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Sustainability

Oh no snow?

25 November 2024

Key takeaways

- In the last 30 years, there has been a loss of about 11-17 inches of snowfall nationally per BofA Global Research. Plus, the season for snowfall has been getting shorter and peak snowfall has been happening earlier. These shifting snow trends ultimately have a large impact on the ski industry, with the potential for snow accumulation to decline by 20-30% across US resorts by 2050.
- Yet, not all ski resorts are equal, and those with higher base altitudes are better positioned to avoid closures due to lack of snow security than those at lower altitudes. And a shorter season puts a majority of ski resorts at risk for either not opening by Christmas or not staying open for 100 skier days, which challenges operations, profitability and sustainability.
- A critical way to address lower snowfall is snowmaking technology, especially for ski and mountain resorts in the Southeast, Midwest and Northeast. However, rising winter month temperatures put snowmaking at risk, even if the physical infrastructure exists.

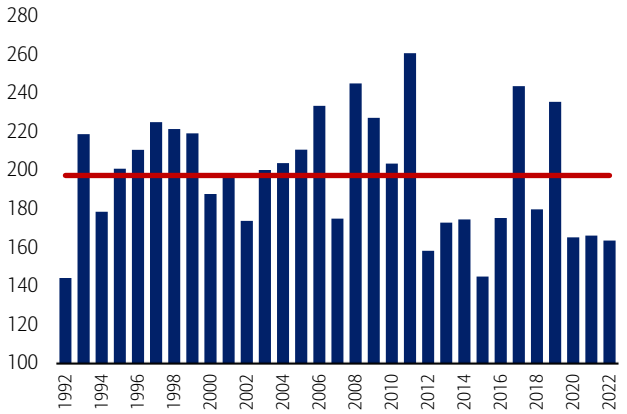
What is the future of snow?

Data from the Environmental Protection Agency (EPA) shows that snowfall across the United States has declined by 0.19% per year on average between 1930-2007. In the last 30 years, BofA Global Research estimates this has resulted in a decline of between 11-17 inches of snow nationally in the United States, with larger declines in the West.

Additionally, data from the National Ski Area Association (NSAA) indicates that reported snow by ski resorts has declined by 17 inches in total (0.27% per year) on a trendline basis between 1991-2022 (Exhibit 1). And snowfall in western ski regions/locations has declined by 24 inches (0.20% per year) on a trendline basis between 1983-2023, according to data from the US Department of Agriculture's (USDA) snow telemetry (SNOTEL) system.

Exhibit 1: Per data from the NSAA, the average US ski resort receives/reports just under 200 inches of snowfall per year over the last 30 years

US average annual snowfall (inches) 1991-2022 (NSAA data)



Source: NSAA
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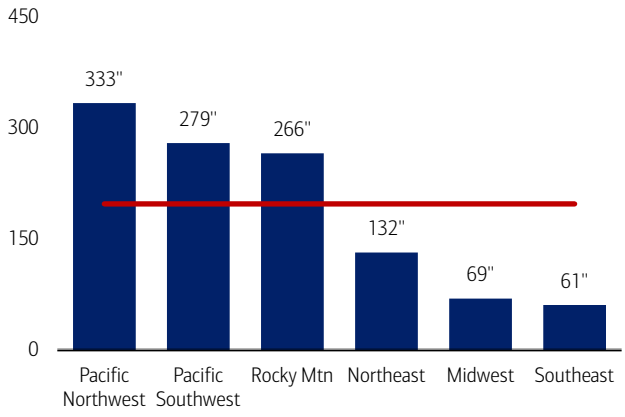
Exhibit 2: Per data from the NSAA, the Pacific Northwest receives the largest amount of snowfall annually at over 300 inches, with the Pacific Southwest and Rockies each above 250 inches per year over the last 30 years

US annual snowfall by region (in inches) 1991-2022 (NSAA)



Source: NSAA
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The impact of a changing climate on ski resorts

