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Climate Impacts on the Winter Tourism Economy in the United States

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About the Authors

Protect Our Winters (POW) and Natural Resources Defense Council (NRDC) contracted with Elizabeth Burakowski and Matthew Magnusson from the University of New Hampshire to independently examine the economic impacts of the winter tourism industry.

Elizabeth Burakowski is a Ph.D. candidate in the University of New Hampshire's interdisciplinary Natural Resources and Earth Systems Science program. This study builds on her existing work in measuring and modeling winter weather and climate. She drew on experience she gained from her 2008 peer-reviewed work "Trends in wintertime climate in the northeastern United States: 1965–2005," published in the *Journal of Geophysical Research;* the 2006 Clean Air-Cool Planet report, "Winter Recreation and Climate Variability in New Hampshire: 1984–2006"; and climate impact assessments for the Casco Bay watershed in Maine (2009) and the Great Bay watershed in New Hampshire (2011).

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About NRDC

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Livingston, and Beijing. Visit us at www.nrdc.org and follow us on Twitter @NRDC.

NRDC's policy publications aim to inform and influence solutions to the world's most pressing environmental and public health issues. For additional policy content, visit our online policy portal at www.nrdc.org/policy.

About POW

Protect Our Winters is the environmental center point of the winter sports community, united together towards a common goal of reducing climate change's effects on our sport and mountain economies. Founded in 2007, POW re-invests contributions in educational initiatives, activism and supporting community-based initiatives.

For more information, visit http://protectourwinters.org/. Stay in touch on Facebook at: http://www.facebook.com/protectourwinters

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EXECUTIVE SUMMARY

We have all witnessed the extreme weather events in recent years, —often in our own backyards. Extreme weather has damaged homes and ended lives. For the winter season there have been all-or-nothing winters—blizzards in some places, only a dusting all season-long in others. These radically divergent weather patterns have been unsettling to those who mark the seasons' change in the great outdoors. For those whose livelihood depends upon a predictable winter season, such unpredictability and lack of snow can translate into a precipitous fall in revenue, an early economic indicator of what climate change looks like.

In the many U.S. states that rely on winter tourism, snow is currency and climate change is expected to contribute to warmer winters, reduced snowfall, and shorter snow seasons. This spells economic devastation for a winter sports industry deeply dependent upon predictable, heavy snowfall. The estimated $12.2 billion dollar U.S. winter tourism industry, as analyzed in this report, has already felt the direct impact of decreased winter snowpack and rising average winter temperatures. Across the United States, winter temperatures have warmed 0.16 degrees Fahrenheit per decade since 1895 the rate of warming has more than tripled to 0.55 degrees Fahrenheit per decade since 1970. Furthermore, the strongest winter warming trends have occurred in the northern half of the United States, where snow plays an important economic role in their winter season (Figure 1).[1]

All of this translates into less snow and fewer people on the slopes. December 2011 through February 2012 was the fourth warmest winter on record since 1896 and the third lowest snow cover extent since 1966, when satellites began tracking snow cover.[2,3] The National Ski Areas Association (NSAA) reported for the 2011-12 ski season, the ski resort industry "experienced its most challenging season since 1991–92."[4] According to NSAA's Kottke End of Season Survey, 50 percent of responding ski areas opened late and 48 percent closed early, with every region experiencing a decrease in overall days of operation.

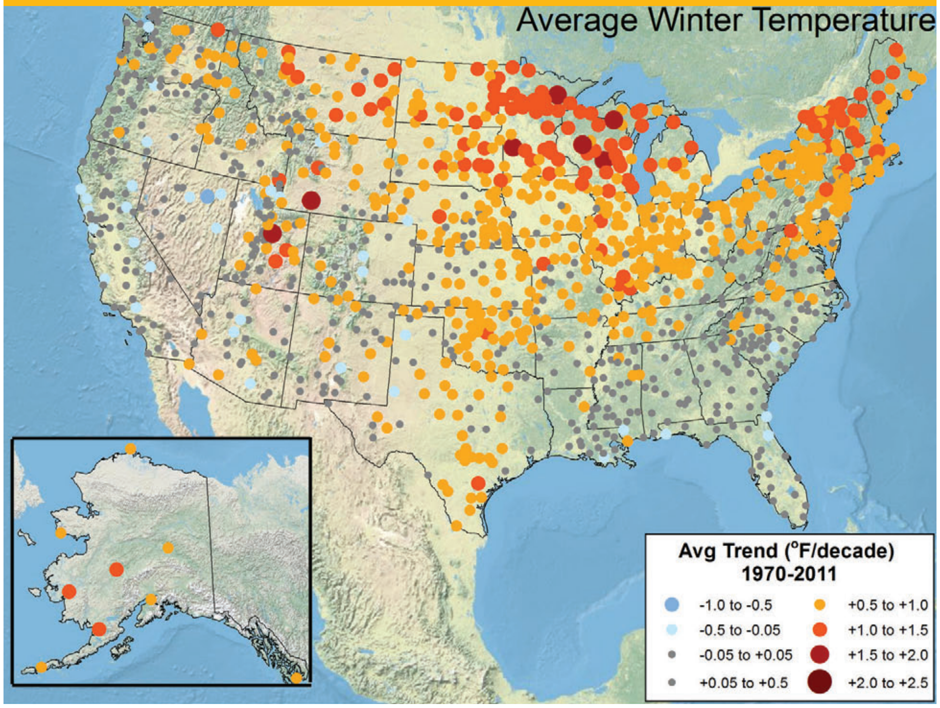
By the 2009-10 ski season, 88 percent of resorts belonging to the National Ski Areas Association were also using snowmaking to supplement natural snow cover.[5] Snowmaking keeps resorts in business over low-precipitation winters but comes at a $500,000 expense annually and consumes up to 50 percent of resort energy costs. And, as the weather warms over time, the process of snowmaking will become increasingly challenging. The snowmobiling industry—one entirely reliant upon natural snow—has had relatively flat registrations since 2000.[6]

According to this research conducted for the Natural Resources Defense Council (NRDC) and Protect Our Winters (POW), climate change spells trouble for all businesses dependent on winter weather from snowmobiling, snowboarding, and ice fishing to snowshoeing and skiing. The shrinking numbers of winter sports tourists also affect restaurants, lodging, gas stations, grocery stores, and bars.[7] This study aims to help policy makers understand both the ski and snowmobile industry's current economic scale as well as the potential economic impacts that climate change may cause.

Using industry data collected in 2009-10 the analysis in this report provides a national picture of the economic scale of the winter tourism industry. Some highlights of the 2009-10 numbers include:

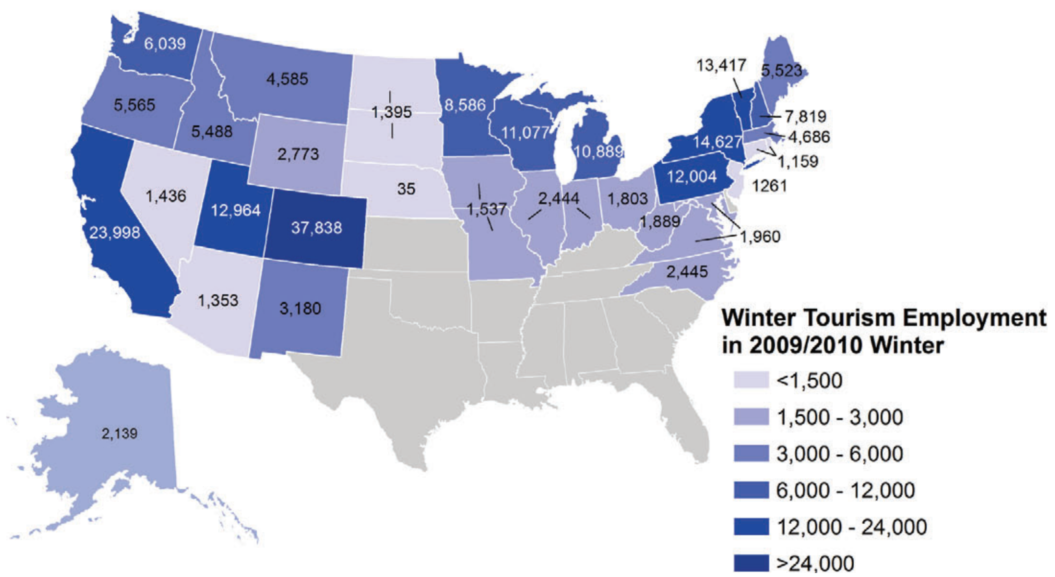
- More than 23 million people[8] participated in winter sporting activities (measured through visits to downhill ski resorts and snowmobiling), adding an estimated $12.2 billion in economic value to the U.S. economy, through spending at ski resorts, hotels, restaurants, bars, grocery stores, and gas stations.
- Some 38 states experienced added value to their economies from downhill ski and snowboard visits, and snowmobiling trips.
- With 59.8 million skier and snowboarder visits[9] and an estimated 14.5 million snowmobile trips[10] in 2009-10, this analysis found that winter sport activities supported 211,900 jobs earning a total of $7.0 billion in salaries, wages, and benefits (figure 2)[11]. In turn, this economic activity resulted in $1.4 billion in state and local taxes and $1.7 billion in federal taxes.
- Resort operations contributed the greatest amount of employment and value added to the economy, with 75,900 employed (36 percent of total winter tourism-related employment) and $2.9 billion in added economic

Figure 1: Winter Temperature Trends, 1970–2011



Data analysis performed for NRDC/POW by Burakowski et al. (in prep)[20]

Figure 2. Employment Supported by Winter Tourism in 2009/2010



Data analysis performed using IMpact analysis for PLANning (IMPLAN) economic model (MIG, Inc). See Appendix for more details on methodology.

value (23 percent of total winter-tourism-related economic value added). Dining (in bars and restaurants) was the second biggest source of income, contributing 31,600 jobs (15 percent of total winter tourism-related employment) and $942 million in added economic value (8 percent of total economic value added).

The study also analyzes how historical changes in the winter season have already impacted the ski tourism industry with a focus on the most recent decade's skiing statistics and a review of the historical winter climate observations. The study finds a significant difference in skier visits between lower and higher snowfall winters in nearly all states with a ski industry (Figure 3).[12] Key findings include:

- The downhill ski resort industry is estimated to have lost $1.07 billion in aggregated revenue between low and high snow fall years over the last decade (November 1999 - April 2010).
- The resulting employment impact is a loss of between 13,000 to 27,000 jobs (6 to 13 percent employment change), with the 6 percent jobs difference corresponding to over 15 million fewer skier visits.
- The largest changes in the estimated number of skier visits between high and low snowfall years (over 1 million) occurred in: Colorado (-7.7 percent), Washington (-28 percent), Wisconsin (-36 percent), California (-4.7 percent) , Utah (-14 percent), and Oregon (-31 percent). The resulting difference in economic value added to the state economy ranged from -$117 million to -$38 million.
- In the Eastern region of the U.S. the states with the largest estimated changes in skier visits between low and high snowfall years were: Vermont (-9.5 percent), Pennsylvania (-12 percent), New Hampshire (-17 percent), and New York (-10 percent). The resulting difference in economic value added to the state economy ranged from -$51 million to -$40 million.

The economic magnitude (in terms of employment and economic value added) of the national winter tourism industry was determined by estimating the number of ski and snowmobile trips taken at the state level and the average expenditures per trip in 2009-2010. National expenditure estimates were then developed in order to draw the overall economic impact of the winter tourism industry (from a trip-based perspective). In order to better understand the service sector contribution (e.g., ski facilities, hotels, restaurants, gas stations), a discussion of direct, indirect and induced economic impacts is provided. The analytical methods were applied to compare the differences in winter tourism economic activity during lower-snowfall seasons to higher-snowfall seasons from 2000 to 2010. The methodology is explained fully in Appendix I.

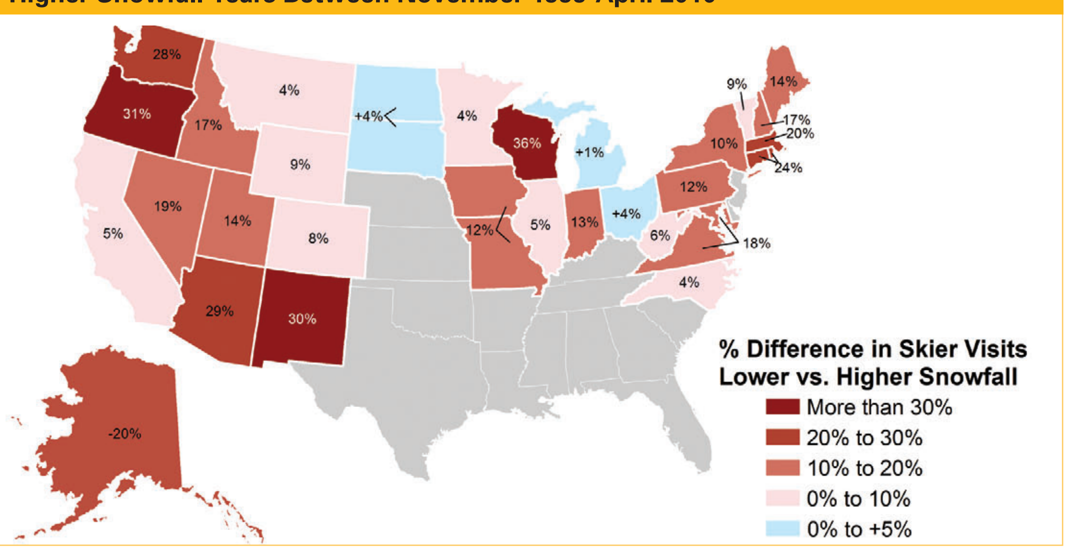
The future winter climate projections are evaluated, using lower- and higher-emission scenarios that incorporate assumptions about population, energy use, and technology through the end of the century.[12] Lower-emissions scenarios are associated with a slowing of greenhouse gas accumulation in the atmosphere, while higher-emissions scenarios correspond to increased rates of greenhouse gas emissions.

