THE ECONOMICS OF SNOW FOR RECREATION IN A CHANGING CLIMATE

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ABSTRACT: The U.S. winter sports industry is an important economic sector, proving jobs and revenues to mountain towns across the country. It has already been impacted by climate change. The results presented here summarize findings in our February 2018 report, *The Economic Contributions of Winter Sports in a Changing Climate,* published with support from Protect Our Winters (POW) and Recreational Equipment, Inc. (REI). In this report we estimate the economic contributions of winter snow sports to reveal the current magnitude of this part of the economy that is highly vulnerable to impacts from climate change. We also examine how economic contributions have decreased in years with less snow between 2001-2016. We modeled how expenditures made in the winter of 2015-16 by downhill skiers, snowboarders and snowmobilers rippled through the U.S. economy to add a total of $20.3 billion in economic value. We then examined how skier visits changed with natural snow cover between 2001-2016 and identified strong positive relationships in the majority of US states examined. During years of high snow, participation increased 7% on average and added 11,800 jobs and $692.9 million to the economy. During low snow years, participation decreased 10% on average, resulting in 17,400 fewer jobs and $1 billion less in economic value added compared to average seasons. The research also evaluated how climate change may impact skier values called “consumer surplus,” which are values of skiing over and above the costs. Lastly, we discuss the innovative strategies ski resorts are implementing to adapt to warmer, lower snow winters and to mitigate climate impacts in the industry.

KEYWORDS: Climate change, snow, economic impact, ski, snowmobile

1. INTRODUCTION

Present-day (1986-2016) winter temperatures are 0.8ºC warmer than they were between 1901-1960 (USGCRP, 2017). Warmer winters have been accompanied by reduced snow cover (Harpold et al. 2012; Burakowski et al. 2008), heavier and wetter snow (Hodgkins et al. 2006), and more winter precipitation falling as rain instead of snow (Knowles et al. 2006; Feng and Hu, 2007; Safeeq et al. 2016). Rapidly warming winters pose a serious challenge for the winter recreation industry, one that has been addressed through adaptive strategies such as snowmaking, year-round business models, and innovative snow management.

The paper presented here summarizes findings in our February 2018 report, *The Economic Contributions of Winter Sports in a Changing Climate*, published with support from Protect Our Winters (POW) and Recreational Equipment, Inc. (REI). The research estimates the economic contributions of winter sports and examines how economic contributions decrease in years with warmer temperatures and reduced natural snow.

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2. PARTICIPATION IN SNOW SPORTS

The U.S. has world's second largest ski industry, following the Alps in Europe (Vanat, 2018). However, the number of ski areas in the U.S. has been steadily decreasing since the 1980’s: at the beginning of the 1980s, there were over 700 ski areas in operation, whereas today there are approximately 480 (Vanat, 2018). The industry is now dominated by several large corporations that operate a number of integrated resorts at locations across the country (Vanat, 2017).

Though the number of ski resorts available to choose from has decreased, participation has remained relatively stable. Between 2007 and 2016, the number of U.S. winter sports participants grew by 4 million people (the U.S. experienced population growth of 22 million over the same period: see Figure 1). Alpine skiing and snowboarding had some years of increased participation offset by declining participation in following years. Telemark skiing, snowshoeing and freestyle skiing are growing sports, while there has been a slight decline in snowmobiling. A total of 23.5 million Americans participated in winter outdoor recreation in the winter season of 2015–2016 (SIA, 2017).

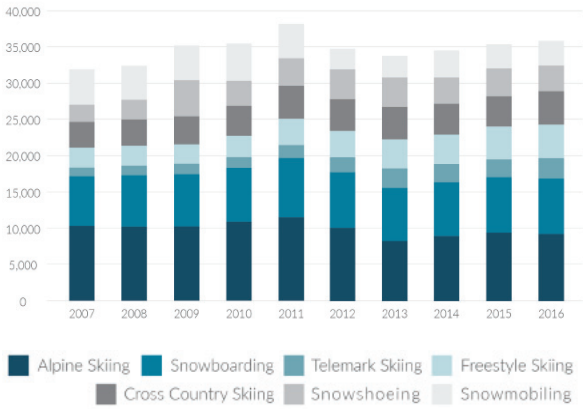

Figure 1. Trends in Winter Sports Participation.