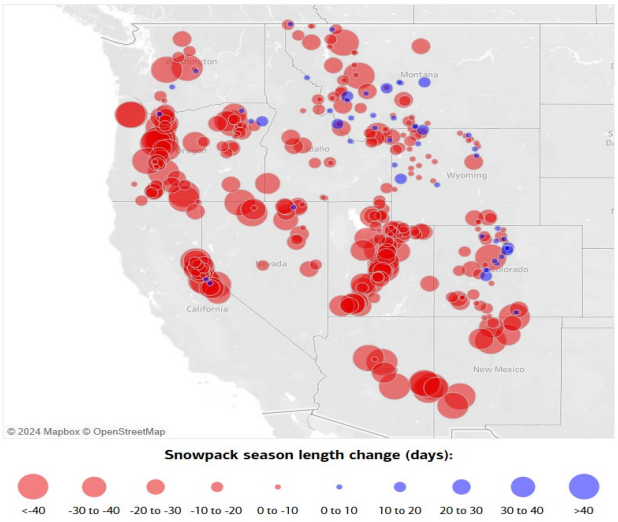
In addition to declining snowfall amounts, the snow season has been getting shorter and timing of peak snowfall has been getting earlier. Even after accounting for snowmaking activity, which is the production of snow via technology, the ski season across four main ski regions has already declined by a visit-weighted average of just over five days or about -4% (on an average season length of 115 days) since the 1960's-1970's[1].

This is consistent with NSAA data that shows between 1991 and 2022 the ski season has declined by three days in the Rockies and six days in the Pacific Northwest, both where snowmaking is less prevalent (Exhibit 4). Conversely, the ski season has increased in the Northeast, Midwest and Southeast where snowmaking is the most prevalent.

The EPA estimates that from 1955 to 2023, April snowpack declined at 81% of sites and declined across all 12 states where it was measured. The average change across all sites amounts to about an 18% decline. And from 1982 to 2023, the snowpack season decreased by about 15 days, on average, and became shorter at about 80% of the sites where snowpack was measured (Exhibit 3). The peak snowpack has also moved eight days earlier from April 10th to April 2nd.

Exhibit 3: From 1982 to 2023, the snowpack season became shorter at about 80 percent of measured sites. Across all sites, the length of the snowpack season decreased by about 15 days, on average

Change in snowpack season in Western US 1982-2023 (EPA)



Source: US EPA
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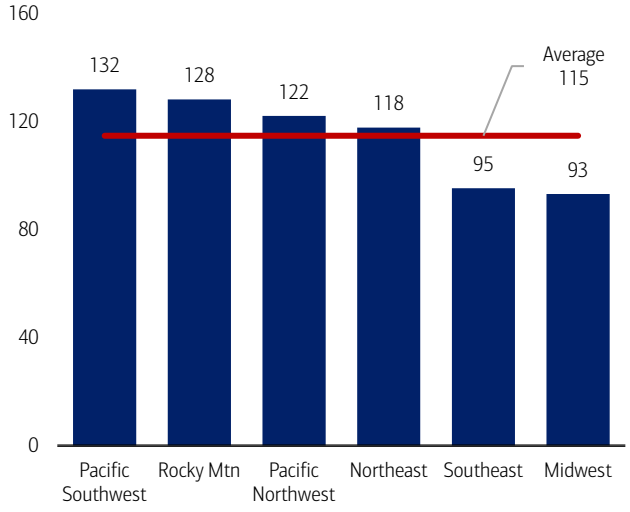
Exhibit 4: According to data from the NSAA, the average ski season length is 115 days with the longest seasons in the Pacific Southwest and Rockies and the shortest seasons in the Southeast and Midwest

Average season length in days by region (1992-2022)



Source: NSAA
BofA Global Research

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The weather forecast: snow could decline by 20-30% across US resorts by 2050

According to BofA Global Research, there are two generally accepted climate models: Representative Concentration Pathways (RCP) 4.5 and RCP 8.5. These models measure and predict how different scenarios effect how much radiation enters and leaves Earth, resulting in a warmer atmosphere. More technically, the radiative force (as measured in Watts/meter squared) of the amount of energy that enters Earth's atmosphere vs. the amount of energy that leaves it.

- **RCP 4.5**: Assumes a medium effort to curb emissions, including becoming more reliant on renewable energy sources, higher usage electric vehicles, and expanding forests. Under this scenario, the average temperature would increase by 1.8C (3.24F) by the year 2100.

- **RCP 8.5:** Assumes a low effort to curb emissions, and a high reliance on coal-fired power, and high use of gas dependent cars and trucks. Under this scenario, there would be a large increase in extreme weather, and the average temperature would increase 3.7C (6.67F) by the year 2100.