Finally, the report presents five statewide case studies, for Colorado, Montana, New Mexico, New Hampshire, and Pennsylvania (appendix III).

Surmised from all this data is a portrait of the American winter landscape with more than three-quarters of states benefitting economically from these winter sports and 211,900 jobs either directly or indirectly supported by the industry. The ramifications of changing snow fall patterns are already altering people's outdoor habits—taking an economic toll on the ski resort industry of over $1 billion in the last decade.

Without intervention, winter temperatures are projected to warm an additional 4 to 10 degrees Fahrenheit by the end of the century, with subsequent decreases in snow cover area, snowfall, and shorter snow season.[13] Snow depths could decline in the west by 25 to 100 percent.[14] The length of the snow season in the northeast will be cut in half.[15] In order to protect winter—and the hundreds of thousands whose livelihoods depend upon a snow-filled season—we must act now to support policies that protect our climate, and in turn, our slopes.

Figure 3. Average Difference in Skier Visits for Lower-Snowfall Years Compared to Higher-Snowfall Years Between November 1999-April 2010



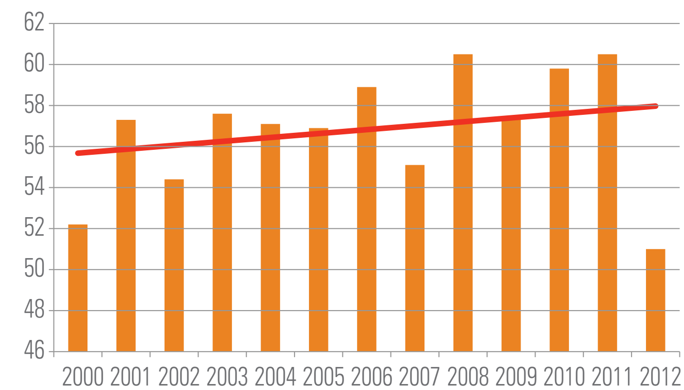
I. BACKGROUND

Previous studies have found that the winter sports industry contributes significantly to the U.S. economy. A study by Southwick Associates found that 16 million Americans participated in recreational snow sports (defined as downhill, telemark, and nordic skiing; snowboarding; and snowshoeing), generating more than 560,000 jobs and $8.8 billion in federal and state taxes.[16] In addition, the International Snowmobile Manufacturers Association estimates that the snowmobiling industry contributes 70,000 jobs in U.S. manufacturing, retail, and tourism-related business, and more than $400 million in U.S. retail sales.[17]

Unfortunately, climate change is expected to have severe negative impacts on the winter tourism industry, as states around the country experience less snowfall and rising temperatures. Historical winter warming trends are prevalent across the United States. The proportion of total winter precipitation is falling as snow has decreased in the northeastern and western United States, with concurrent decreases in snowpack in both regions.[18] In the western US, snowfall and snow cover is decreasing most rapidly at lower elevations.[19] In the United States, December through February average winter temperatures have increased by 2.2°F since 1970, with the strongest warming trends occurring in the northern regions of the country and in minimum nighttime temperatures (Figure 6).[20]

While there has been an overall slight increase (as indicated by the trend line in Figure 4) in skier visits since

Figure 4: National Skier Visits for the Winter Ski Seasons, 2000 to 2012 (millions)



Source: National Ski Areas Association (Kottke National End of Season Surveys, 1999–2010)

2000, the significant decline observed in the 2002 (November 2001 through April 2002) ski season relative to the previous winter coincided with low snowfall in Colorado and across the northeastern United States. In the 2007 (November 2006 through April 2007) ski season, low snowfall in Tahoe, the northeastern United States, and northern Rockies was likely a strong contributor to the dip of 4 million skier visits relative to the previous winter. And there was a sharp decline in 2012 (November 2011 through April 2012) from previous years of around 9 million skier visits due to the extremely low snowfall ski season we just experienced across the country. The economic recessions that occurred in the United States during March 2001 through November 2001, and December 2007 through June 2009 did not coincide directly with the steep declines in skier visits, suggesting that decreased snowfall was the dominant contributor to changes in skier visits.[21] (As such, this study did not explicitly consider economic conditions when evaluating changes in skier visits.)

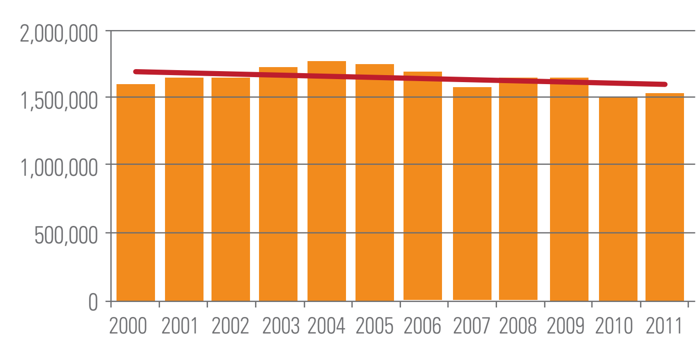
Between 2000 and 2011 snowmobile registrations peaked at 1.77 million in 2004 and have been in a slightly downward trend since that time with 1.55 million national snowmobile registrations in 2010/2011 (Figure 5). Climate change is a major concern for the snowmobile industry, which depends exclusively on natural snow and is therefore more vulnerable to decreases in snow cover, unlike ski resorts which have the ability to make snow. Consecutive years with low snow cover may be a contributing factor to an observed decline in snowmobile registrations between 2000 and 2011.

The magnitude of future warming and impacts on snow will vary depending on the region and future greenhouse gas emissions scenario. But, in general, temperatures will continue to warm in the future, with higher emissions scenarios leading to greater warming than lower emissions scenarios:

- **New York and New England**: Snow cover is projected to decrease substantially in response to warmer temperatures, reducing the average number of days with snow cover by 50% under a lower emissions scenario, and by 75% under a higher emissions scenario.[22]
- **Cascades and the Sierra Nevada:** Snowpack is projected to decrease between 40 percent and 70 percent by 2050 in response to warmer winters under higher-emissions scenarios.[23]
- **Alaska:** Average annual temperatures are projected to warm an additional 8°F under lower emissions, and up to 13°F under higher emissions, increasing the length of the snow-free season over the next century.[24]
- **Southwestern United States and Central Rocky Mountains**: Decreases in winter snowpack, shortened snow seasons, and increases in wet-snow avalanches will affect ski resorts.[25] Under a higher-emissions scenario, Rocky Mountain mean snow depth in winter (Dec-Apr) is expected to drop to zero.[14]

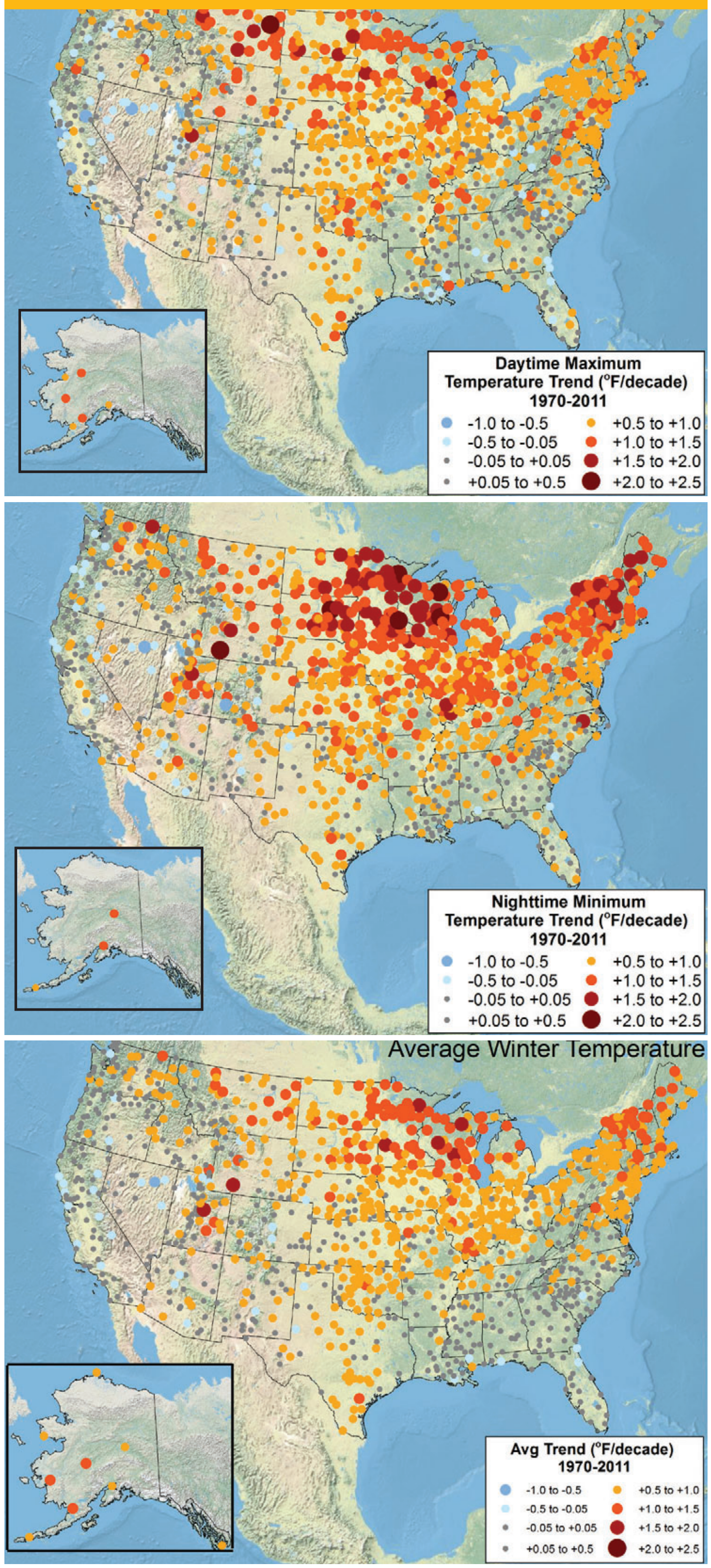
In response to already warming temperatures and lower snowfall, snowmaking and enhanced programming (e.g., mountain biking, hiking, canopy tours, conferences, and events) in fall and summer have helped to insulate ski-resort profit margins from the impacts of snow variability. Eighty-eight percent of U.S. ski resorts participating in the National Ski Areas Association (NSAA) annual survey for the 2009/2012 snow season indicated that they were using snowmaking to supplement natural snow cover. Snowmaking, however, is expensive, carrying an annual

Figure 5: National Snowmobile Registrations, 2000 to 2011



Source: International Snowmobile Manufacturers Association, unpublished data provided by Ed Klim at ISMA on Feb. 21, 2012.

Figure 6. Winter* Nighttime Minimum Temperature Trends Outpace Warming of Daytime Maximum Trends



Source: United States Historical Climatology Network (USHCN).[20]

*Winter is defined as December through February

A study on Northeastern U.S. ski resorts estimates that only four out of 14 major ski resorts will remain profitable by 2100 under a higher-emissions scenario.[19]

price tag of $500,000 or more, and consuming consuming up to 50 percent of resort energy costs.[16]

Even with snowmaking capabilities, many resorts suffer from "backyard syndrome," namely the fact that urban skiers will not get out on the slopes unless they see snow in their own backyards.[26] Furthermore, nighttime temperatures must be cold enough to allow for snowmaking. With nighttime minimum temperatures warming at a faster rate than daytime maximum temperatures (Figure 6), it is uncertain as to what extent snowmaking will last as an adaptation strategy.[27]

The continuation of observed warming trends at night documented here would limit snowmaking capabilities at ski resorts and place limits on the profitability of the winter tourism industry as a whole. However, the Intergovernmental Panel on Climate Change Fourth Assessment Report projects stronger increases in daytime maximum temperature than nighttime minimum temperature through the end of the century.[1] A comprehensive study on northeastern U.S. ski resorts estimates that only four out of 14 major ski resorts will remain profitable by 2100 under a higher-emissions scenario, and a reliable snowmobile season (more than 50 days of natural snow cover) will be completely eliminated. A detailed study on the future of western US resorts indicates that Park City, Utah will lose all mountain snow pack by the end the century while Aspen Mountain, Colorado snowpack will be confined to the top quarter of the mountain under a higher emissions scenario.[25]

Uncertainty remains in quantifying the future economic impact of winter climate variability on the ski and snowmobile industry under lower and higher emissions scenarios . While previous studies predict warmer winter temperatures, decreases in the length of the snow season and snowpack, and more precipitation coming in the form of rain instead of snow, there have been few attempts to estimate the economic impact of such climate variability on the ski industry.