3. ECONOMIC CONTRIBUTIONS OF WINTER RECREATION

3.1 National economic contributions from expenditures

We estimated the total economic impact of expenditures made by skiers, snowboarders and snowmobilers during their outings, using the IMPLAN model. IMPLAN uses regional industry purchasing patterns to examine how changes in one industry affect others to estimate total economic impacts. The model calculates employment, labor income, and overall value added* to the economy.

In the winter season of 2015–2016, more than 20 million people participated in downhill skiing, snowboarding, and snowmobiling, with a total of 52.8 million skiing and snowboarding days (NSAA, 2017) and 11.6 million snowmobiling days (snowmobile registrations from ISMA, 2017 and conversion factor of 9.64 day visits per registration from Burakowski and Magnusson, 2012). These recreationists spent money at resorts, hotels, resorts, restaurants, bars, grocery stores, sporting goods stores and gas stations. The IMPLAN model suggests that these expenditures supported over 191,000 jobs, generated a total of $6.9 billion in wages, and added a total of $11.3 billion in economic value to the national economy.

3.2 Breakdown of contributions

The total economic impact is comprised of direct, indirect, and induced effects as follows (Table 1):

Direct economic activities from skiing and snowmobiling expenditures contributed approximately 121,000 jobs and $4.7 billion in value added to the national economy.

Indirect effects arise due to linkages in the supply chain, such as local industries buying goods and services from other local industries (e.g., a ski shop hiring a local accountant). Indirect winter tourism economic activity provided 27,000 additional jobs and added $2.8 billion in economic activity.

Induced effects are a result of employee household spending. An additional 44,000 jobs and $3.9 billion in added value to the national economy was attributed to induced expenditures by employees from direct and indirect industries on personal consumption, including bill payment, health care, and grocery purchases.

Impact Type	Employment	Labor Income ($ Billions)	Total Value Added ($ Billions)
Direct Effect	121,000	$ 3.10	$ 4.66
Indirect Effect	27,000	$ 1.57	$ 2.78
Induced Effect	44,000	$ 2.24	$ 3.91
Total Effect	191,000	$ 6.90	$ 11.35

Table 1. National economic impacts from winter sports (skiing and snowmobiling) in 2015–2016.

3.3 State-level economic contributions

Colorado led the U.S. in economic contribution from these sports, with over 43,000 jobs and $2.56 billion in total economic value added in 2016 (Figure 2). California had the next highest level of economic activity, with over 21,000 employed and $1.24 billion in economic valued added. Vermont and New York led the eastern U.S. in winter tourism economic activity, collectively supporting 20,000 employees and generating more than $1.2 billion in value added to their economies.

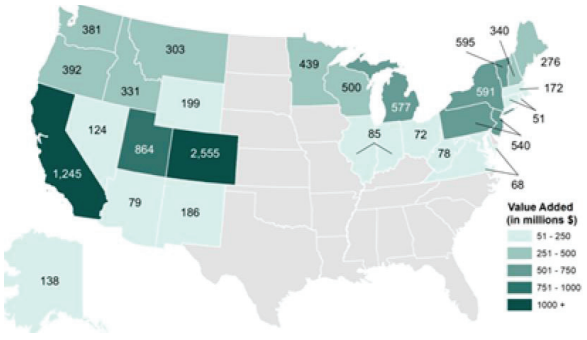

Figure 2. Map of Winter Sports Economic Contributions (Value-Added) in 2016.

3.4 Contributions from other winter activities

Further economic contributions occur from winter events, such as ski races, and other winter sports

** Value added, or net revenue, is the difference between what someone sells a good for and what one pays for all of the components used in producing the good. It is the same measure as Gross Domestic Product.*

such as cross-country skiing, snowshoeing, skate skiing, backcountry skiing, splitboarding, heli-skiing, cat skiing, snowshoeing, sledding, snow tubing, and ski biking. Data limitations prevented their inclusion in our economic modeling, but their economic contributions are noteworthy. Therefore, the results of the modeling represent an extreme lower bound of the total economic activity from winter recreation.

Human-powered snow sports (e.g., snowshoeing and backcountry skiing) are the fastest growing segment of winter recreation (Winter Wildlands Alliance, 2017), yielding significant economic contributions.

4. RELATIONSHIP BETWEEN SNOW AND SKIER VISITS

4.1 Skier days in the U.S.

While the number of people annually participating in skiing changes only modestly from year to year, the number of total annual skier visits (days) fluctuated considerably over the period 2001 to 2016, from over 60 million in 2008 to a low of under 50 million in 2012 (Figure 3).