[1] Scott, D., & Steiger, R. (2024). How climate change is damaging the US ski industry. *Current Issues in Tourism*, *27*(22), 3891–3907. https://doi.org/10.1080/13683500.2024.2314700

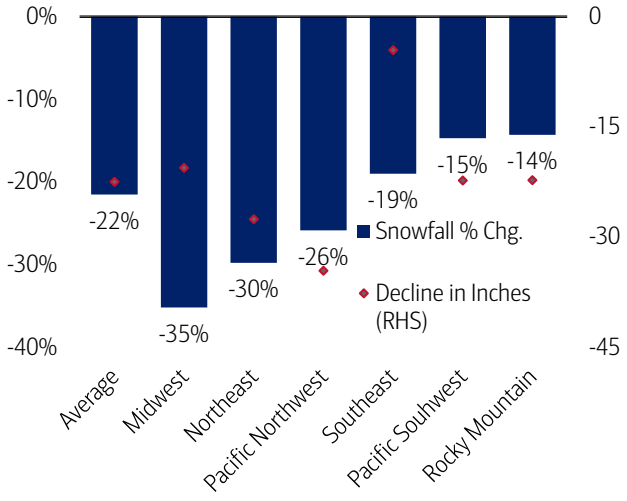
The Midwest is more at risk for declines in ski visitation

Cameron Wobus and a team from the University of Colorado Boulder in their 2017 paper "Projected climate change impacts on skiing and snowmobiling" (2017) studied how snow conditions across 247 ski areas in the US would evolve under the RCP 4.5 and 8.5 climate scenarios. From a baseline of 2017, Wobus estimated that the amount of snowfall in key ski resort geographies could decline by between 14-50% by the year 2050 (Exhibits 5 and 6).

When weighted for ski visitation in these geographies, BofA Global Research found average declines at -22% (-22 inches of snow) for RCP 4.5 (medium emissions) and -29% (-33 inches of snow) for RCP 8.5 (higher emissions). In both scenarios, ski resorts in the Midwest are most at risk, while the Rockies are the least at risk.

Exhibit 5: According to research by Cameron Wobus, by 2050 under RCP 4.5 (medium emissions), projected snowfall across US ski resort regions would decline by -22% (22 inches) on average and 14-35% overall

Projected snowfall decline by 2050 under RCP 4.5 (Wobus)



Source: Adapted from "Projected climate change impacts on skiing and snowmobiling" (2017); Cameron Wobus, Eric E. Small, Heather Hosterman, David Mills, Justin Stein, Matthew Rissing, Russell Jones, Michael Duckworth , Ronald Hall , Michael Kolian, Jared Creason, Jeremy Martinich
Note: Average is weighted by average annual skier visitation over the last 20 years
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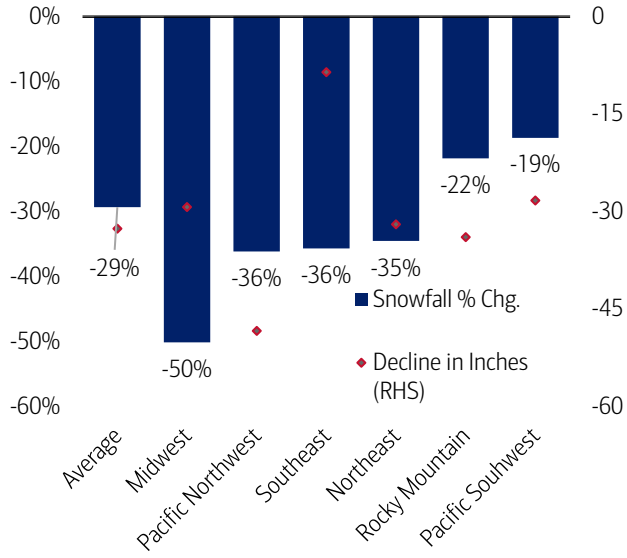
Exhibit 6: According to research by Cameron Wobus, by 2050 under RCP 8.5 (high emissions), projected snowfall across US ski resort regions would decline by -29% (33 inches) on average and 19-50% overall

Projected snowfall decline by 2050 under RCP 8.5 (Wobus)



Source: Adapted from "Projected climate change impacts on skiing and snowmobiling" (2017); Cameron Wobus et. al
Note: Average is weighted by average annual skier visitation over the last 20 years
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Implications of snowfall: Higher is clearly better

Different mountain ranges and different ski regions in the United States differ materially in their base altitude. Using SNOTEL data, BofA Global Research found that elevations below 2,500 feet (~760 meters) have lost nearly three inches of snow per year or almost five times as much as the 0.52 inches per year lost at elevations above 2,500 feet over the last 41 years.

