real relationship between the temperature at Haverhill and the number of Nordic skiers in the northern part of New Hampshire. This is probably because, except for extremely warm winters, northern New Hampshire's Nordic areas are very likely to have snow cover regardless of the weather at Haverhill.

New Hampshire Alpine Skiing Trends and Regional and National Trends

The 2005-6 season in New Hampshire was average in terms of the number of skier days, ranking 11th highest of the 23 most recent seasons. The number of skier days was down 10.9 % from the 2004-5 skiing season. The Northeast region, which includes the six New England states plus New York, was down 8.5 % between 2004-5 and 2005-6. Nationally, the number of alpine skier days was up by 3.5 % between the two seasons and hit a new all-time record of 58.9 million days or visits. Of the 41 states with ski areas, only three states had greater percentage decreases between the 2004-5 and 2005-6 seasons: Arizona, off 87.8 %; New Mexico, off 49.4 %; and Maine, off 14.5 %. New Hampshire ranked ninth of the 41 states with ski areas in terms of the total number of skier days, with 2.0 million. In some years it has ranked as high as seventh nationally.

The National Ski Areas Association provides detailed data and analysis at the state and regional levels in an annual report known as the Kottke National End of Season Survey. The information reviewed here is from the 2005-06 season report.

At the regional level, this report found that the Northeast had an average season during 2005-6. The Northeast was the only region with a decrease in the number of skier days between 2004-5 and 2005-6, down by 8.5 %, with average total snowfall down by 16 % from the previous winter. The Southeast (Alabama to Pennsylvania) had its second highest season ever, up by 6.1 % in skier days, while average total snowfall was down by 12 % from the previous winter. The Midwest region had its fifth best season ever, with skier days up by 3.4 % and average total snowfall up by 14 % over the previous season. The Pacific region had its third best season ever, with a 13.9 % increase in skier days and a 13 % increase in average total snowfall in comparison with the 2004-5 season. The Rocky Mountain region is the largest region in terms of total skier days. This region had its best season ever, which helped the nation achieve its highest total ever. The number of skier days was up by 5.7 % in 2005-6 over 2004-5, while the average total snowfall was up by 14 %. Strong growth in skier visits and total snowfall in the central and northern Rockies offset the large drops in Arizona and New Mexico.

Region	Snowfall	Skier Days
Northeast	- 16 percent	- 6.5 percent
Southeast	- 12 percent	+ 6.1 percent
Midwest	+ 14 percent	+ 3.4 percent
Rockies	+ 14 percent	+ 5.7 percent
Southwest		- 68.6 percent
Pacific	+ 13 percent	+ 13.9 percent
N. H.		- 10.9 percent

The report reinforces the data from New Hampshire, indicating that loss of snow is tied to a reduction in skier days and revenue for ski areas, except in the Southeast, where skier days was up by more than 6 percent, although snowfall decreased by 12 percent. The fact that skier days in New Hampshire were down, but rooms and meals revenue – as a measure of visitor days – was up slightly, indicates that visitors may feel New Hampshire offers sufficient alternatives to skiing to keep it an attractive place to go regardless of ski conditions. While it is difficult to say whether this data reflects changes in snowfall and skier days in states to our south, it does indicate that it would be wise for New Hampshire ski areas and resorts, and their communities, to work together wisely in planning ways to continue to keep New Hampshire an attractive destination by diversifying the types of activities visitors can engage in here.

6. Ice Fishing Licenses and Snowmobile Registrations

The data used to track ice fishing and snowmobile activity during the winter is not as direct as for alpine and Nordic skiing. First of all, these data are statewide totals. Second, there is no specific ice fishing license other than for the small number of limited day fishing licenses sold only to New Hampshire residents during the winter months. Third, the data for fishing licenses are available only for the 1989 to 2005 time period. Finally, most of the licenses purchased during the months of December, January, and February are annual hunting and fishing licenses. It was assumed that licenses were purchased at this time of year to enable ice fishing. Licenses sold during March were not included as the non-ice fishing season opens at the crack of dawn on April 1st and most licenses sold during March are in anticipation of that event. Finally, the NH Fish and Game Department had a significant increase in its license fees during 2002 and 2003. Thus, the sale of licenses did not rebound to the levels that might be anticipated after the warm winter of 2002.