An individual's decision to ski is influenced by a set of factors that include amount of snow, ticket prices, travel costs, ski resort characteristics, skiing budget, leisure time, and skiing ability (Dawson et al. 2013; Englin and Moeltner, 2004; Hamilton et al, 2007; Malasevska, 2017; Taks and Ragoen, 2016; Shih et al, 2008; Vanat, 2017).

Nationally, all of the years that showed a decline in skier visits (in Figure 3) correlated with low snowfall in states hosting a large proportion of national skier visits. The only exceptional year occurred in 2008—2009, which experienced a 5% reduction in skier visits despite normal to above average snowfall in most regions. The 2008—2009 season was however a severe recession year and supports the finding that skiers are responsive to economic conditions as well (Englin and Moeltner, 2004). All of the other winters in which participation declined were not in recession years. The winter of 2011—2012 had extremely low snowfall and warm winter temperatures across the country. This season saw the largest decrease in skier visits of over 9 million visits from the previous winter (2010/2011), and 5.7 million fewer visits than the long-term 2001-2016 average (56.6 million).

4.2 Correlations between skier visits and snow in the U.S.

Examining correlations between skier visits and snow gives insight into the influence of weather and climate conditions on skier participation. Between 2001 and 2016, data for the northeastern

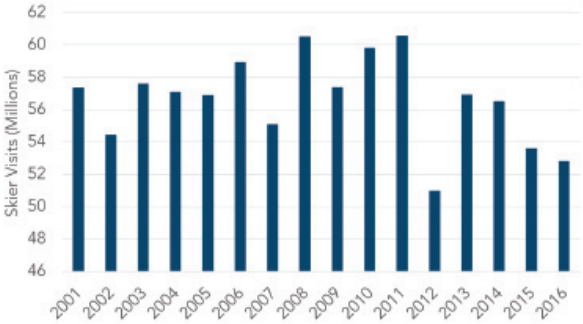

Figure 3. United States skier visits, 2000/2001 to 2015/2016 (Source: NSAA and RRC Associates, 2016).

U.S. showed strong and significant positive correlations between days with greater than four inches of snow cover and skier visits (Figure 4). These results are consistent with previous research that found aggregated skier visitation in the Northeastern U.S. was strongly and significantly correlated to season length (Wobus et al. 2017). Correlations are weaker and not statistically significant in the Southeast and Midwest, with the exception of Wisconsin.

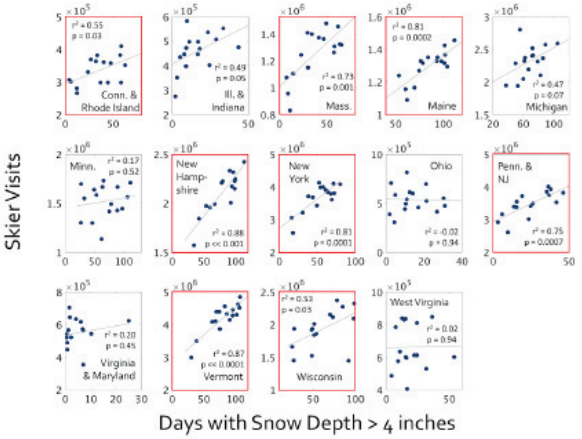

Figure 4. Correlation between skier visits and days with snow depth > 10.16 cm in the Northeastern U.S. Red indicates statistically significant ($p < 0.05$.)

Unlike the eastern U.S., the western U.S. has a network of stations that track snow water equivalent (SWE) at high elevation stations, some near ski resorts (SNOTEL, 2017). The analysis for this report found that snowpack persists well into late spring and summer at higher elevations. The snow season length at these stations often exceeds the ski season length at resorts, so using the same metric as the eastern U.S. (based on snow-covered days) does not work for the West. Alternately, an analysis of the correlation between skier visitation and SWE serves as a proxy for the relationship between snowfall and skier visits. Figure 5 shows the correlations between skier visits and total SWE in the West. Total SWE is the sum of all daily SWE values, or the area

integrated under the seasonal (Nov-April) SWE curve. Results show strong positive correlation between skier visits and total SWE for most states in the western U.S. Shelesky (2016) also found that average SWE is a significant driver of skier visitation in Colorado, and that variation in SWE is largely driven by precipitation (i.e., snowfall).