This report uses economic modeling to assess the potential impacts from climate change, using the IMPLAN 3.0 model (2010 data), a regional input-output economic analysis, which calculates employment, wages and benefits, and overall value added to the economy. (See Appendix I for a full discussion of the methodology). It documents the overall size of the U.S. winter tourism industry and provides an estimate of the national and state economic impact on the industry from low snowfall as compared to high snowfall conditions between November 1999 through April 2010.

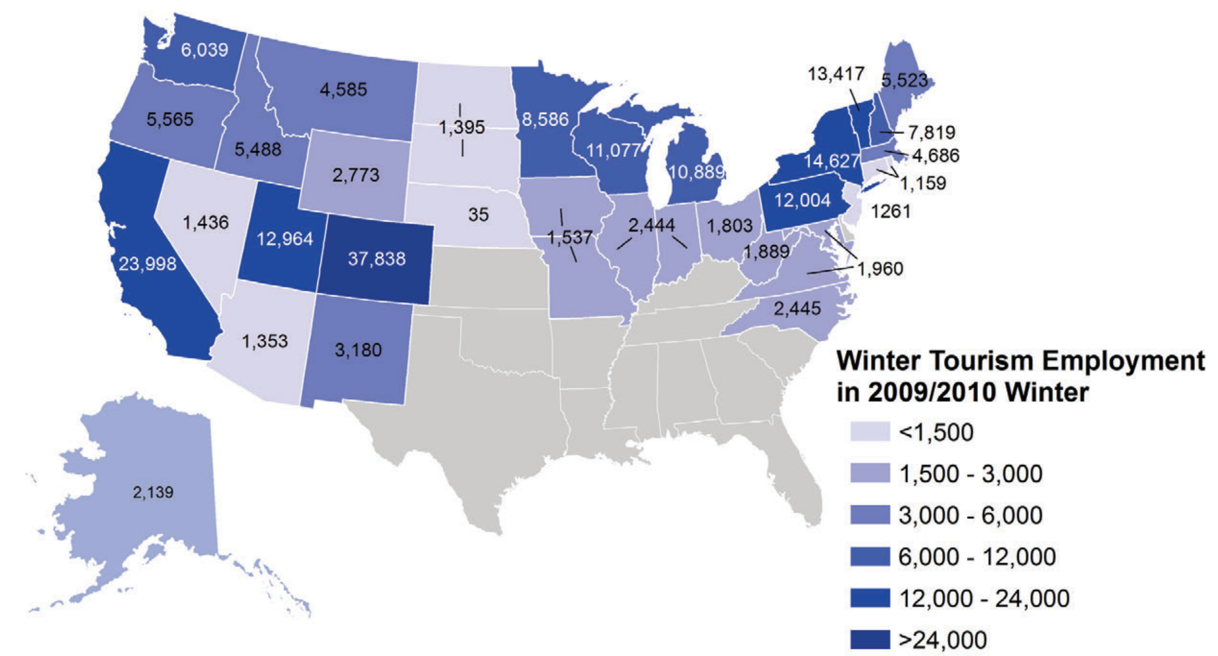
II. KEY FINDINGS

TOTAL CONTRIBUTION OF WINTER TOURISM INDUSTRY TO NATIONAL ECONOMY

In 2009/2010, more than 23 million people participated in winter sporting activities as measured through visits to downhill ski resorts and snowmobiling, adding $12.2 billion in economic value to the U.S. economy. Thirty-eight states had value added to their economies from downhill ski resorts or snowmobiling trip visits. With 59.8 million skiing visits and an estimated 14.5 million snowmobile day-trips, these winter sport activities supported the employment of 211,900 and generated a total of $7.0 billion in wages (see Table 1 and Figure 7). This economic activity resulted in $1.4 billion in state and local taxes and $1.7 billion in federal taxes.

Downhill skiing and snowboarding were the predominant

Figure 7. Employment Supported by Winter Tourism in 2009/2010

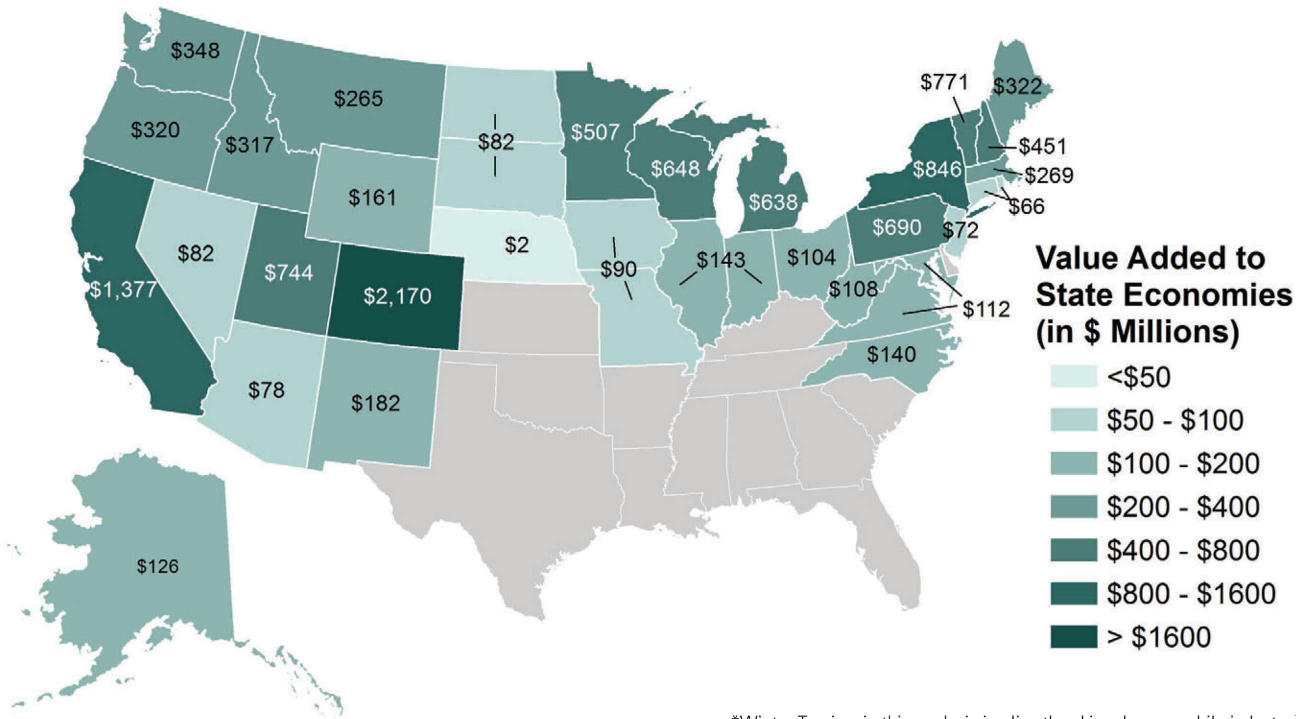


Data analysis performed using IMpact analysis for PLANning (IMPLAN) economic model (MIG, Inc). See Appendix for more details on methodology.

Table 1: National Economic Impacts from Winter Tourism Activities in 2009/2010 by Winter Activity

Skiing / Snowboarding	EMPLOYMENT (thousands)	187.9
	LABOR INCOME ($ billions)	6.1
	VALUE ADDED ($ billions)	10.7
Snowmobiling	EMPLOYMENT (thousands)	24.0
	LABOR INCOME ($ billions)	0.9
	VALUE ADDED ($ billions)	1.5
TOTAL	EMPLOYMENT	211.9 THOUSAND
	LABOR INCOME	$7.0 BILLION
	VALUE ADDED	$12.2 BILLION

Figure 8: Value Added to State Economies ($ Millions) by Winter Tourism Industry 2009/2010*



*Winter Tourism in this analysis implies the ski and snowmobile industry.[7]

economic winter activities, accounting for 187,900 employees and $10.7 billion in value added to the national economy. Snowmobiling accounted for 24,000 employees and $1.5 billion in value added to the economy. Table 4 and Figure 8 show the value added to state economies by the ski and snowmobile industry in 2010 using the proportional weighting methodology as described in Appendix I.

Direct economic activities contributed approximately 125,000 jobs and added $4.9 billion in economic activity to the national economy through expenditures by skiers or snowmobilers at hotels, resorts, restaurants, bars, grocery stores, and gas stations (Table 2). Indirect winter tourism economic activity provided 32,000 jobs and added $2.9 billion in value to the economy. This included activity in wholesale trade, manufacturing, and professional services, providing goods and services to industries directly involved in winter sports tourism. An additional 55,000 jobs and $4.4 billion in added value to the national economy was attributed to expenditures by employees from direct and indirect industries on personal consumption, including the payment of bills, the provision of health care, and the purchase of groceries.

Winter sports tourism is also a significant contributor to local, state, and federal tax revenue.

In 2009/2010, state and local governments received $1.4 billion from the employment and economic activity created by winter tourism, while the federal government received $1.7 billion.

As shown in table 3, ski resort operations contributed the most to winter tourism employment and value added to the overall economy, with 75,900 employed (36 percent of total winter tourism employment) and $2.8 billion in added economic value (23 percent of total economic value added)

Table 2: National Economic Impacts from Winter Tourism Activities in 2009/2010 by Type of Impact			
	Impact Type Employment (thousands)	**Labor Income ($ billions)**	**Value Added ($ billions)**
Direct Effect	125.3	$2.7	$4.9
Indirect Effect	31.4	$1.7	$2.9
Induced Effect	55.2	$2.5	$4.4
Total Effect	**211.9**	**$7.0**	**$12.2**

Table 3: National Economic Impact in the Top 10 Industries by Employment in 2009/2010			
Industry	**Winter Tourism Employment (thousands)**	**Labor Income ($millions)**	**Value Added ($ millions)**
Resort operations	75.9	$1,495.8	$2,851.5
Dining (bars and restaurants)	31.6	$612.6	$941.5
Accommodations	17.6	$558.9	$1,035.1
Professional services	8.4	$659.0	$779.8
Administrative support services	8.0	$257.8	$296.1
Food & beverage stores	5.2	$148.7	$214.7
Government	4.6	$307.9	$358.7
General merchandise stores	4.3	$113.3	$176.5
Real estate	4.2	$74.3	$1,157.3
Health care	3.6	$239.8	$255.6

in 2009/2010. Dining (bars and restaurants) was the second greatest contributor to the economy, with 31,600 employed (15 percent of total winter tourism employment) and $940 million in added economic value (8 percent of total economic value added).

Our estimates show that Colorado was the state that benefited most from winter sports tourism, with 37,800 employed, generating $2.2 billion in total economic value added. California had the next highest level of economic activity, with 24,000 employed and $1.4 billion in economic value added. New York and Vermont led the eastern United States in winter tourism economic activity, collectively supporting 28,044 employees and generating more than $1.6 billion in value added to their economies.

Table 4: Estimated State Contributions from Winter Tourism 2009/2010					
State	**Skier Visits**	**Snowmobile Days**	**Employment**	**Labor Income ($ millions)**	**Value Added ($ millions)**
Colorado	11,881,889	304,961	37,838	$1,240.6	$2,170.4
California	7,523,916	216,061	23,998	$787.0	$1,376.7
NewYork	3,985,053	1,269,241	14,627	$485.2	$845.8
Vermont	4,106,246	310,900	13,417	$440.9	$770.8
Utah	4,018,731	203,221	12,964	$425.5	$744.2
Pennsylvania	3,611,237	396,358	12,004	$395.0	$690.3
Wisconsin	2,374,208	2,180,105	11,077	$373.4	$647.7
Michigan	2,193,927	2,408,544	10,889	$368.4	$638.3
Minnesota	1,426,294	2,473,653	8,586	$293.3	$506.7
NewHampshire	2,223,783	501,280	7,819	$258.5	$451.1
Washington	1,761,851	303,371	6,039	$199.3	$347.9
Oregon	1,688,102	157,691	5,565	$183.0	$319.9
Maine	1,314,849	838,680	5,523	$185.0	$321.5
Idaho	1,516,837	435,130	5,488	$181.8	$317.1
Massachusetts	1,411,717	150,731	4,686	$154.2	$269.4
Montana	1,257,440	382,515	4,585	$152.0	$265.1
NewMexico	1,012,003	0	3,180	$104.1	$182.2
Wyoming	690,811	363,428	2,773	$92.6	$161.1
Alabama/NorthCarolina/ Tennessee	778,134	0	2,445	$80.1	$140.1
Illinois/Indiana	537,124	455,721	2,444	$82.3	$142.8
Alaska	402,948	526,344	2,139	$72.6	$125.7
Maryland/Virginia	623,770	0	1,960	$64.2	$112.3
WestVirginia	601,299	0	1,889	$61.9	$108.3
Ohio	548,795	47,236	1,803	$59.3	$103.6
Iowa/Missouri	332,416	296,893	1,537	$51.8	$89.8
Nevada	457,058	0	1,436	$47.0	$82.3
North/SouthDakota	305,695	261,823	1,395	$47.0	$81.5
Arizona	430,508	0	1,353	$44.3	$77.5
NewJersey	401,392	0	1,261	$41.3	$72.3
Connecticut/RhodeIsland	368,967	0	1,159	$38.0	$66.4
Nebraska	0	21,208	35	$1.3	$2.1
Total	**59,787,000**	**14,505,096**	**211,911**	**$7,010**	**$12,231**

SKI INDUSTRY IMPACTS OF LOWER VS. HIGHER SNOWFALL

While the previous section analyzed the national scale of the ski and snowmobile industry in 2009 - 2010, and what is thus at stake from future climate change, in this section we look at the differences in employment at ski resorts, and the indirect and induced employment, between high and low snowfall years over the last decade. This gives us an appreciation for the impacts on the ski industry from reduced snowfall and what to expect in future years from a warming climate. See Appendix I for definitions and details of the methodology.