Figure 6.1 compares the number of Fish and Game licenses sold during the months of December, January, and February of each winter season with the average temperature at Lakeport, New Hampshire. For the period of overlap, there is not a strong relationship between these two variables (R = -0.06). Part of this poor relationship can be explained by the steep drop in fishing licenses sold in 2002 due to the warm winter combined with an increase in the license fees. The data in Figure 6.1 does show that warm winters (e.g., 1995, 2002, 2006) were years when fewer licenses were sold, with the warm winter in 2006 showing by far the fewest number of licenses sold.

There is a longer-term downward trend over the past 5 years in the number of winter fishing licenses that suggests that fewer people are now involved in winter fishing and hunting activities. This reflects a combination of factors, including changing demographics and more expensive licenses. The warm winters of 2002 and 2006 may also have been important drivers of this trend.

One of the shortcomings of the snowmobile license data is that the number of registrations sold to New Hampshire residents during the four winter months is available only since 1997. Data is available for the 1987 to 2006 winter seasons for the number of registrations sold to non-residents and can be used to investigate longer term trends. Since the year 2000, the number of licenses sold to NH residents tracks snow-on-ground days in Pinkham Notch fairly well, with close to 44,000 licenses sold in the cold, snowy winters of 2001 and 2003, and less than 34,000 in the warm, less snowy winter of 2002, and fewer than 27,000 licenses during the warm and relatively snowless winter of 2006.

In 2002, snowmobile registration fees were changed so that everyone who registers a snowmobile in New Hampshire needs to also be a member of a NH snowmobile club or pay an extra $30 per snowmobile registration. While these additional funds provide support for improvements to trail systems in New Hampshire, it may not have been an attractive proposition to out-of-state residents who spend fewer days per winter snowmobiling in comparison with residents of the state. Despite the new requirement, snowmobile licenses for residents increased almost 10,000 during the relatively good winter of 2002-3. Following this winter, sales of

registrations to residents and non-residents dropped, and plummeted during the relatively warm and snowless winter of 2006.

It appears that the number of people engaging in ice fishing and snowmobiling activities in New Hampshire have a different relationship with the weather than the number of skiers. During moderate or cold, snowy winters, there is no apparent relationship. On the other hand, both ice fishing and snowmobiling licenses decrease considerably during warm, relatively snowless winters. Another important factor in the trends appears to be NH registration fees compared to those of competing states such as Vermont and Maine. Also important for snowmobiling is the overall state of the economy, including the cost of fuel, as this is a far more expensive sport than is alpine skiing.