When looking by state and region, Colorado and Utah on average (both considered the Rockies) have the highest base elevations for ski resorts at 8,800 feet (~2,700 meters) and 7,400 feet (~2,250 meters), respectively.

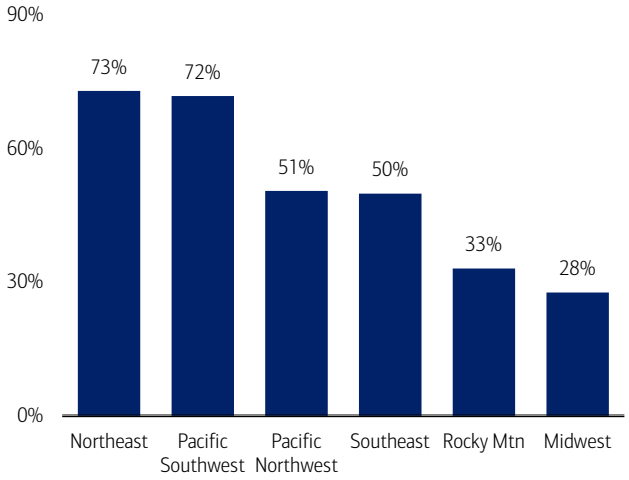
Average elevations in the Pacific Northwest and British Columbia are substantially lower, while the Northeast, MidAtlantic and Midwest do not even reach 1,500 feet. Averages by mountain range also highlight some of the risks, with the Rockies (Colorado and Utah) and Sierra Nevadas (California) being more protected.

More Après ski, less time for the slopes?

In their recent paper "How climate change is damaging the US ski industry" (2024), Daniel Scott (University of Waterloo) and Robert Steiger (University of Innsbruck) showed a similar analysis and potential risk for ski season length.

On average, Scott & Steiger predict that US ski resorts could lose between 17 and 28 days (15% and 24% of their season length) by 2050 under the RCP 4.5 and RCP 8.5 scenarios, respectively (Exhibit 8). Importantly, Scott & Steiger's modeling incorporates the use of snowmaking as an offset for less snowfall.

Exhibit 7: According to data from the NSAA, the correlation between snowfall and season length is not uniform. This likely has to do with both snowmaking capabilities and coverage as well as receiving enough overall snow to remain open
Correlation of snowfall vs. season length (NSAA data)



Source: NSAA, BofA Global Research

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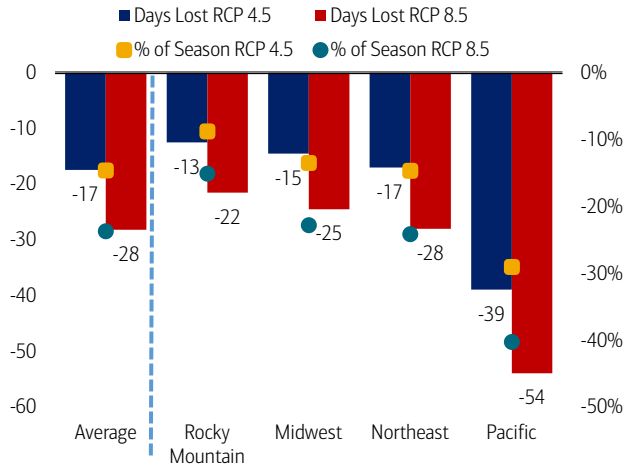
Exhibit 8: By the 2050s at RCP 4.5 and 8.5, Scott & Steiger model that US ski resorts could lose between 17 and 28 skier days or 15% to 24% of their season. The largest season declines would be in the Pacific and Northeast.
Projected ski season decline by the 2050s (Scott & Steiger)



Source: Adapted from "How climate change is damaging the US ski industry" (2024); Daniel Scott & Robert Steiger