Analyzing the winter snowfall data across the U.S. from November 1999 to April 2010 the analysis finds that lower-snowfall winters were associated with fewer skier visits in nearly all states with a significant ski industry, compared to higher-snowfall years in those states (Figure 9 and Table 7). Only four states (the Dakotas, Michigan, and Ohio) recorded increases in skier visits during low-snowfall compared to higher snowfall years.

The total revenue difference between high- and low-snow years for the downhill ski resort industry aggregated was estimated to be $1.07 billion over the past decade (Table 5). The $1.07 billion difference in revenue applied to the IMPLAN model suggested a total employment loss of 13,000 to 27,000 (6 percent to 13 percent), as indicated in table 5. In the IMPLAN model, household expenditures were allocated to households with incomes ranging between $75,000 and $100,000, based on the average household income obtained from recent survey data.[28] The loss of the lower bound 13,000 jobs assumes that the approximate $1.07 billion was spent on other household expenditures in the economy (a realistic assumption). Job losses occurred even though skiers spent their money elsewhere in the economy, as the winter tourism industry is service-based and domestic, while expenditures in the wider economy can include a significant number of purchases of goods originating from outside the United States. The loss of the upper bound of 27,000 jobs assumes that the money that would have been spent in the winter tourism industry was not spent in the national economy. Furthermore, based on the IMPLAN results, a low-snowfall year is expected to reduce national economic value added at a level between $810 million and $1.9 billion (Table 6).

REGIONAL IMPACTS ON THE SKI INDUSTRY

The employment impact of lower snow years compared to higher snow years calculated using IMPLAN found a national difference in winter ski tourism employment ranging from 6 to 13 percent based upon the difference in skier visits averaged for the state's 2 lowest versus 2 highest snowfall years between 2000 and 2010 (Table 5 and Appendix I). Taking the more conservative 6 percent difference, which

Figure 9. Average Difference in Skier Visits for Lower-Snowfall Years Compared to Higher-Snowfall Years, November 1999–April 2010

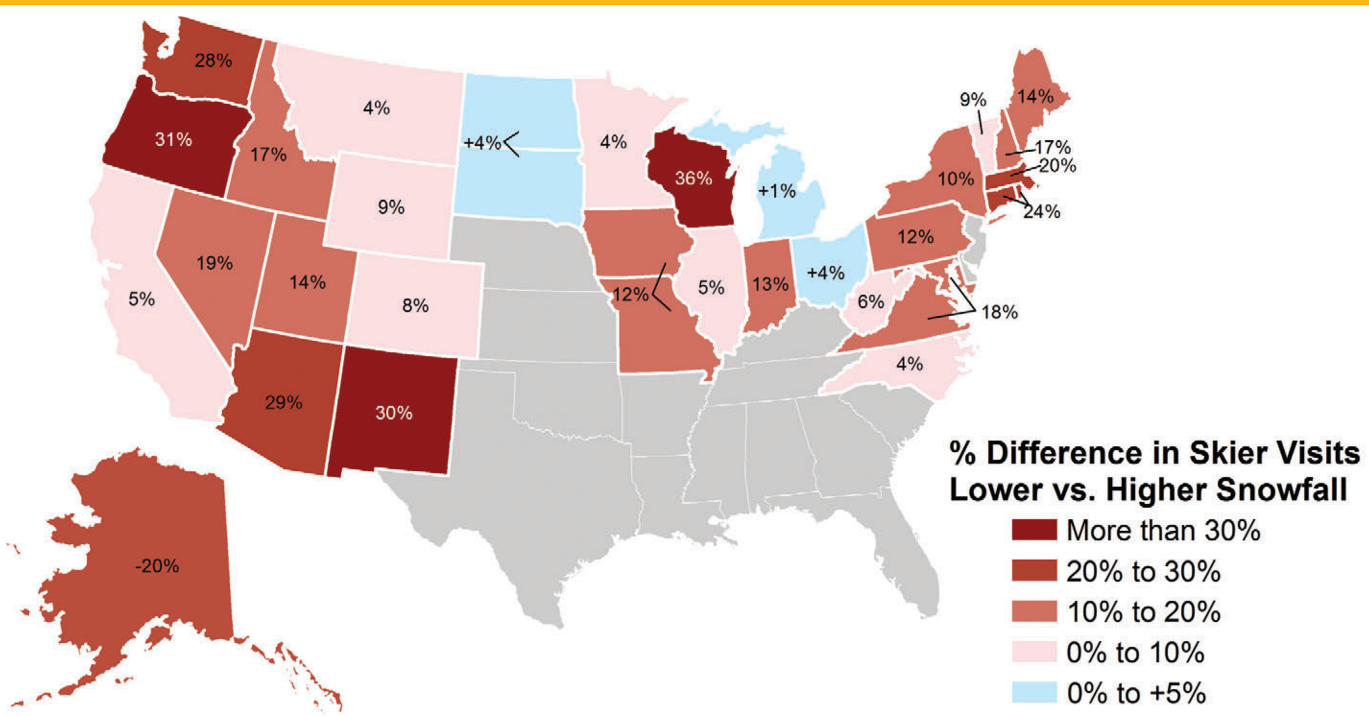


Table 5: IMPLAN Model Projections of National Employment Difference, Good Snow Year vs. Bad Snow Year					
		With Replacement Consumer Spending		Without Replacement Consumer Spending	
	2010 Employment	Employment Difference (# of jobs)	Percent Change	Employment Difference (# of jobs)	Percent Change
Direct	125,300	-16,455	-13%	-16,455	-13%
Indirect	31,400	-3,775	-12%	-3,775	-12%
Induced	55,200	7,265	13%	-6,600	-12%
Total	**211,900**	**-12,965**	**-6%**	**-26,830**	**-13%**

Table 6: IMPLAN Model Projections of Difference in National Economic Value Added, Good Snow Year vs. Bad Snow Year					
		With Replacement Consumer Spending		Without Replacement Consumer Spending	
	2010 Value Added ($billions)	Difference in Value Added ($ millions)	Percent Change	Difference in Value Added ($ millions)	Percent Change
Direct Effect	$4.9	$(797.2)	-16%	$(797.2)	-16%
Indirect Effect	$2.9	$(446.9)	-15%	$(446.9)	-15%
Induced Effect	$4.4	$434.3	10%	$(689.6)	-16%
Total Effect	**$12.2**	**$(809.8)**	**-7%**	**$1933.7**	**-16%**

corresponds nationally to 12,965 fewer jobs, over 15 million fewer skier visits, and a loss in ski resort industry revenue of over $1 billion, Table 7 shows the estimated differences for each state's ski industry for lower vs. higher snowfall years.

States in the Pacific Northwest (Washington, Oregon) and the Pacific South (Arizona, New Mexico) experienced the largest differences in skier visits, ranging from 28 percent to 31 percent in lower-snowfall years compared to higher-snowfall years. Lower elevation resorts in these regions receive less snowfall and endure warmer temperatures than higher elevation resorts in the northern Rocky Mountains. Furthermore, the Pacific Northwest and Pacific South have historically invested less money in snowmaking and are therefore much more sensitive to fluctuations in natural snowfall.[5] Future ski industry analyses should evaluate the impact of elevation and snowmaking on the profitability of resorts in the western US.[29] The difference in resort revenue between a high- and low-snowfall year in these ski regions ranged from $7 million in Alaska to $79 million in Washington. California, also included in the Pacific South region, saw an average 5 percent fewer skier visits during low-snowfall years compared to high snowfall years, resulting in a resort revenue difference of nearly $100 million across the state and 1,200 fewer jobs in the local economy.

In the northeast region of the United States, the difference in skier visits between low snowfall years and high snowfall years ranged from 9 percent in skier visits ranged from 9 percent in Vermont to 24 percent in Connecticut and Rhode Island combined. In northern New England (Maine, New Hampshire, Vermont), low snowfall cost the region more than 1,700 jobs, compared to high-snowfall years and $108 million in economic value added to this region. Despite heavy investments in snowmaking, the northeastern United States remained susceptible to fluctuations in natural snowfall.

In terms of lost revenue, Pennsylvania suffered the worst, in the mid-Atlantic region, missing out on more than $67 million in potential resort revenue and over 800 fewer jobs, during low-snowfall years, compared to colder, snowy years. Virginia and Maryland saw a larger percentage difference in skier visits, 19 vs. 12 percent, but the impact on revenue ($17.9 million) was about one-third of Pennsylvania's revenue difference due to the much smaller ski industries in Virginia and Maryland.

The Rocky Mountain region supported the largest number of skier visits in the country, accounting for more than one-third of all U.S skier visits. Colorado led the nation with almost 12 million skier visits per year in 2009-2010 (Table 4). Thus, the 8 percent difference in Colorado skier visits seen for lower snowfall compared to higher snowfall years equated to $154 million in lost revenue and 1,900 fewer jobs. Utah skier visits, which typically are about four million per year, are 14 percent lower during low snowfall years compared to high snowfall years and cost the state $87 million in revenue and over 1000 fewer jobs compared to snowy years. Revenue differences in other Rocky Mountain states ranged from $43.2 million, in Idaho, to $11 million, in Wyoming. The region as a whole including Montana saw a loss in economic value added in the low snow years of $235 million compared to high snowfall years.

Table 7. Difference in Skier Visits, Ski Resort Revenue, and Employment for Low-Snowfall Years Compared to High-Snowfall Years, November 1999–April 2010					
State	**Difference in Skier Visits (%)[29]**	**Avg. Revenue per Skier Visit[5] (09/10–10/11)**	**Difference in Ski Resort Revenue (millions)**	**Difference in Total Employment[30]**	**Difference in Economic Value Added ($ millions)**
Maine	-396,588 (-14%)	$68.42	-$27.1	-329	-$20.5
New Hampshire	-793,088 (-17%)	$68.42	-$54.3	-658	-$41.1
Vermont	-889,264 (-9.5%)	$68.42	-$60.8	-737	-$46.0
Massachusetts	-521,622 (-20%)	$68.42	-$35.7	-433	-$27.0
Connecticut & Rhode Island	-179,919 (-24%)	$68.42	-$12.3	-149	-$9.3
New York	-760,968 (-10%)	$68.42	-$52.1	-632	-$39.5
Pennsylvania	-828,260 (-12%)	$81.65	-$67.6	-820	-$51.2
Virginia & Maryland	-219,306 (-19%)	$81.65	-$17.9	-217	-$13.6
West Virginia	-89,893 (-6.2%)	$81.65	-$7.34	-89	-$5.6
North Carolina	-43,855 (-3.7%)	$81.65	-$3.5	-42	-$2.7
North Dakota & South Dakota	+37,999 (+3.6%)	$64.58	$2.45	30	+$1.9
Minnesota	-138,769 (-4.3%)	$64.58	-$9.00	-109	-$6.8
Wisconsin	-1,583,140 (-36%)	$64.58	-$102	-1237	-$77.3
Michigan	+100,755 (+1.4%)	$64.58	$6.51	79	+$4.9
Illinois	-17,658 (-4.8%)	$64.58	-$1.14	-14	-$0.9
Indiana	-86,856 (-13%)	$64.58	-$5.61	-68	-$4.2
Ohio	+53,196 (+4.3%)	$64.58	$3.44	42	+$2.6
Montana	-195,267 (-4.0%)	$82.59	-$16.1	-188	-$11.7
Wyoming	-133,134 (-9.0%)	$82.59	-$11.0	-133	-$8.3
Colorado	-1,864,477 (-7.7%)	$82.59	-$154	-1867	-$116.6
New Mexico	-577,550 (-30%)	$82.59	-$47.7	-578	-$36.1
Idaho	-523,105 (-17%)	$82.59	-$43.2	-524	-$32.7
Utah	-1,053,548 (-14%)	$82.59	-$87	-1055	-$65.9
Nevada	-166,763 (-19%)	$74.96	-$12.5	-152	-$9.5
Arizona	-247,557 (-29%)	$74.96	-$18.6	-226	-$14.1
California	-1,324,967 (-4.7%)	$74.96	-$99.3	-1204	-$75.2
Oregon	-1,021,186 (-31%)	$49.29	-$50.3	-610	-$38.1
Washington	-1,607,497 (-28%)	$49.29	-$79.2	-960	-$60.0
Alaska	-142,172 (-20%)	$49.29	-$7.00	-85	-$5.3
Total	**-15,214,459**	**--**	**-$1,069.3**	**12,965**	**-$809.8**

Even the Midwest wasn't immune where Wisconsin, the key Midwestern ski state, saw a loss in skier visits in the low snowfall years of 36 percent resulting in a decrease in ski resort revenue of $102 million, with over 1200 fewer jobs.

SNOWMOBILE INDUSTRY ANALYSIS

It was not possible to estimate the economic impact of a high- versus low-snowfall year for the snowmobile industry due to lack of available data. This section, however, provides slightly more detail on the scope of activity in that industry.

In 2009/2010, there were an estimated 14.6 million snowmobile trip-days nationally. This usage level resulted in $1.5 billion in value added to the U.S. economy and supported the employment of 24,000 workers earning income of $900 million (Table 1).