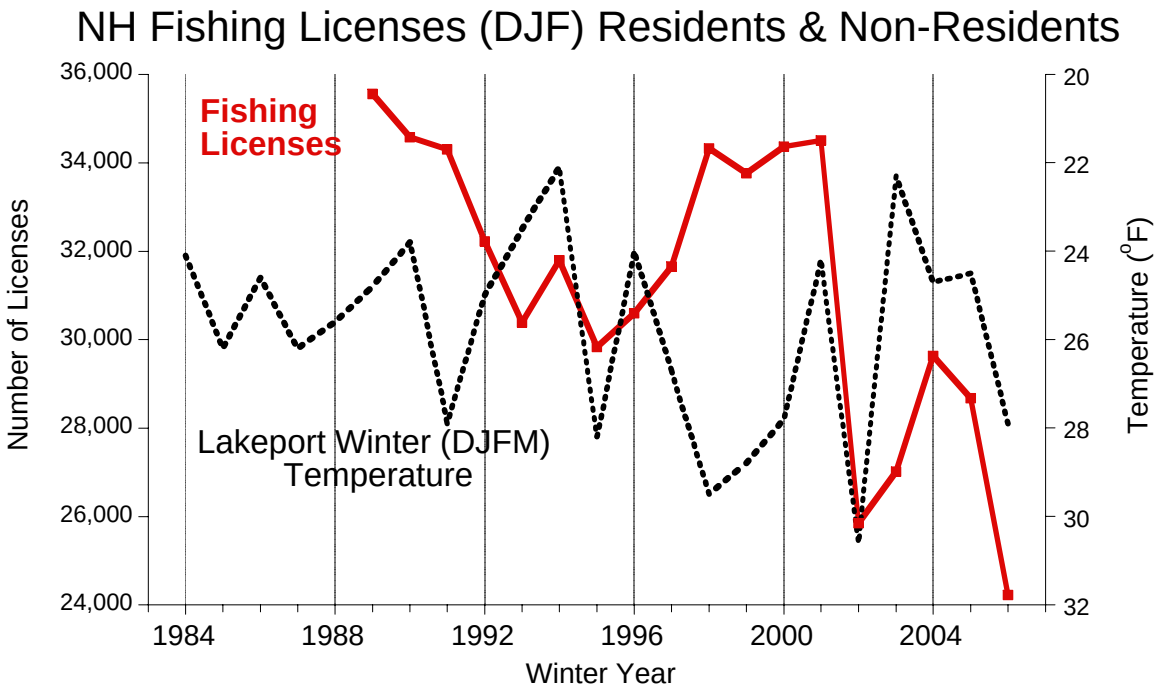


Figure 6.1 NH Winter (DJF) Fishing Licenses for Residents and Non-Residents, 1986 – 2006. This figure shows the total fishing licenses issued to both residents and non-residents of the state during the months of December, January and February only. The warm winters of 1995, 2002 and 2006 showed significantly lower sales of licenses. The long term trend appears to be due to a range of factors, including demographic changes, the rising cost of licenses, and the warmer winter weather in recent years.

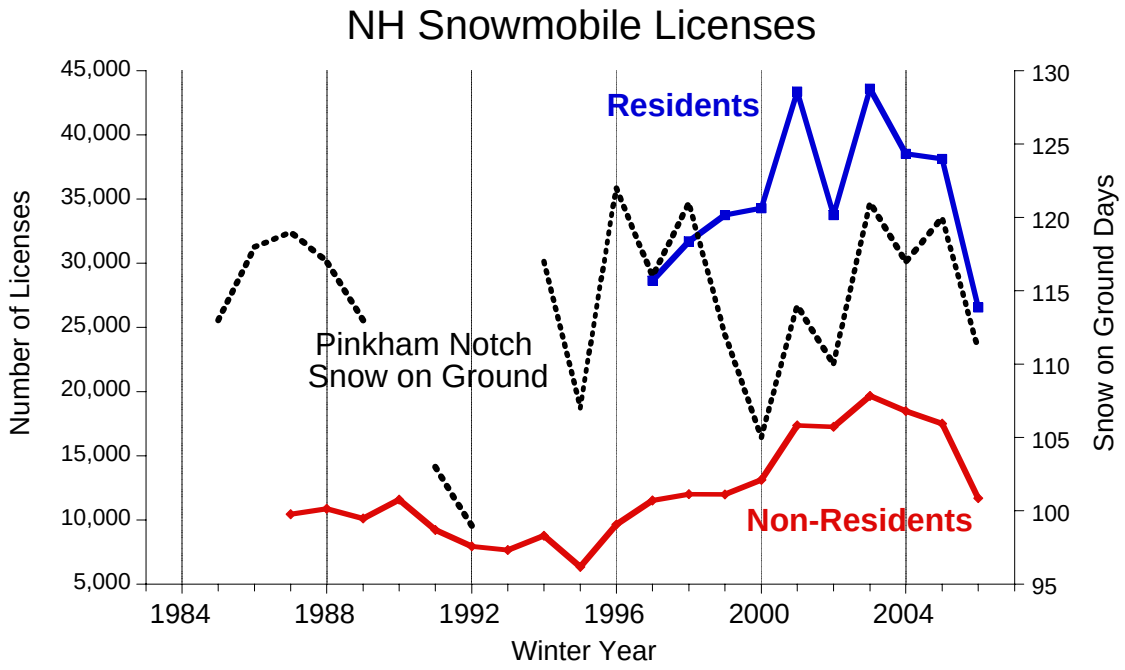


Figure 6.2 NH Winter (DJFM) Snowmobile Registrations for Residents and Non-Residents, 1987– 2006. Snowmobile registration data is available for non-residents for the 1987 to 2006 period and for residents for the 1997 to 2006 period. Shown are licenses purchased during the four winter months, which would enable a response to winter snow conditions by the purchaser. Since 2000, there is a good relationship between the number of days with snow on the ground at Pinkham Notch and the number of licenses purchased, with the warm relatively snowless winter of 2006 showing the lowest number of licenses purchased by NH residents.