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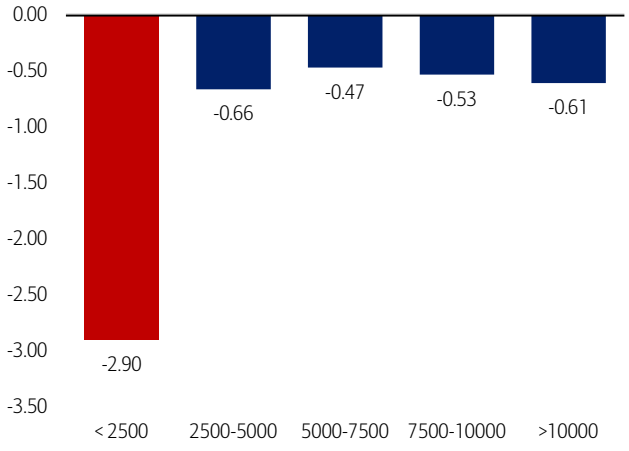
Ski season timing, however, is not equally at risk, and Cameron Wobus has also analyzed the timing and impact of ski opening dates. By 2050, his team estimates the end of the season could move early by 21 days from April to March 20th (under RCP 4.5) and by 25 days to March 16th (under RCP 8.5).

The late season is more at risk than the early season due to the changing climate, with the early season shifting by 11-12 days. However, this shift could put the financially important Christmas holiday opening at risk at a majority of US ski resorts by 2050.

According to Cameron Wobus and team, there are two generally accepted wisdoms for operating ski resorts profitably. First, the "Christmas rule," where ski resorts rely on opening by the important two-week period around Christmas and western New Year for about a quarter of their season's revenue.

Exhibit 9: Analyzing SNOTEL data shows a very large difference in the trendline of snowfall change based on altitude. Altitudes below 2,500 feet have seen an annual loss of nearly 3" of snow, nearly 5x that of higher elevations
Change in annual snowfall by altitude in western US (SNOTEL data)



Source: USDA SNOTEL, BofA Global Research

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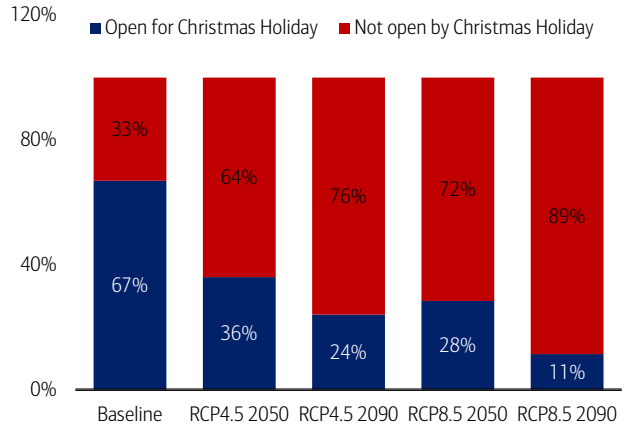
Exhibit 10: Projections from Cameron Wobus indicate that the majority of US ski resorts are at risk of not being open for the start of the Christmas holiday
Christmas rule: Projected season openings for RCP 4.5/8.5



Source: Adapted from "Projected climate change impacts on skiing and snowmobiling" (2017); Cameron Wobus et. al
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When looking at the Christmas rule, Cameron Wobus and team analyzed the risk of opening by Christmas (December 25th) for US ski resorts under the various climate scenarios. By 2050, RCP 4.5 and 8.5, between 64-72% of US ski resorts are at risk of not opening by Christmas, up from just 33% today, putting this important vacation period at risk for operators (Exhibit 10). Importantly, this analysis did factor in snowmaking, with the exception of Nordic skiing.

The second is the "the 100-day rule". To analyze the 100-day rule, BofA Global Research combined current average operating length data from the NSAA with the season length climate scenarios run by Daniel Scott and Robert Steiger. By 2050, under both RCP 4.5 and 8.5, the average ski resorts in all regions except for the Rockies are at risk of not being able to sustain a 100-day season.