Currently, 1.5 million snowmobiles are registered in the United States. Minnesota has the highest number overall, with 256,000 registrations; and Alaska has the highest registrations per capita, with 77 registrations per thousand of population (Table 8). Snowmobilers spent an average of $113 per trip, resulting in an annual nationwide expenditure of $1.6 billion in 2009/2010 appendix I, tables 3 and 4.

Furthermore, snowmobile registrations have been declining gradually since 2004 (Figure 4). While ski resorts can and have invested heavily in snowmaking technology, the snowmobile industry remains vulnerable to fluctuations in natural snowfall. A comprehensive study published in 2007 estimated that warmer and less snowy winter seasons in the Northeast would virtually eliminate the snowmobile season in this region by the end of the century under a higher-emissions scenario,[31] resulting in a potential loss of nearly $400 million in annual spending by snowmobilers.

Table 8. Snowmobile Statistics for 2009/2010

State	Population	Registrations	Registrations Per Thousand of Population	Snowmobile Visit-Days
Minnesota	5,303,925	256,603	48.4	2,473,653
Michigan	9,883,640	249,849	25.3	2,408,544
Wisconsin	5,686,986	226,152	39.8	2,180,105
New York	19,378,102	131,664	6.8	1,269,241
Maine	1,328,361	87,000	65.5	838,680
Alaska	710,231	54,600	76.9	526,344
New Hampshire	1,316,470	52,000	39.5	501,280
Idaho	1,567,582	45,138	28.8	435,130
Pennsylvania	12,702,379	41,116	3.2	396,358
Montana	989,415	39,680	40.1	382,515
Wyoming	563,626	37,700	66.9	363,428
Illinois	12,830,632	36,902	2.9	355,735
Vermont	625,741	32,251	51.5	310,900
Colorado	5,029,196	31,635	6.3	304,961
Washington	6,724,540	31,470	4.7	303,371
Iowa	3,046,355	30,798	10.1	296,893
California	37,253,956	22,413	0.6	216,061
Utah	2,763,885	21,081	7.6	203,221
Oregon	3,831,074	16,358	4.3	157,691
Massachusetts	6,547,629	15,636	2.4	150,731
South Dakota	814,180	13,742	16.9	132,473
North Dakota	672,591	13,418	19.9	129,350
Indiana	6,483,802	10,372	1.6	99,986
Ohio	11,536,504	4,900	0.4	47,236
Nebraska	1,826,341	2,200	1.2	21,208
Total	**159,417,143**	**1,504,678**	**9.4**	**14,505,096**

III. CONCLUSIONS

Every nation's major scientific body, including the United States' own National Academy of Sciences, has spoken unequivocally about the realities and implications of climate change. Indeed, extreme weather has become the new norm.

The snow sports community has seen some of the earliest and most tangible evidence of climate change's impact on our nation's mountains. Impacts have ranged from reduced snowpack and melting glaciers to dying alpine forests and shorter winter seasons. Climate change is already happening and we are seeing its effects every day.

The damage to the environment goes hand in hand with damage to local economies and individual businesses. From Maine to California, resorts, hotels, restaurants, shops, and thousands of other small businesses all rely on winter sports to maintain their vibrancy and welfare. The winter tourism industry—(as reflected, in this study's focus on the economic activity at downhill skiing resorts and from snowmobiling)—exerts a significant impact on the national economy. More than 38 states have value added to their state economies through downhill ski resorts and/or snowmobiling. Ski facilities alone supported nearly 76,000 jobs and $1.5 billion in salaries, wages, and benefits during the period studied.

When direct, indirect, and induced effects were accounted for, the ski and snowmobile industry supported 211,900 jobs and accounted for $12.2 billion in value added to the U.S. economy.

With winter temperatures rising and expected to continue to rise through at least the end of the century[1], it is important to recognize the significant economic impact that winter sports tourism has on states' economies and the national economy. We found that below-average snowfall resulted in fewer skier visits across much of the United States. Generally, skier visits are between 4 percent and 36 percent lower during low snowfall years compared to high snowfall years, depending on the state and region. Colorado, which leads the nation in skier visits, loses a potential $154 million in ski resort revenue during low-snowfall years compared to high-snowfall years. Depending on how consumers redistribute money that otherwise would have been spent on winter tourism-related activities, low snowfall leads to a 6 percent to 13 percent decline in winter tourism-related employment, or about 9,400 to 27,000 fewer jobs in the winter tourism industry.

On average, a nationwide low-snowfall year results in an estimated 15.2 million fewer skier visits, $1.07 billion in lost potential revenue at ski resorts, nearly 13,000 fewer jobs, and $810 million less value added to the U.S. economy as compared to a nationwide high-snowfall year.

Winter temperatures are projected to warm an additional 4ºF to 10ºF by the end of the century.[1] As a result, more winter precipitation will come in the form of rain instead of snow.[23] Snow depth is expected to decline by 25 percent to 100 percent in the western United States, with the largest decreases occurring at lower elevations.[14] The length of the snow season in the northeastern United States is expected to shorten by as much as 50 percent.[27]

We need to protect one of America's greatest assets—a stable climate. Without it, a vibrant winter sports industry, the economies of mountain communities everywhere, and the valued lifestyle of winter will be gone, not just for us, but for our children. Winter as we know it is on borrowed time and we cannot afford to wait.

We must safeguard our winters and with them, a way of life for thousands of communities, a global winter sports industry, and local business across the United States. We can do this by supporting clean-energy and climate policies that reduce our carbon pollution, and opposing attempts to block such policies from moving forward. We need to protect the laws we have, specifically the Environmental Protection Agency's authority under the Clean Air Act to set carbon pollution standards for major polluting industries. And we need to put in place policies and standards for the longer term that will ensure that vibrant, prosperous winters endure for generations to come.

APPENDIX I. METHODOLOGY

Economic impact analysis can provide an estimate of economic activity in the winter tourism industry. We use IMPLAN (IMpact analysis for PLANning) to provide a "snapshot" of economic activity for a given moment in time, using economic multipliers. IMPLAN estimates employment, wages, and economic value added, and is discussed in greater detail below. In this section, we provide an overview of the assumptions and process used in the IMPLAN modeling.

The economic size (in terms of employment and economic value added) of the national winter tourism sports industry was determined by using the following methodology:

Table 1: National Day-Trip Estimates for 2009/2010

NATIONAL SKI DAY-TRIPS	59,787,000
SNOWMOBILE DAY-TRIP	14,505,096

Obtaining estimates of ski and snow mobile day-trips at the state level

State ski day-trip statistics between 2000 and 2010 were obtained from the National Ski Areas Association (NSAA) Kottke National End of Season Survey reports, which are based on ski resort survey data. Snowmobile trip statistics were more challenging to obtain, as no national estimate of this value exists. The International Snowmobile Manufacturers Association provides a list of snowmobile registrations by state but does not compile visit statistics. However, snowmobiling economic studies conducted at the state level were consulted, and a national survey of snowmobile participants was obtained from the Sporting Goods Manufacturers Association. Based on these sources, modeler judgment was exercised to determine that the average number of snowmobile day trips per snowmobile registered was 9.64 in 2009/2010. Due to limitations in data availability our estimates are uncertain. However, for reasons discussed below, we expect them to be conservative. National day trip estimates for skiing and snowmobiling day trips are shown for 2009/2010 in table 1.

Obtaining estimates of average expenditures per day-trip

Economic studies of the ski and snowmobile industry were consulted to estimate the total number of trips and average expenditures per trip in six distinct economic areas corresponding to industry sectors in IMPLAN:
1) food and beverage stores; 2) gasoline stations; 3) general-merchandise stores; 4) amusement outlets; 5) accommodations; and 6) food service and drinking establishments.

While the studies were all regionally based, we estimated average expenditures for ski and snowmobiling at a national level due to data limitations. Thus, only one set of average expenditures (one for ski trips and one for snowmobile trips) was calculated. The research team exercised judgment in determining the average expenditure per trip. These average expenditures took into account the weighted proportion of day trips to overnight trips. For example, survey results in an economic impact study in Montana found that ski trips consisted of 65 percent day trips and 35 percent overnight trips. A Michigan study found that the ratio of day to overnight trips was 55 percent to 45 percent (Appendix II). However, the 65 percent day trips to 35 percent overnight trips ratio was used, as it provided a more conservative estimate of ski trip expenditures. Based on the studies consulted, ski day trips were estimated to be $137.91 per person-trip and overnight trips were estimated at $1,209.12 per person-trip, such that the weighted average person trip came to $141. The estimated average expenditures per ski and snowmobile day trip for six distinct economic areas are listed in table 3, with total expenditures per economic activity in table 4.

The economic impact analysis, uses IMPLAN 3.0 (2010 data), a system of software and databases produced by the Minnesota IMPLAN Group (MIG), which is a widely used and accepted regional input-output (I/O)economic model. The IMPLAN model calculates economic activity by tracing back the associated employment, government tax revenue, and inputs from industries necessary to provide a given total expenditure on a commodity or industry. The IMPLAN program uses an ordered series of steps to build the model, starting with selection of a study area. The study area can be set at the county level (including multiple counties), the state level (including multiple states), or the national level. As discussed above, the study area was set at the national level. The results were then proportioned out to individual states to get an estimate of impacts at the state level.

Table 2: IMPLAN Summary Measures of Economic Activity	
Measure	**Description**
Output	The value of production by industry in a calendar year. Output is measured by sales or receipts and other operating income, plus the change in inventory. For retailers and wholesalers, output is equal to gross margin, not gross sales.
Labor Income	All forms of employment income, including employee compensation (wages and benefits) and proprietor income.
Value Added	The difference between total output and the cost of intermediate inputs. This is a measure of the contribution to Gross Domestic Product (GDP) and equals output minus intermediate inputs. Value added consists of compensation of employees, taxes on production and imports—less subsidies, and gross operating surplus.
Employment	The annual average of monthly jobs in an industry; this includes both full-time and part-time workers.

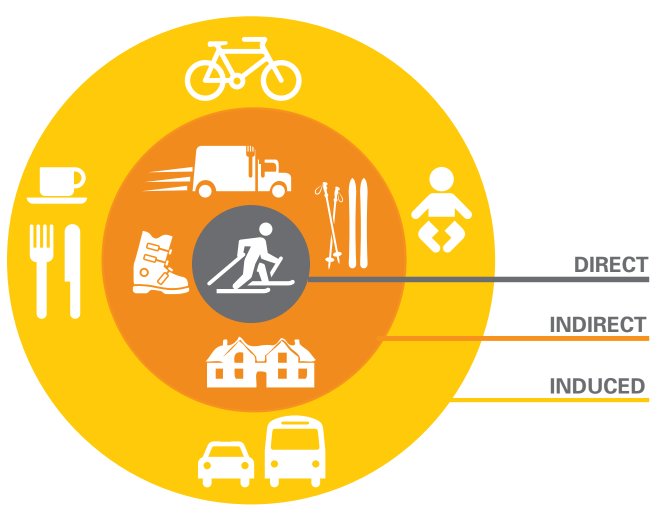
With the creation of the study area database, the model describes the transfer of money between industries and institutions. It provides data tables on regional economic accounts that capture local economic interactions. These tables describe the local economy in terms of the flow of dollars from purchasers to producers within the study area region. The model also produces trade flows—the movement of goods and services within a study area and the outside world (regional imports and exports).

The model has a set of I/O multipliers that estimate total regional activity based on a change entered into the IMPLAN model. Multiplier analysis is used to estimate the regional economic impacts resulting from a change in final demand. New industries or commodities can be introduced to the local economy; and industries or commodities can be removed to show the consequences (on output, employment, labor income, and value-added) of the various changes (Table 2).

As with any model, the I/O multiplier approach has limitations. It includes the assumption of a linear production function. This means that, in IMPLAN, if the sales of a company double, its impact on regional employment also will double; or, conversely, if sales drop in half, the company's impact on regional employment also will decrease by half. This can lead the model to over- or under-predict the impacts of changes on employment and value added in the study-area economy, as the rate of marginal change in these economic values is expected to not remain constant depending on the magnitude of output change.

Figure 1: Direct, Indirect, and Induced Economic Impacts

TOTAL ECONOMIC IMPACT =
DIRECT + INDIRECT + INDUCED ECONOMIC IMPACTS



DIRECT—Direct impacts were defined as the employment and businesses required to provide goods and services to ski and snowmobile participants on a skiing or snowmobiling trip. Direct activities included purchases made at lodgings, restaurants, resorts, gas stations, and grocery stores. While these types of activities are often categorized as indirect in other economic analyses, we followed other winter tourism studies' classification systems.

INDIRECT—Indirect impacts were the employment and economic activity created by the expenditures of businesses directly involved in supporting the direct industries. An example is the economic activity of wholesale food distributors servicing restaurants and resorts being visited by ski or snowmobile participants. Indirect activity also included local purchases of equipment, supplies, and professional services.

INDUCED—Induced impacts were the employment and economic activities created through the expenditure of income and earnings in the broader economy by individuals directly and indirectly employed by industries servicing the ski and snowmobile market. This could include expenditures on goods and services, including: food, clothes, utilities, transportation, recreation, health care, and child care.