7. Summary

We have performed an analysis on year-to-year variability of winter rooms and meals spending and indicators of outdoor recreational activity in northern New Hampshire, and climate variables across New Hampshire and in northeastern Massachusetts. We did not find any significant year-to-year variability in spending on rooms and meals related to changes in climatic conditions. This indicates that visitors still travel to the northern counties during warm and less snowy years and spend money on rooms and meals, but engage in activities that do not rely on cold, snowy conditions. These other activities likely include (but are not limited to) shopping, scenic driving, walking, and hiking. While not included in this study, warmer winters do produce an increase in rooms and meals tax revenues in the three counties which border Massachusetts compared to colder winters. What is not clear is whether or not visitors will continue to travel to the region and spend the money on rooms and meals if there is a series of warm, less snowy winters that are not conducive to outdoor recreation.

All of the other indicators of outdoor winter recreation activities we analyzed showed that there is an increase in the number of people who participate in outdoor winter recreation during cold, snowy winters (which we have identified as 1994, 1996, 2001, 2003,and 2005) compared to warm, less snowy winters (which we have identified as 1995, 1997, 2000, 2002, 2006). These results are summarized in Table 7.1. This difference is significant at the 95 percent level for alpine skier days in the north and total; for Nordic skier days in the south and total; and for snowmobile licenses (Table 7.2). The differences in climatic variables are also significant at the 98 percent confidence level for all but snow-on-ground days for Pinkham Notch, which does not show much year-to-year variability.

What does this mean? The answer is rather obvious and has implications for the future. Winters that are cold and snowy show an increase in the number of people participating in winter outdoor recreation. This includes 14 percent more alpine skiers (309,000 more skier days), 30 percent more Nordic skiers (43,000 more skier days), and 26 percent more snowmobile licenses purchased by NH residents (almost 11,000 more licenses). This corresponds to approximately $11.5 million for alpine ski tickets, $0.7 million for Nordic ski tickets, and $0.9 million for snowmobile registrations (Table 7.3). The difference between a cold, snowy winter and a warm, less snowy winter also means a difference of about 3,000 jobs. While the short-term response to warm, less snowy winters may not affect overall rooms and meals spending, it is clearly affecting the bottom line for many individuals and businesses that are directly involved in outdoor winter recreation activities.

As mentioned in the introduction, several studies have documented a warming trend in New England over the past 30 years, with winter temperatures rising 4.4 F over that time period. Other evidence includes fewer days with snow on the ground, a decrease in the snow-to-rain ratio in winter precipitation, earlier lake ice-out dates, and earlier center-of-volume flows on the regions unregulated rivers (2). Two new scientific papers (7) and a report published by the Union of Concerned Scientists (8) use recent advances in climate modeling to assess how emissions of greenhouse gases – derived primarily from the burning of fossil fuels -- may further affect climate in the Northeast. The study is based on two different greenhouse gas emission

pathways, one where humans continue to rely primarily on fossil fuel for energy (higher emissions scenario) and a second where society transitions to a more sustainable future through the development of renewable sources of energy (lower emissions scenario). The results show that the emission pathway we choose will largely determine how much warmer our climate will get. By the middle of the century, the results indicate that winter temperatures will warm by 3.5 to 5 F (lower emissions scenario) to 4 to 7 F (higher emissions scenario). By the end of the century winter temperatures will warm by 5 to 7.5 F (lower emissions scenario) to 8 to 12 F (higher emissions scenario), and snow-on-ground days will decrease by 25 percent (lower emissions scenario) to 50 percent (higher emissions scenario).