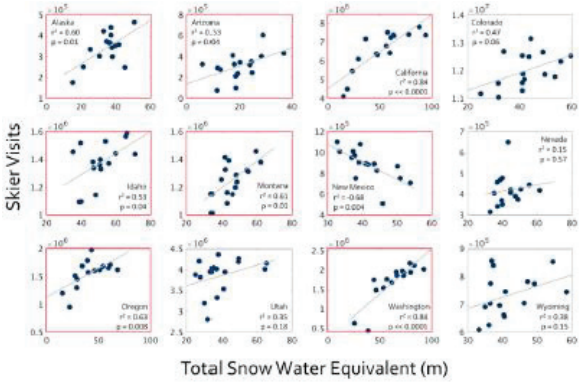

Figure 5. Correlations between skier visits and total Snow Water Equivalent (SWE) in the Western U.S. (Plots highlighted in red are statistically significant, with $p < 0.05$.)

5. CHANGE IN ECONOMIC CONTRIBUTIONS DURING LOW AND HIGH SNOW YEARS

5.1 Analytical approach

To understand the impact of varied snow conditions on economic contributions from the downhill ski and snowboarding industries, we:

- Estimated the average participation and related economic contributions for the 16-year period from 2001–2016;
- Determined the state-level average participation of the five highest snow years and of the five lowest snow years and compared those figures against the average participation over the 16-year period; and
- Used the IMPLAN model to calculate the difference in economic contributions that accompanied these varying levels of participation.

Visitation increased 7% during high snow years added an extra $692.9 million in value added and over 11,800 extra jobs nationwide compared to average participation. In low snow years, participation declined 10% on average and value added declined by over $1 billion and cost 17,400 jobs compared to average participation (Table 2).

Therefore, it appears that low snow years have larger (negative) impacts on the economy than the increases experienced in high snow years. In short, snow is directly tied to jobs and money. During a high snow year, resorts can reach capacity and may not be able to accommodate more ski-visits. In a low snow year, visitation can decline to zero, as was the case for Mt. Ashland in Oregon in 2013/2014 (Tomlinson, 2014).

The comparison of high- and low-snow impacts were also compared at the state-level (Table 2). California showed the largest differences in economic contributions between high and low snow years. While the state experienced a $175.7 million dollar increase over the average in high snow years, it endured a $246.6 million loss of value added during low years relative to average participation. Washington and Oregon showed the largest percent reduction in skier visits in response to low snow years, with losses of 31 percent and 18 percent, respectively, against the average.

	Average Skier Visits 2001-2016	% Average change in skier visits		Average difference in jobs		Average difference in value added ($ millions)	
		Top five snow years	Bottom five snow years	Top five snow years	Bottom five snow years	Top five snow years	Bottom five snow years
CA	6,578,334	14%	-20%	2,980	4,182	$175.7	-$246.6
OR	1,556,083	6%	-18%	320	890	$18.8	-$52.5
WA	1,692,472	20%	-29%	1,117	1,569	$65.8	-$92.5
US	**55,381,272**	**7%**	**-10%**	**11,752**	**17,358**	**$692.9**	**-$1,023.5**

Table 2. Average skier visits (2001-2016), percentage change in skier visits and associated change in economic contributions during the five highest and lowest snow years.

5.2 Other results from the literature

Results from other studies examining relationships between snow and skier visits include:

- Shih et al (2008) found ticket sales at two resorts in Michigan increased with increases in snowfall and lower temperatures.
- Hamilton et al (2007) found sales to increase with snowfall at two areas in New Hampshire. The study also found that the busiest 10 percent of days of the season accounted for 30+ percent of the season's revenue. Importantly, urban snow conditions increased skier demand (referred to as the "backyard effect"), suggesting that snowmaking has limits as an adaptation strategy in the northeastern U.S.
- Dawson et al. (2013) report skier demand and projected decreases in supply (ie: shorter season, fewer economically viable mountains) are not likely to be proportionate. The results suggest that future participation may be similar to that seen during marginal snow seasons in the recent past. Furthermore, they project a geographical market shift (i.e. greater market share for the ski areas that can remain open in a warmer climate).

6. CONSUMER SURPLUS IMPACTS

6.1 Consumer surplus

Snow has an impact on each skier's perceived value of skiing. As with many recreational

activities, the total value of skiing has two components: (1) the direct costs individuals actually pay to ski (e.g., ticket prices, equipment, transportation), and (2) what they would be willing to pay above the actual dollar value paid. The total value is referred to as "willingness to pay" (WTP).