Table 3: Average Day-Trip Expenditures Estimates

IMPLAN Code	Industry	Estimated Trip Expenses per Ski Day Visit	Estimated Trip Expenses per Snowmobile Day
445	Food & Beverage Stores	$8.46	$15.86
447	Gasoline Stations	$11.28	$34.22
452	General Merchandise Stores	$7.05	$8.56
713	Amusement—Gambling & Recreation[32]	$76.14	$0
721	Accommodations	$21.15	$30.90
722	Food Service & Drinking Places	$16.92	$23.46
Total		**$141.00**	**$113.00**

Table 4: Aggregate Direct Impact IMPLAN Sectors Inputs for the IMPLAN Model ($ millions)

IMPLAN Code	Industry	Ski Expenditures	Snowmobile Expenditures
445	Food & Beverage Stores	$505.8	$231.6
447	Gasoline Stations	$674.4	$499.8
452	General Merchandise Stores	$421.5	$125.0
713	Amusement–Gambling & Recreation	$4,552.2	$0.0
721	Accommodations	$1,264.5	$451.3
722	Food Service & Drinking Establishments	$1,011.6	$342.6
Total		**$8,430.0**	**$1,650.2**

The IMPLAN economic modeling system was used to calculate the direct, indirect, and induced jobs based on the total estimated consumer expenditures in 2009/2010 on skiing and snowmobiling (Figure 1). The estimates included any outdoor gear, equipment, or clothing purchased during ski or snowmobile trips, but did *not* include outdoor gear, equipment, or clothing purchased outside of actual trips. The rationale was that this criterion provided a conservative estimate of the total economic impact of the winter sports tourism industry, and specifically focused on the tourism and recreational associated impacts; also, these data were available in the regional economic studies consulted for this study. A national multiplier was used to calculate economic impacts, see appendix II; State impacts were then estimated based on their proportion of skier visits and snowmobile day trips relative to national estimates.

Use of IMPLAN to Measure Impacts of Lower vs. Higher Snowfall

The economic impact of lower vs. higher snowfall on winter tourism was quantified as the change in winter tourism employment and economic activity calculated using IMPLAN. Snowfall was chosen as the key indicator to estimate the decline in skier visits, resort revenue, and winter tourism employment due to differences between lower-snowfall winters compared to higher-snowfall years.

Snowfall data for the entire United States were retrieved from the United States Historical Climatology Network (USHCN) Daily Dataset and the Global Historical Climatology Network (GHCN).[33] SNOwpack TELemetry Network (SNOTEL) station data were used to supplement temporally or spatially sparse USHCN and GHCN in the western United States.[34]

Total winter snowfall for each station was calculated as the sum of total monthly snowfall for the months of November through April the following year, from November 1999 to April 2010. For SNOTEL sites, the monthly snow water equivalent was used as a proxy for snowfall.

For each state, all available climate station records were used to identify the two highest snowfall winters and the two lowest snowfall winters between 2000 and 2010 (Table 5 with further detail in appendix IV). For larger states, stations located in mountainous regions were selected, and if needed, clustered into sub-regions based on regional climate, topography, station availability, and proximity to lakes that generate lake-effect snow (e.g., The Great Salt Lake, Utah). In most of the western United States, the regions were predominantly delineated based on topography.

The top-two snowiest and the bottom-two snowiest snowfall years were used to calculate the difference in winter tourism-related employment and economic activity estimated by the IMPLAN model.

The difference in skier visits between higher-snowfall years and lower-snowfall years was used to estimate the change in ski resort revenue. The change in revenue was used as an input to the IMPLAN economic model and was calculated by multiplying the difference in skier visits for higher- and lower-snowfall years by the 2009/2010 and 2010/2011 average total revenue per skier visit within the following regions: (1) Northeast, $68.45; (2) Southeast, $81.65; (3) Midwest, $64.58; (4) Rocky Mountain, $82.59; (5) Pacific South, $74.96; and Pacific North $49.29.[5] Even though the low and high snowfall years varied by region the change in skier resort revenue was input into the IMPLAN model for the 2009-2010 year. This assumes that the amount of economic activity needed to support a visit to a ski resort is approximately equivalent across the years. The IMPLAN model calculated the difference in direct, indirect, and induced economic impacts for higher- versus lower-snowfall years using a fixed multiplier ratio, and as such did not include fixed labor costs. It is unknown what impact not including fixed labor costs in the model would have on estimating the impacts of changes in snowfall on the winter tourism industry.

Table 5: Top Two High- and Low-Snowfall Years, by State, November 1999 to April 2010

State	High Year 1	High Year 2	Low Year1	Low Year 2
Alaska	2004	2002	2003	2006
Arizona	2001	2008	2002	2009
California	2005	2008	2007	2003
Colorado	2008	2003	2002	2004
Connecticut & RI	2003	2001	2002	2007
Idaho	2008	2006	2007	2003
Illinois	2008	2009	2002	2004
Indiana	2008	2003	2002	2004
Maine	2008	2001	2006	2004
Massachusetts	2005	2003	2007	2000
Michigan	2009	2004	2003	2007
Minnesota	2001	2009	2000	2005
Montana	2003	2008	2002	2005
Nevada	2006	2005	2007	2009
New Hampshire	2008	2009	2007	2002
New Mexico	2007	2005	2006	2002
New York	2001	2003	2002	2006
North Carolina	2010	2003	2002	2008
North Dakota & South Dakota	2009	2001	2005	2000
Ohio	2003	2008	2002	2006
Oregon	2002	2008	2003	2005
Pennsylvania	2003	2010	2002	2009
Utah	2008	2004	2007	2003
Vermont	2008	2001	2006	2002
Virginia & Maryland	2003	2010	2008	2002
Washington	2008	2004	2005	2006
West Virginia	2010	2003	2008	2002
Wisconsin	2008	2009	2003	2000
Wyoming	2008	2009	2005	2007

APPENDIX II. ECONOMIC MULTIPLIERS

The employment economic multiplier calculated by IMPLAN was 1.7 and the economic value added multiplier was 2.48. These were slightly above the average of the studies referenced (Table 1) but do not exceed the bounds of the studies referenced collectively. These values were not adjusted from the output of the IMPLAN model and are believed to be reasonable assumptions of economic activity due to the winter sports tourism industry being more service sector and labor intensive.

Economic measures developed from the national IMPLAN model were applied at the state level in proportion to their percentage share of skier and snowmobile activity days. This was the most cost-effective approach suitable to developing a national estimate of economic impact from winter tourism industries. County and state data sets were available for analysis using IMPLAN, but it was believed that this level of detail would add little additional value to the quality of the analysis. The IMPLAN model considered 440 industry sectors in its economic analysis engine. In this analysis, the model aggregated the 440 industry sectors in IMPLAN down to 86 industry sectors using the *IMPLAN 3 Digit NAICS for IMPLAN 440* aggregation library.

Table 1. Economic Studies on Winter Tourism and Multipliers Used

Study	Industry	Region	Economic Multipliers	
			Employment	Value Add or Output
The Active Outdoor Recreation Economy, Southwick Associates (2006).	Outdoor Recreation	National	n/a	2.56
Bitterroot Resort Economic Impact Analysis, ECONorthwest (2007).	Skiing	Montana	1.36	1.55
An Economic Evaluation of Snowmobiling in Maine: An Update for 1997–98, Univ. of Maine (1998).	Snowmobiling	Maine		1.5
Economic Impacts of Michigan Downhill Skiers and Snowboarders, 2000–01. Michigan State University (2001).	Skiing	Michigan	1.60	1.59
Economic Impact Analysis of Proposed Ski Interconnect Between The Canyons Resort and Solitude Mountain Resort, Utah, Robert Charles Lesser & Co. (2010).	Skiing	Utah	n/a	1.52
An Economic and Social Assessment of Snowmobiling in Utah, Utah State University (2001).	Snowmobiling	Utah	n/a	n/a
The Economic Impact of Snowmobiling in Valley County, University of Idaho (2006).	Snowmobiling	Idaho	n/a	1.65
The Economic Impact of Ski Areas Represented by the Inland Northwest Ski Association, Eastern Washington University (2005).	Skiing	Idaho/Washington	1.42	1.71
Economic Impact and Skier Characteristics: Montana, University of Montana (2010).	Skiing	Montana	n/a	n/a
Economic Significance of Downhill Skiing and Snowboarding in Wisconsin Final Results, RRC Associates (2011).	Skiing	Wisconsin	1.7	1.7
Kottke National End of Season Survey, NSAA & RRC Associates (2011).	Skiing	National	n/a	n/a
NSAA National Demographic Survey, NSAA & RRC Associates (2011).	Skiing	National	n/a	n/a
National Ski Areas Association Economic Analysis of United States Ski Area Report, 2010/2011, NSAA & RRC Associates (2011).	Skiing	National	n/a	n/a
North Carolina Ski Areas Association Economic Value Analysis Final Results: 2009–2010, RRC Associates(2010).	Skiing	North Carolina	n/a	1.65
Single Sport Report—2011: Snowmobiling, Sporting Goods Manufacturers Association (2010).	Snowmobiling	National	n/a	n/a
Snowmobiling in Minnesota: Economic Impact and Consumer Profile, University of Minnesota (2005).	Snowmobiling	Minnesota	n/a	n/a
State and Regional Economic Impacts of Snowmobiling in Michigan. Michigan State University (1998).	Snowmobiling	Michigan	1.63	2.0
Average			**1.54**	**1.74**

APPENDIX III.
FIVE STATE CASE STUDIES

In addition to the overall analysis, we highlight the impacts in several states across the country by providing state-specific maps and summaries of the results. The state-specific maps include those of Colorado, Montana, New Mexico, New Hampshire, and Pennsylvania. For all state-specific maps, the data sources are as follows:

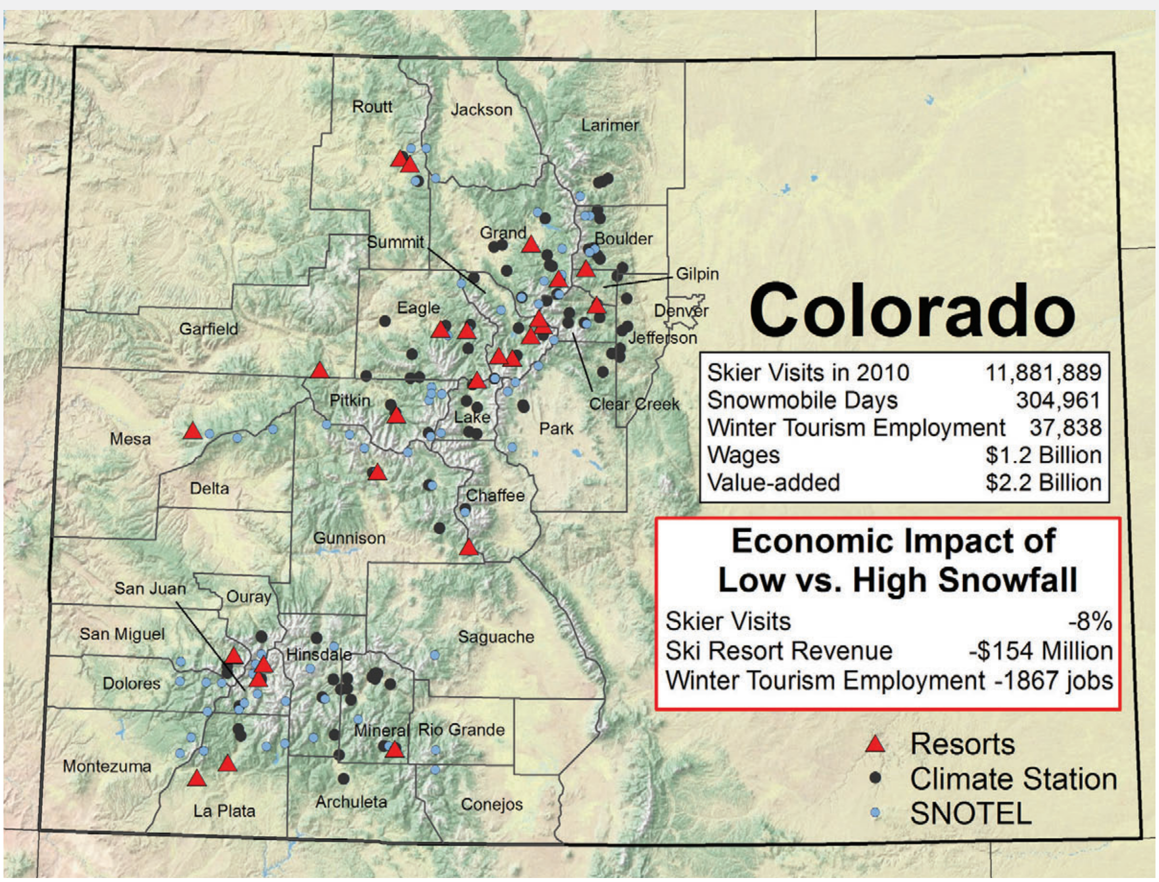
- Skier visit data come from the National Ski Areas Association's "Economic Analysis of United States Ski Areas Report, 2009/2010," RRC Associates.
- Snowmobile data were provided by the Sporting Goods Manufacturers Association.
- Employment, Wages and Value Added were generated from the IMPLAN Economic Model.

COLORADO

Colorado supports the largest ski industry in the United States, accounting for 20 percent of the total skier visits in the United States. In 2010, there were nearly 12 million skier visits and more than 300,000 snowmobile days. More than 37,000 employees earned $1.2 billion in wages through direct, indirect, and induced economic activity, contributing $2.2 billion in value added to the Colorado economy.