Based on our analysis here, a difference of 5 F is the measure between a relatively good and relatively poor year for winter recreation in New Hampshire. The results of the modeling study quoted above therefore indicate that the relatively warm and snowless winter of 2006 is more likely to be the "normal" winter over the next 50 years. Figure 7.3 illustrates the difference in revenue from winter recreation between a cold, snowy winter and this new "normal" or analogue winter of 2006. Particularly striking are the losses to Nordic skiing in the southern part of New Hampshire, which are certainly not sustainable, and the more than 14 percent loss of income for alpine ski areas in northern New Hampshire. Finally, if 2006 becomes the norm for winters, state coffers could expect an average of 14 percent fewer dollars from snowmobile registrations and fishing licenses.

Clearly, based on this analysis, if we do not begin soon to reduce our greenhouse gas emissions, the 8 to 12 F warming by the end of the century will have a significant impact on winter recreation and the businesses that rely upon winter snow.

Table 7.1. Summary of changes in winter indicators for 5 cold and snowy winters (1994, 1996, 2001, 2003, 2005) verses 5 warm and less snowy winters (1995, 1997, 2000,2002, 2006),

Winter Indicator	Cold Snowy Winters (94,96,01,03,05)	Warm, Less Snowy Winters (95,97,00,02,06)	Difference	Percent Change
Alpine Skier Days				
North	1,412,966	1,247,713	165,253	12%
South	828,473	684,231	144,243	17%
Total	2,241,439	1,931,944	309,495	14%
Nordic Skier Days				
North	107,568	83,433	24,136	22%
South	37,624	18,631	18,993	50%
Total	145,193	102,064	43,129	30%
Fishing Licenses	30,519	29,188	1,332	4%
Snowmobile Registrations	41,706	30,814	10,892	26%
Winter Temperature (F)				
Haverhill	28	33	5	16%
Concord	23	29	5	24%
Pinkham Notch	17	22	5	28%
Snowfall (inches)				
Haverhill	90	35	55	61%
Concord	82	44	38	47%
Pinkham Notch	123	92	31	25%
Snow-on-Ground (days)				
Haverhill	74	22	52	70%
Concord	94	64	30	32%
Pinkham Notch	119	110	9	8%

Table 7.2. Summary of changes in winter indicators for 5 cold and snowy winters (1994, 1996, 2001, 2003, 2005) verses 5 warm and less snowy winters (1995, 1997, 2000,2002, 2006). Also included in the table are the standard deviations and the level of significance of the difference between the means as determined using a *t*-test.

Winter Indicator	Cold Snowy Winters (94,96,01,03,05)	Standard Deviation	Warm, Less Snowy Winters (95,97,00,02,06)	Standard Deviation	difference	Significant at 95% Confidence Level?
Alpine Skier Days						
North	1412966	88142	1247713	65774	165253	YES
South	828473	141670	684231	86540	144243	NO
Total	2241439	204426	1931944	102134	309495	YES
Nordic Skier Days						
North	107568	10071	83433	19479	24136	NO
South	37624	9837	18631	5858	18993	YES
Total	145193	18862	102064	22690	43129	YES
Fishing Licences	30519	2881	29188	4157	1332	NO
Snowmobile Registrations	41706	3089	30814	3809	10892	YES*
Winter Temperature (F)						
Haverhill	74	14	22	9	52	YES*
Concord	94	8	64	20	30	YES*
Pinkham Notch	119	3	110	4	9	YES*
Snowfall (inches)						
Haverhill	90	13	35	11	55	YES*
Concord	82	11	44	16	38	YES*
Pinkham Notch	123	33	92	17	31	NO
Snow-on-Ground (days)						
Haverhill	28.1	1.0	32.7	1.6	4.6	YES*
Concord	23.2	1.4	28.7	1.3	5.5	YES*
Pinkham Notch	17.4	0.9	22.3	1.3	4.9	YES*

* Indicates the difference between the mean values is also significant at the 98% level.

Table 7.3. Estimated ticket sales and license fees in 2006 dollars for cold, snowy winters verses warm, less snowy winters, and comparison of spending for the winter of 2006, which science indicates is likely an "analogue" – or typical – for winters in NH for the next 50 years.