While the first component (expenditures) was modeled by the IMPLAN analysis, we also examined the second component: the extra benefits skiers receive, which are termed "consumer surplus."

WTP and consumer surplus are important measures of economic benefits used by the federal government when conducting benefit-cost analysis (USOMB, 2000; U.S. Water Resources Council, 1983, used by the U.S. Army Corps of Engineers and U.S. Bureau of Reclamation).

Rosenberger, et al., 2017, conducted an extensive literature review of recreation valuation studies for the US Forest Service: the average consumer surplus value is $77.63 per downhill skier or snowboarder, $36.84 per cross-country skier, and $60.61 per snowmobiler.

6.2 Consumer surplus impacts from climate change

Warming winters could impact consumer surplus associated with winter recreation in at least two ways:

1) Less snow reduces the total number of ski visits per year and thereby reduces the collective annual value (total annual consumer surplus = $ per day x number of days per year).
2) Less snow could reduce consumer surplus values by reducing a skier's enjoyment of skiing, and thus reduce the per-day value (Englin and Moeltner, 2004).

For impact 1), we evaluate the effect of reduced visitation during low snow years on consumer surplus. For downhill skiing and snowboarding, low snow years had, on average, 10 percent less visits than an average year. This results in a consumer surplus loss of $430 million annually for skiing and snowboarding. Applying the 10 percent reduction in visits to snowmobiling and cross-country skiing (due to lack of estimates particular for these sports), a loss of consumer surplus of $112 million would occur to cross-country skiers and $82 million to snowmobilers.

For impact 2), further research needs to be conducted to determine how snowfall impacts skier consumer surplus values. Some skiers might not have a preference between natural snow and man-made snow; some skiers prefer the consistency and compactness of man-made snow; and many skiers prefer natural snow, which is typically softer and less icy than man-made snow. Some skiers prefer larger quantities of natural snow, as reflected by increased volumes of skiers on 'powder days,' after 6 inches or more of snow has fallen overnight.

Englin and Moeltner, 2004, found that consumer surplus values increase with snowfall. The study also found the marginal effect of temperature on expected demand is negative. "On average, therefore, riders prefer lower temperatures and more snow… An abundance of fresh snow is especially desirable on more difficult and out-of-bounds runs… [L]ower temperatures allow for better and longer lasting 'powder' conditions."

A 10–30 percent reduction in consumer surplus for skiers would lead to a further loss of $430 million to $1.3 billion, assuming the 2001–2016 average participation. However, any loss in consumer surplus to skiers experienced to date has not been estimated. The impact of reduced snow and higher temperatures on consumer surplus for snowmobiling, cross-country skiing, and other winter sports is also unknown.

It is likely that industries which are able to make snow would have experience less of a loss in per-day consumer surplus values than sports reliant upon natural snow, such as backcountry skiing.

7. SKI RESORT ADAPTATION STRATEGIES

This industry relies on snowfall and below freezing temperatures. A minimum amount of snowfall is needed for ski resorts to run their operations, both physically (there needs to be enough snow to ski) and financially (there needs to be enough skiers to cover operational costs).

Resorts recognize the impact of snow on visitation and have upped investments in sustainability, education, and adaptation strategies to mitigate climate change and become more resilient to low snow years.

Some resorts are aiming to generate their own power from clean energy or are working with their utility to develop contracts for clean energy if they do not have the means for developing their own. Often businesses can develop small hydro, solar, or other clean power sources as income generators and clean power providers.

Sustainability projects at ski areas generally fall into six categories: (1) energy efficiency of buildings, (2) snowmaking efficiency, (3) utility energy management, (4) food and beverage waste reduction and recycling, (5) sustainability marketing and communications, and (6) human resource efforts to increase retention and worker productivity (Wortman 2014). Increasing snowmaking efficiency requires the largest capital investment

(averaging $550,000) but can reduce operational costs by over $130,000 per year (Wortman, 2014).

Additional ski resort management responses to reduced snow and increased unpredictability include (1) increased snowmaking (for the 89% of ski areas that make snow), (2) geographic diversification (for companies owning multiple resorts) to ensure at least some resorts under a company's profile have good snow in a given year, and (3) changing dates of operations (opening later and closing earlier in the spring).

Some resorts are finding success investing in other recreation options, including mountain biking, zipline tours, rock climbing walls, alpine slides, indoor water parks, and events such as music concerts and weddings. Resorts are finding that diversifying their business can ease impacts of low snow years.

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