The difference in skier visits was 8 percent during lower-snowfall years (e.g., 2001/2002 and 2003/2004), compared to higher-snowfall years (e.g., 2002/2003 and 2007/2008). 1.86 million fewer skier visits during low-snow winters cost Colorado resorts an estimated $154 million dollars in resort revenue compared to revenue from a high-snowfall winter and over 1800 jobs.

In Colorado, average winter temperatures are projected to increase an additional 5°F to 7°F under a higher-emissions scenario over the next century, resulting in a 25 percent to 75 percent decrease in snow depth depending on region.[14] Additionally, a greater proportion of winter precipitation will fall as rain instead of snow. Strong increases in nighttime minimum temperatures will limit the effectiveness of snowmaking as an adaptation strategy for ski resorts, stress water resources, and exacerbate wildfire risk.

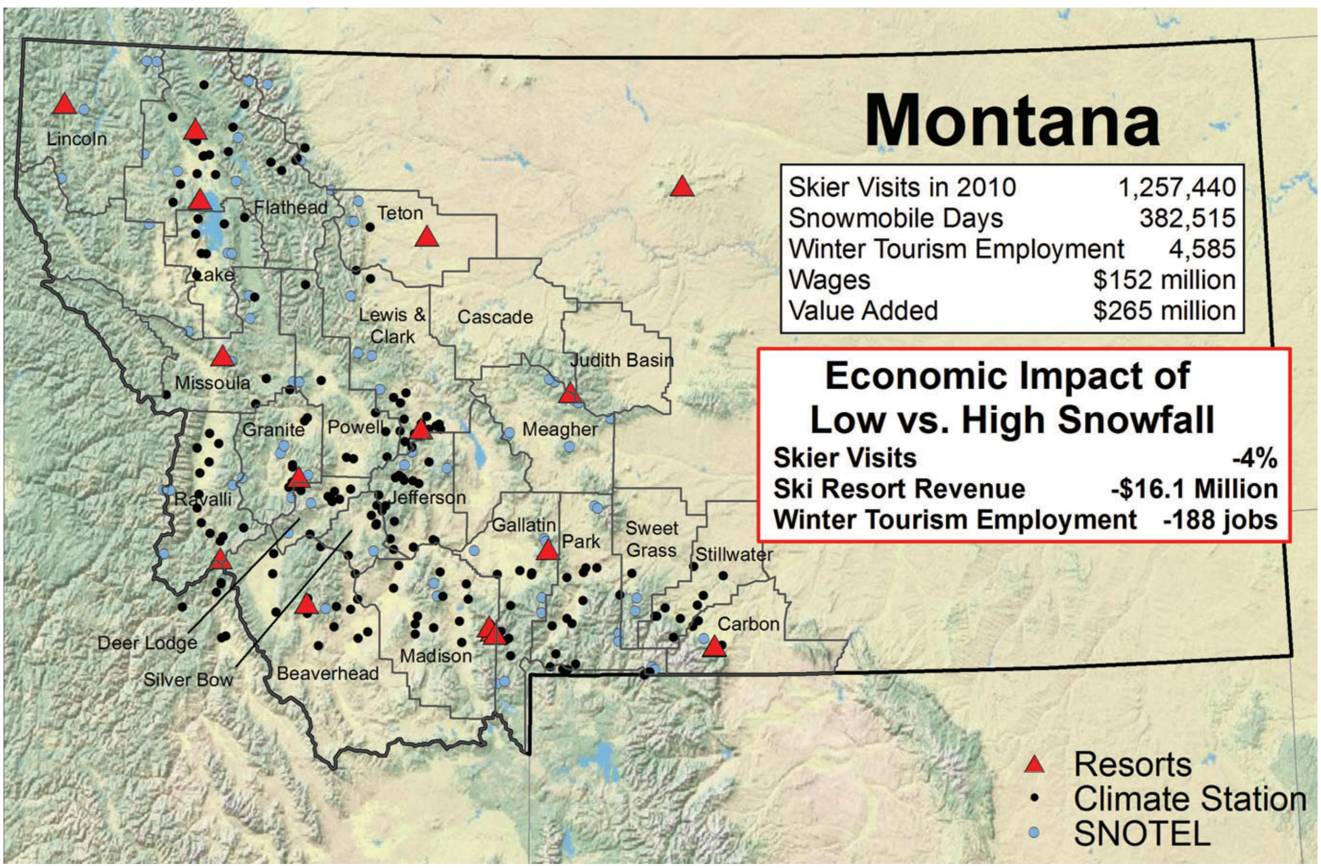


Sources: NSAA Economic Analysis Report, 2011. International Snowmobile Manufacturers Association, Bureau of Labor Statistics, and IMPLAN Economic Model. Statistics shown are for the 2009/2010 winter season. Economic impact data shown are for difference between top two highest snowfall and bottom two lowest snowfall years.

MONTANA

Montana's winter tourism industry provided more than $152 million in income to over 4,500 employees through direct, indirect, and induced economic activity. Skiing and snowmobiling activities contributed more than $265 million to the Montana economy during the 2009/2010 winter, with more than 1.2 million skier visits and 382,000 snowmobile days. Over the past 40 years, winter temperatures have increased between 0.5°F and 1.0°F per decade, or about 2°F to 4°F total. Lower-snowfall winters (e.g., 2001/2002 and 2004/2005) have cost Montana ski resorts over $16 million in revenue and supported 188 fewer jobs compared to higher-snowfall winters (e.g., 2002/2003 and 2007/2008).

By the end of the current century, winter temperatures are projected to increase an additional 5°F to 7°F under a higher-emissions scenario if delays in development of renewable energy continue.[1] As a result, snow depth is expected to decline 50 percent to 100 percent in the southwestern mountains and between 10 percent and 50 percent in the northwestern part of the state relative to 1960–1990 averages.[14] The severe declines in winter snowpack will undoubtedly stress water resources, which will limit the viability of snowmaking as an adaptation strategy.



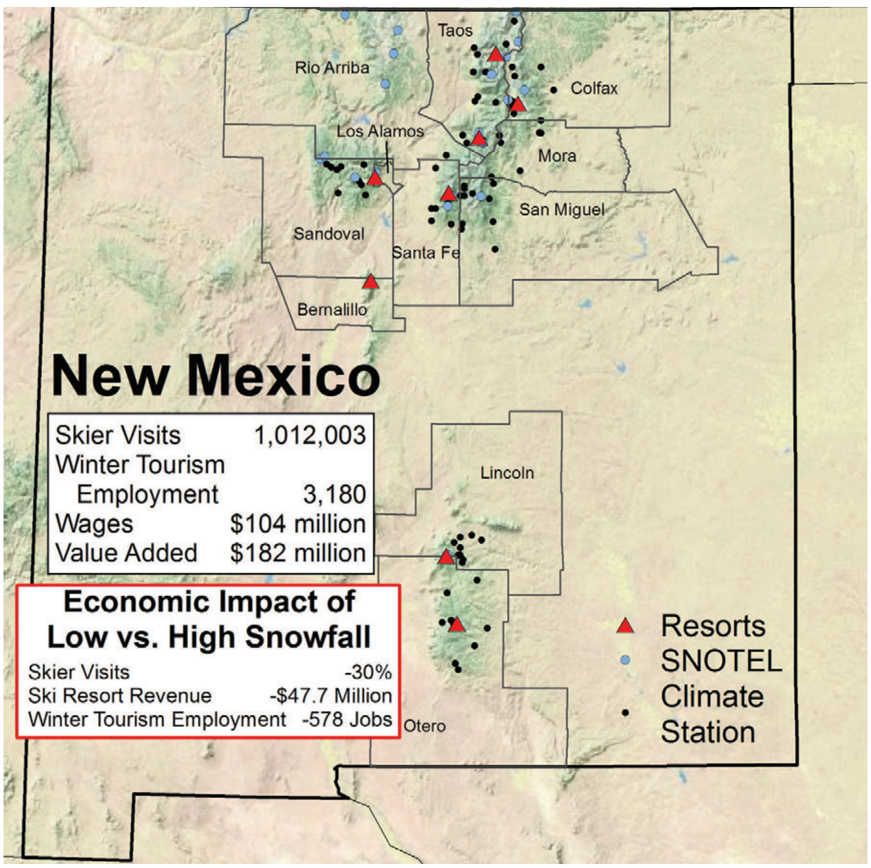
Sources: NSAA Economic Analysis Report, 2011. International Snowmobile Manufacturers Association, Bureau of Labor Statistics, and IMPLAN Economic Model. Statistics shown are for the 2009/2010 winter season. Economic impact data shown are for difference between top two highest snowfall and bottom two lowest snowfall years.

NEW MEXICO

The ski resorts to the north of Santa Fe, dotting the Sangre de Cristo range, are the primary drivers of New Mexico's $182 million ski industry. Winter tourism across the state collectively provided more than 3,100 jobs and $104 million dollars in wages through direct, indirect, and induced economic activity.

Lower snowfall years (e.g., 2001/2002 and 2005/2006) in New Mexico resulted in an estimated $48 million difference in ski resort revenue, a 30 percent change in skier visits, and 578 fewer jobs compared to higher-snowfall years (e.g., 2004/2005 and 2006/2007).

Winter temperatures are expected to warm an additional 5°F to 6°F by the end of the century under a higher-emissions scenario. As a result, snow depth in the Sangre de Cristo Range, where the largest New Mexico resorts operate, could plummet between 50 percent and 75 percent below the 1960 to 1990 average.[1]



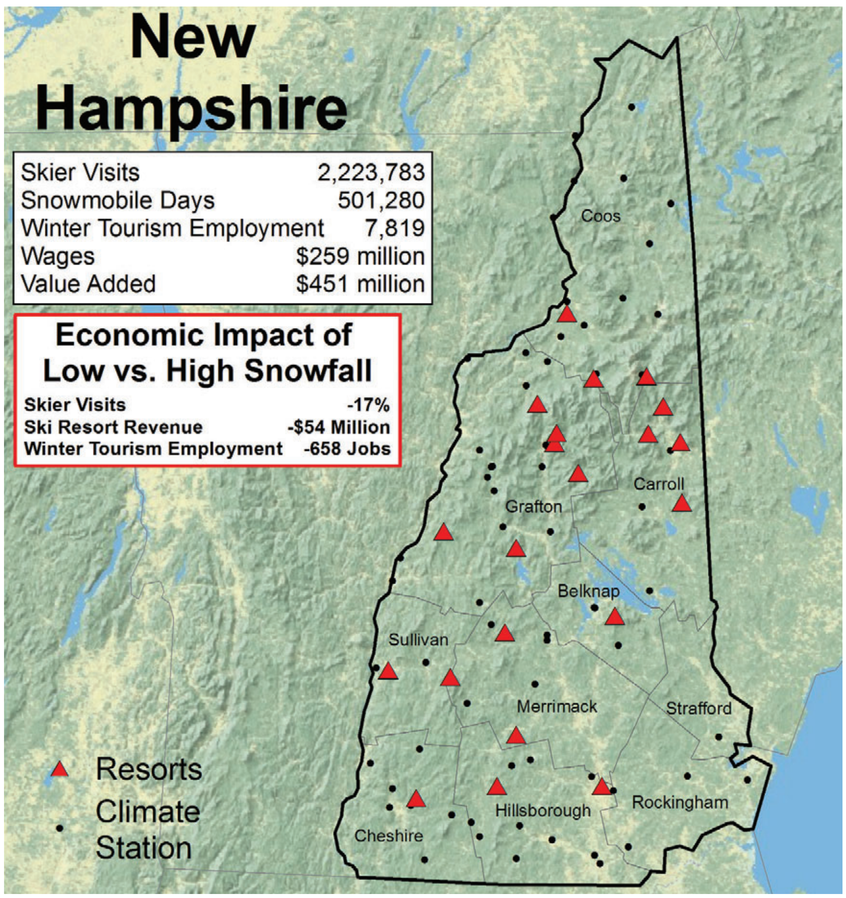
Sources: NSAA Economic Analysis Report, 2011. International Snowmobile Manufacturers Association, Bureau of Labor Statistics, and IMPLAN Economic Model. Statistics shown are for the 2009/2010 winter season. Economic impact data shown are for difference between top two highest snowfall and bottom two lowest snowfall years.

NEW HAMPSHIRE

Ski resorts are found in almost every county in New Hampshire, with the exception of Rockingham and Strafford. The state provided winter recreation opportunities to 2.2 million skier visits and 500,000 snowmobile visits in 2010. The winter tourism industry supplied jobs for almost 8,000 employees, who earned $259 million in wages.

Lower-snowfall winters (e.g., 2001/2002 and 2006/2007) cost New Hampshire ski resorts an estimated $54.3 million in lost revenue and a 17 percent fewer skier visits compared to higher-snowfall winters (e.g., 2007/2008 and 2008/2009).