Winter Indicator		Cold Snowy Winters	Warm Less Snowy Winters	Difference	Percent Change	"Analogue" winter of 2006	Change from cold, snowy winters
Alpine Skier Days							
	North	$55,812,157	$49,284,664	$6,527,494	12%	$47,858,240	14%
	South	$28,582,319	$23,605,970	$4,976,349	17%	$28,020,210	2%
	Total	$84,394,496	$72,890,634	$11,503,862	14%	$75,878,450	10%
Nordic Skier Days							
	North	$1,721,088	$1,334,928	$386,160	22%	$1,067,584	38%
	South	$526,736	$260,834	$265,902	50%	$141,946	73%
	Total	$2,247,824	$1,595,762	$652,062	29%	$1,209,530	46%
Fishing Licenses		$1,678,545	$1,605,340	$73,205	4%	$1,299,400	23%
Snowmobile Regis.		$3,534,583	$2,588,736	$946,207	27%	$3,160,989	11%
Revenue (reg. & lic.)		$5,213,128	$4,194,076	$1,019,052	20%	$4,460,389	14%
Total		**$91,855,448**	**$78,580,477**	**$13,174,976**	**14%**	**$81,548,369**	**11%**

8. References

(1) IPCC, *Climate Change 2001:The Science of Climate Change*. Cambridge University Press, NY, NY. 2001

National Assessment Synthesis Team. 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. US Global Change research Program, Washington, DC. (available online at: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm)

New England Regional Assessment Group. 2001. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. New England Regional Overview. US Global Change research Program, 96 pp., Univesity of New Hampshire (available online at: http://www.necci.sr.unh.edu/2001-NERA-report.html)

(2) Hodgkins, G A, R. W. Dudley, and T. G. Huntington (2003) Changes in the timing of high river flows in New England over the 20th century. *Journal of Hydrology* 278:244 - 252.

Hodgkins, G A, R. W. Dudley, and T. G. Huntington (2005) Changes in the number and timing of ice-affected flow days on New England rivers, 1930-2000. *Climatic Change* 71, 217-236.

Huntington, T. G., G. A. Hodgkins, B. D. Keim, R.W. Dudley, 2004. Changes in the proportion of precipitation occurring as snow in New England (1949 to 2000), *Journal of Climate* 17:2626-2636.

Keim, B.D., Wilson, A.M., Wake, C.P. and Huntington, T.G. (2003) Are there spurious temperature trends in the United States Climate Division database? A New England example. *Geophys. Res. Lett.*, 30(7), 1404, doi:10.1029/2002GL016295.

Keim, B.D., Fischer, R.F., and Wilson, A.M. (2005) Are there spurious precipitation trends in the United States Climate Division database? *Geophys. Res. Lett. 32*, L04702, doi:10.1029/2004GL021985.

Trombulak, S. C., and R. Wolfson (2004) Twentieth-century climate change in New England and New York, USA, Geophys. Res. Lett., 31, L19202, doi:10.1029/2004GL020574.

Wolfe, D.W., M.D. Schwartz, A.N. Lakso, Y. Otsuki, R.M. Poole, N.J. Shaulis (2005) Climate change and shifts in spring phenology of three horticultural woody perennials in the northeastern United States. International Journal of Biometeorology 49, 303-309, doi: 10.1007/s00484-004-0248-9

(3) Markham, A. and C. Wake (2005) Indicators of Climate Change in the Northeast – 2005. Clean Air – Cool Planet, Portsmouth, NH. (http://cleanair-coolplanet.org/)

(4) Goss, Laurence. 2004. The Impact of Spending by Snowmobiliers on New Hampshire's Economy During the 2002-03 Season. Plymouth, NH: Institute for New Hampshire Studies, Plymouth State University.

Goss, Laurence.2005. New Hampshire Fiscal Year 2004 Tourism Satellite Account. Plymouth, NH: Institute for New Hampshire Studies, Plymouth State University.

Goss, Laurence. 2005. The New Hampshire Ski Industry, 2003-2004: Its Contribution to the State's Economy. Plymouth, NH: Institute for New Hampshire Studies, Plymouth State University, (Unpublished).

(5) From Institute for New Hampshire Studies at Plymouth State University visitor surveys conducted during the winter of 2003-4.

National Ski Areas Association. Kottke National End of Season Survey 2005/06 Final Report. July 2006.

(6) Hamilton, L.C., D.E. Rohall, C. Brown, G. Hayward, and B.D. Keim. 2003. Warming winters and New Hampshire's lost ski areas: An Integrated Case Study. *International Journal of Sociology and Social Policy* 23: 52-73.