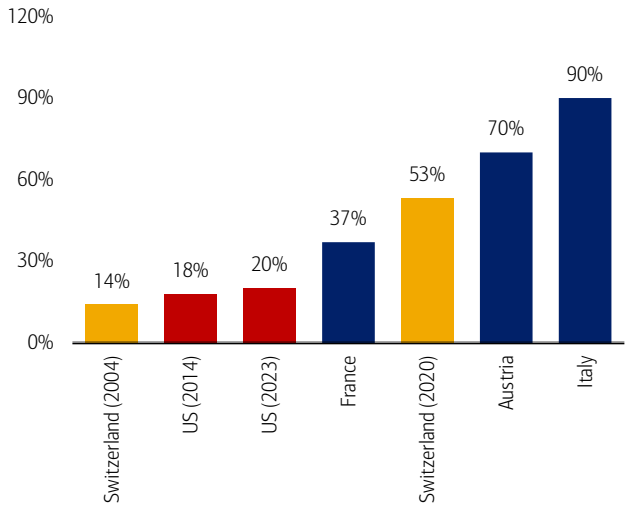
Snowmaking creates powder

A critical way to address lower snowfall is snowmaking technology. But snowmaking requires its own specific factors to be successful: 1) low enough temperatures and appropriate humidity, 2) significant amounts of water and infrastructure including pumps and pipes to get the water to the right place, and 3) labor and electricity.

Snowmaking varies by region and has increased modestly over time. On average, about 20% of US ski resort terrain (skiable acres) is covered by snowmaking, according to BofA Global Research (Exhibit 12). Regions that are the least snow secure – including the Southeast, Midwest and Northeast – tend to have the most coverage at 66-97%, while the highest snowfall regions of the Pacific Northwest and the Rockies only average 4-11% coverage. Over the last decade, snowmaking coverage has increased by around 2pp, from 18% to 20% of skiable acres.

However, rising temperatures put optimal conditions at risk. Snowmaking requires ideal "wet-bulb temperatures," which is a combination of air temperature and the amount of moisture (humidity) in the air. Low humidity allows for more optimal wet-bulb temperatures. Snowmaking requires a wet-bulb temperature of 28F (-2C) and the humidity relationship helps explain why rain (100% humidity) is often the enemy of snowmaking.

Exhibit 11: Given the lower altitude of ski resorts in Europe, they have invested more heavily in snowmaking and on average have 63% snowmaking coverage
Global skiable acreage covered by snowmaking (%)



Source: NSAA

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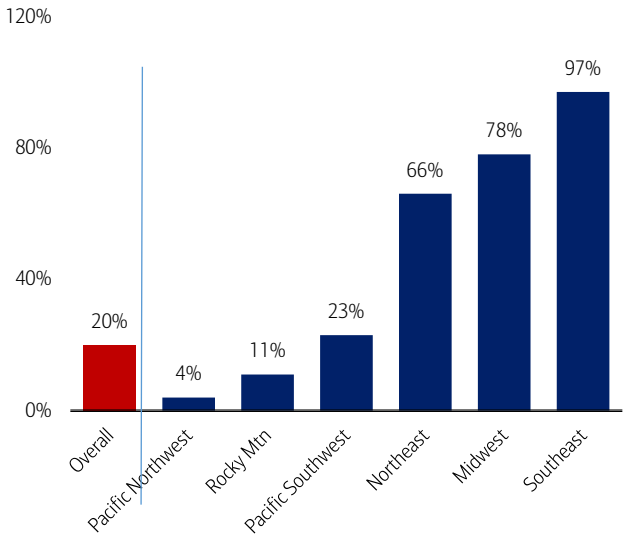
Exhibit 12: 20% of skiable acres in the US are covered by snowmaking with the highest coverage in the least snow secure regions of the Northeast, Midwest and Southeast
Skiable acreage covered by snowmaking in the US (%)



Source: NSAA

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Methodology

This report relies heavily on in-depth academic papers and research published by Cameron Wobus and team including "*Projected climate change impacts on skiing and snowmobiling" (2017)* and Daniel Scott and Robert Steiger including *"How climate change is damaging the US ski industry" (2024)*. These researchers have applied detailed climate modeling that incorporates the *net* effects after accounting for snowmaking to the various topics, regions and timeframes cited throughout this report. We cite these sources clearly in the Exhibit titles and footnotes where appropriate. Additional sources include data from the EPA, USDA's SNOTEL system, Climate Impact Study, and the National Ski Areas Association.

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