Winter temperatures are expected to increase an additional 6ºF to 10ºF by the end of the century under a higher-emissions scenario. Warmer winter temperatures will mean less snowfall, more winter rain, and earlier melting of snowpack. The length of the snow season could be reduced by 25 percent to 50 percent, with larger reductions under higher-emissions scenarios.[27]



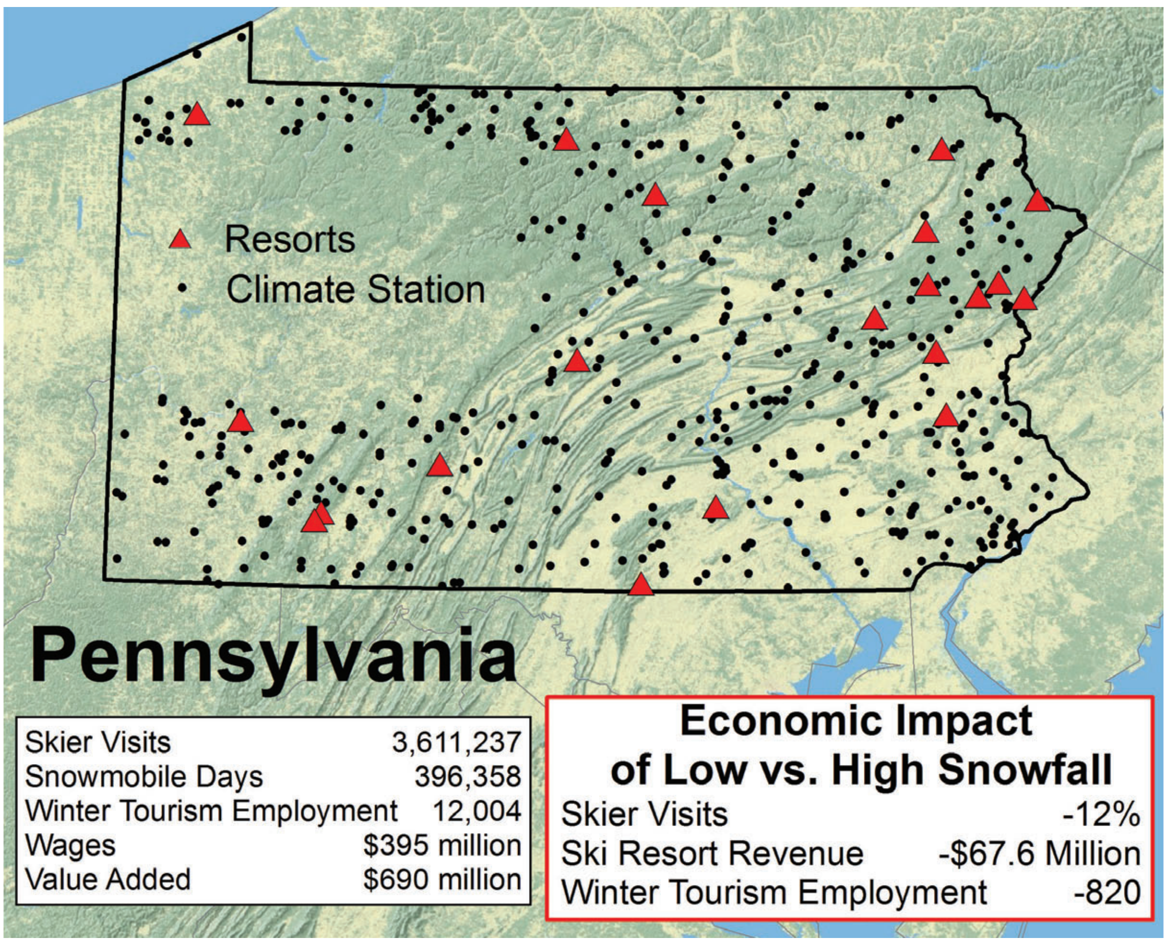
Sources: NSAA Economic Analysis Report, 2011. International Snowmobile Manufacturers Association, Bureau of Labor Statistics, and IMPLAN Economic Model. Statistics shown are for the 2009/2010 winter season. Economic impact data shown are for difference between top two highest snowfall and bottom two lowest snowfall years.

PENNSYLVANIA

With 3.6 million skier visits in 2009/2010, Pennsylvania rivals the combined total skier visits of Idaho, Montana, and Wyoming. In 2010, Pennsylvania's winter tourism industry supported 12,000 employees, who earned $395 million in wages. Skiers, snowboarders, and snowmobilers contributed $690 million in value added to the state's economy

During lower-snowfall years (e.g., 2001/2002 and 2008/2009), Pennsylvania sees 12 percent fewer skier visits compared to visits during higher-snowfall winters (e.g., 2002/2003 and 2009/2010). Consequently, the net loss in ski resort revenue was an estimated $67.6 million with 820 fewer jobs**.**

In the northeastern region of the United States, winter temperatures are expected to increase an additional 6°F to 10°F by the end of the century under a higher-emissions scenario. Average nighttime minimum temperatures will likely exceed 32°F, reducing the viability of snowmaking as an adaptation strategy. By the end of the century, the snow season will likely be confined to the highland regions.[35]



Sources: NSAA Economic Analysis Report, 2011. International Snowmobile Manufacturers Association, Bureau of Labor Statistics, and IMPLAN Economic Model. Statistics shown are for the 2009/2010 winter season. Economic impact data shown are for difference between top two highest snowfall and bottom two lowest snowfall years.

APPENDIX IV.
HIGHER AND LOWER SNOWFALL YEARS

Table 1. Top Two Higher- and bottom Two Lower-snowfall Years Derived from States and, If Applicable, Sub-regions, Over The Years Between The 1999/2000 and 2009/2010 Winter Tourism Seasons

State, sub-region	High Season 1	High Season 2	Low Season 1	Low Season 2
AK Anchorage	2004	2002	2003	2005
AK Fairbanks	2005	2004	2007	2003
AK Juneau	2007	2008	2006	2003
AZ_Flagstaff	2005	2001	2006	2002
AZ_Sunrise	2003	2008	2002	2009
AZ_Tucson	2001	2007	2005	2003
CA_Mammoth	2005	2008	2007	2002
CA_Shasta	2001	2008	2003	2007
CA_South	2001	2009	2007	2002
CA_Tahoe	2005	2010	2007	2000
CO_Central	2008	2003	2002	2004
CO_South	2008	2001	2002	2003
CO_North	2008	2009	2001	2002
CT	2003	2001	2002	2007
IA	2008	2004	2002	2005
ID_Central	2008	2006	2003	2005
ID_North	2008	2002	2005	2006
ID_South	2008	2006	2007	2003
IL	2008	2009	2002	2004
IN	2008	2003	2002	2004
MA	2005	2003	2007	2000
ME	2001	2008	2006	2004
MI_South	2009	2005	2007	2002
MI_UPNorth	2009	2004	2007	2003
MN	2001	2009	2000	2005
MT_BigSky	2003	2008	2002	2005
MT_North_Whitefish	2008	2009	2007	2005
MT_Southwest	2003	2008	2007	2000
NC	2010	2003	2002	2008
ND_North	2009	2004	2000	2008
ND_South	2009	2007	2005	2003

Table 1 (Continued). **Top Two Higher- and bottom Two Lower-snowfall Years Derived from States and, If Applicable, Sub-regions, Over The Years Between The 1999/2000 and 2009/2010 Winter Tourism Seasons**

State, sub-region	High Season 1	High Season 2	Low Season 1	Low Season 2
NE	2001	2010	2000	2005
NH	2008	2009	2002	2007
NM_North	2007	2005	2006	2002
NM_SouthCentral	2005	2007	2006	2009
NV_South	2009	2005	2003	2008
NV_West	2006	2005	2007	2009
NY_Adirondacks	2001	2003	2002	2005
NY_South	2003	2001	2002	2006
NY_West	2001	2009	2002	2006
OH	2003	2008	2002	2006
OR	2008	2002	2005	2003
PA	2003	2010	2002	2009
SD	2009	2001	2005	2000
UT_SLC	2008	2006	2003	2007
UT_South	2001	2009	2002	2006
VA	2003	2010	2008	2002
VT	2001	2008	2006	2002
WA_Baker	2009	2008	2005	2006
WA_Bluewood	2009	2004	2006	2007
WA_Central	2008	2009	2005	2003
WA_East	2008	2009	2006	2003
WI	2008	2009	2003	2000
WV	2010	2003	2002	2008
WY_Bighorn	2008	2007	2006	2001
WY_Casper	2009	2008	2005	2007
WY_Northwest	2008	2004	2005	2007
WY_Snowy Range	2009	2006	2004	2005

Endnotes

1 Christensen, et al. (2007): Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

2 State of the Climate Overview, February 2012, Accessed Nov. 19, 2012: http://www.ncdc.noaa.gov/sotc/national/2012/2

3 Rutgers Global Snow Lab, US (no Alaska) Average Winter (Dec-Feb) Snow Cover Extent http://climate.rutgers.edu/snowcover/index.php

4 National Ski Areas Association (NSAA) Kottke End of Season Survey Press Release for 2011/2012. Accessed Sept. 9, 2012. http://www.nsaa.org/nsaa/press/1112/2012-Kottke-Prelim.pdf

5 National Ski Areas Association Economic Analysis of United States Ski Areas 2010/2011 Report. NSAA and RRC Associates.

6 International Snowmobile Manufacturer's Association (ISMA). Unpublished data provided by Ed Klim at ISMA, February 21, 2012.

7 For winter tourism, downhill skiing and snowmobiling are more significant in terms of economic impacts compared to other winter sports (e.g., ice fishing, snowshoeing, and winter hiking). In this report "winter tourism" refers to analysis of just these two winter sports. Furthermore, this analysis focused solely on service-sector economic activity and therefore does not include the economic impacts of the retail sector (i.e., manufacture and sale of winter sporting goods). The term "industry" is used in this manner throughout the report.

8 Physical Activity Council- 2012 Snowsports Industry of America SnowSports Fact Sheet (Total Number of Alpine, Snowboarder, and Cross Country Participants in 2009/2010); 2010 Snow Sports Industries "America Snow Sports Market Intelligence Report. Single Sport Report-2011 Snowmobiling". Sporting Goods Manufacturers Association.

9 National Ski Areas Association Kottke National End of Season Survey Report 2010/2011 Appendix: Estimated Skier Visits by State, 2010/2011 vs. 2009/2010. NSAA and RRC Associates.

10 See Appendix II, Table I for list of studies used to estimate 2009/2010 snowmobile trips.

11 One skier visit/snowmobile trip is defined as one person visiting a ski area or snowmobiling for all or part of a day

12 Nakićenović, N., and Swart, R., ed. (book), Special Report on Emissions Scenarios: A special report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, UK.

13 Frumhoff, et al. (2007) Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists; Hayhoe et al. (2004) *Proceedings of the National Academy of Sciences* **101:** 12422-12427; Wuebbles et al. (2010) *Journal of Great Lakes Research* **36**: 1-6.

14 Peacock et al. (2012). *Journal of Climate* **25**:4405-4429.

15 Frumhoff, et al. (2007) Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists.

16 Southwick Associates. *The Active Outdoor Recreation Economy* (2006), Accessed Sept. 11, 2012: http://www.outdoorindustry.org/national-economic-impact-reports.php?action=detail&research_id=26

17 International Snowmobile Manufacturer's Association website. http://www.snowmobile.org/snowmobilestatistics.asp

18 Knowles et al. (2006) *Journal of Climate* **19**: 4545-4559; Huntington et al. (2004) *Journal of Climate* **17**: 2626-2636; Mote et al. (2005). *Bulletin of the American Meteorological Society* **86**: 39-49; Burakowski et al. (2008) *Journal of Geophysical Research* **113:** D20114.

19 Mote et al. (2005). *Bulletin of the American Meteorological Society* **86**: 39-49.

20 Burakowski et al. (in prep)

21 National Bureau of Economic Research (2010), "US Business Cycle Expansions and Contractions," Accessed Sept. 11, 2012: http:www.nber.org/cycles.html

22 Hayhoe et al. (2007) *Climate Dynamics* **28:** 381-407.

23 Leung et al. (2004) *Climatic Change* **62:** 75-113; Payne et al. (2004) *Climatic Change* **62:** 233-256.

24 Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

25 Lazar and Williams (2008) *Cold Regions Science and Technology* **51**: 219-228.

26 Hamilton et al. (2007) *International Journal of Climatology* **27:** 2113-2124.

27 Frumhoff, et al. (2007) Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists. Scott et al. (2008) *Mitigation and Adaptation Strategies for Global Change* **13**: 577-596.

28 National Ski Areas Association National Demographic Study 2010/2011. NSAA and RRC Associates.

29 Because the economic and skier visit data is aggregated by state it was not possible to tease out differences in elevation. Thus,

data from lower elevation resorts are aggregated with higher elevation resorts in the same state. Future ski industry analyses are needed to evaluate the detailed impact of elevation and snowmaking on the profitability of resorts in the western US.

30 Change in total employment is based on the estimated change in employment from the IMPLAN model, assuming that consumers who do not ski still spend the same amount they would have spent in the overall economy.

31 Scott et al. (2008) *Mitigation and Adaptation Strategies for Global Change* **13**: 577-596.

32 The Amusement-Gambling & Recreation category 713 consists of all ski resort expenditures and therefore represents the direct economic impacts of ski resorts. The 713 category was limited only to skiing facilities in the analysis.

33 Menne et al. (2009) *Bulletin of the American Meteorological Society* **90**: 993-1007. Data accessed Apr. 18, 2012: http://cdiac.ornl.gov/ftp/ushcn_daily/

34 United States Department of Agriculture and the Natural Resources Conservation Service, SNOw TELemetry Network (SNOTEL), (2011) Data accessed Apr. 18, 2012: http://www.wcc.nrcs.usda.gov/snow/

35 Northeast Climate Impacts Assessment (2008) *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State.* Union of Concerned Scientists, Cambridge, MA.

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