Palm, B. (2001) Skiing with Climate Change: An Analysis of Climate Change and the Consequences for the Ski Industry in New Hampshire and Vermont. MSc Thesis, Oxford University, Oxford, U.K.

(7) Hayhoe, K., C.P. Wake, J. Bradbury, T. Huntington, L. Luo, M.D. Swartz, J. Sheffields, B. Anderson, A. DeGaetano, D. Wolfe and E. Wood (2006) Past and future changes in climate and hydrological indicators in the U.S. Northeast. *Climate Dynamics*, in press.

Hayhoe, K., C. Wake, B. Anderson, J. Bradbury, A. DeGaetano, A. Hertel, X.-Z. Liang, E. Maurer,

D.Wuebbles and J.Zhu, (2006) Quantifying the Regional Impacts of Global Climate Change: Evaluating AOGCM Simulations of Past and Future Trends in Temperature, Precipitation, and Atmospheric Circulation in the Northeast U.S. *Bulletin of the American Meteorological Society*, in review.

(8) Northeast Climate Impacts Assessment (2006) Climate Change in the U.S. Northeast. Union of Concerned Scientists. http://www.climatechoices.com

9. The Authors

Elizabeth Burakowski is a master's candidate at the University of New Hampshire, working in the Climate Change Research Center researching changes in winter time climate in the Northeast. She holds a bachelor's in geology from Wellesley College, and served as assistant scientist aboard the sailing school vessels for the Sea Education Association (SEA) before coming to UNH, where she has served as outreach coordinator for the NOAA-funded AIRMAP program, and as a graduate teaching assistant for *Global Environmental Change.* Burakowski was also responsible for compiling and analyzing data for *Cross Border Indicators of Climate Change over the Past Century: Northeastern United States and Canadian Maritime Region*, prepared for the Gulf of Maine Council on the Marine Environment.

She a naturalist for the Seacoast Science Center in Rye, NH.

Laurence Goss is a professor at the Department of Geography at Salem State College. For the past 16 years, he has been an adjunct professor for tourism research at the Institute for New Hampshire Studies at Plymouth State University. Prior to that, he was the program manager for the Coastal Zone Management Program and the Community Development Block Grant Program at the New Hampshire Office of State Planning and also headed up the economic development planning program for the state government.

Goss holds a PhD and MA in geography from the University of Washington at Seattle and an AB degree in geography from Dartmouth College, where he returned from Seattle to serve as an administrator of the Environmental Studies Program and a lecturer. He then became an assistant professor and chair of the Geography Department at SUNY Oswego where he was on the SUNY Sea Grant Advisory Committee for Lake Ontario and a consultant to the Tug Hill Regional Commission before again returning to New Hampshire to serve in state government.

Cameron Wake researches global climate and environmental change. He reconstructs climate change in the past through the collection and analysis of ice cores from around the world. Over the past 20 years, he has been involved in research expeditions to Nepal, China, Pakistan, Kyrgyzstan, the Canadian Arctic, Greenland, and Antarctica. Currently he is leading research programs to develop ice core records from glaciers on the Tibetan Plateau and in the Canadian Arctic. Wake is also involved in the NOAA-funded AIRMAP (Atmospheric Investigation, Regional Modeling, Analysis and Prediction) project, which seeks to improve understanding of New England's changing climate and air quality. In addition he leads a team that is investigating the links between air quality and human health in New England.

Dr. Wake received a B.Sc. in Geology (1984) from the University of Ottawa, an M.A. in Geography (1987) from Wilfrid Laurier University, and a Ph.D. in Geochemical Systems (1993) from the University of New Hampshire.

In addition to climate research at UNH, Dr. Wake serves on the board of the Kittery Land Trust and Seacoast Area Bicycle Routes, is an avid photographer, and spends his weekends living off the grid in a yurt in the mountains of western Maine.

Carbon CO_2alition

New Hampshire Citizens for a Responsible Energy Policy

www.carboncoalition.org

CLEAN AIR COOL PLANET

Finding and promoting solutions to global warming

www.cleanair-coolplanet.org

100 Market Street, Suite 204, Portsmouth, NH 03824