

“My biggest fear is a multi-year drought...”: Climate Exposures in the Intermountain West Ski Industry and Pathways for Action

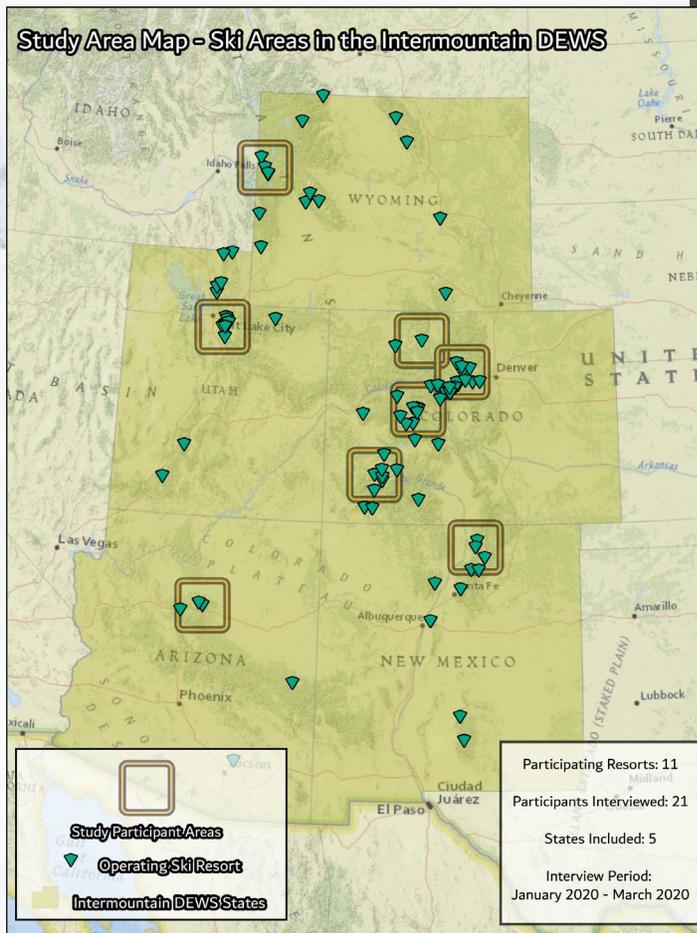
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Introduction

As the climate warms, extreme events become more common, and both intra- and inter-annual weather variability increase, industries that rely upon natural weather phenomena need up-to-date information on how these systems are changing, both now and in the future. Among these, the most critical needs exist in industries that depend upon unique and extreme climatological niches, such as the ski industry, which subsists upon the snow-bearing characteristics of high-elevation mountain parks and valleys long known as particularly challenging to the meteorological community.

In furtherance of the National Integrated Drought Information System’s ongoing work to support decision-makers in climate-sensitive industries, the Colorado Climate Center investigated how ski area managers and decision makers in the Intermountain West understand, utilize, and think about weather and climate information resources. Central to this was an exploration of the various time scales that ski area managers make decisions in, and what role – if any – existing modes of delivering climate and weather data play in their decision-making. Looking further, we also examined how agencies like NIDIS, the CCC, and the broader meteorological community can curate existing data, develop new data products and metrics, and implement programming aimed at improving the ski industry’s capacity to make decisions amid an uncertain future. In this document, we present the high level findings of this research effort, along with several key recommendations for future work by NIDIS and its partners.



Methods

We interviewed 21 ski area managers and critical support staff (including snow-making, safety, risk management, sustainability, strategic planning, and other teams) from 11 resorts across the Intermountain DEWS using telephone, videoconference, and email over the late winter and spring of 2020. Interviews were then transcribed verbatim, and systematically analyzed for themes relating to industry climate and weather exposures, time frames for critical decision-making, key decision types, barriers to the utilization of existing climate and weather data, and opportunities for improvement in the delivery or development of climate and weather data.

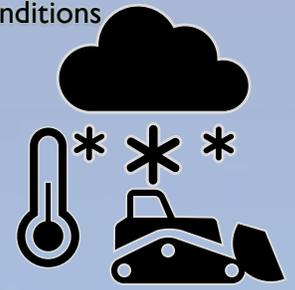
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Climate and Weather Exposures: Beyond Snowpack

Understanding how to serve the meteorological needs of the ski industry begins with understanding their complex relationship with the unique weather systems they interact with. While factors such as existing snowpack and local storm activity play a significant role in day-to-day decisions, at the operational and strategic levels ski area managers must look to yearly weather patterns and multi-year water supply factors as they attempt to maintain profitability and efficiency in an increasingly dynamic, competitive, and diversified industry. For our participants, significant exposures to weather and climate risks (and needs for information) broke down into a variety of levels:

- **Operational Conditions:** Including daily and forecasted snowfall, wet-bulb temperatures, snowmaking suitability, snowpack conditions, insolation levels, wind risks, and near-term storm formation, as well as other extreme event risks to life, property, and operational excellence.
- **Seasonal Mountain Conditions:** Including year-to-date snow histories, interactions between rain and snowpack, temperature-driven melt events, storm event impacts to avalanche and landslide risk, and near-term costs associated with risk mitigation.
- **Inter-annual Resource Conditions:** Especially as relates to water supplies in reservoirs year-to-year for future snow-making. Long-term drought and long-term drying can also impact diversification strategies, as well as costs associated with snow-making.
- **Local Ecological Conditions:** Forests are the “walls” of the ski slope. As such, exposures related to forest health and fire risks, forest and landscape management considerations, and permitting considerations related to infrastructure development are all critical to consider.
- **“Off-Season” Diversification Exposures:** As ski resorts continue their efforts to capitalize on spring, summer, and fall activities, overall resort function requires a better understanding of land and weather conditions tied to a variety of activities, such as mountain biking, outdoor education, musical events, fund-raising, weddings, and more.
- **Community and Regional Exposures:** No ski resort is an island, and impacts to mountain communities and the regions of which they are a part can also affect both operations and long-term strategies at the resort level. This is especially true when planning expansions and working with community partners to mitigate other resort-level risks.

Operational Conditions



Seasonal Mountain Conditions



Resource Supply and Demand



Ecological Risks and Management Costs



“Off-Season” Diversification Exposures



Community and Regional Trends



Ski Industry Decision-Making Time Horizons

Running and maintaining a ski resort requires managers to make decisions relating to a variety of time horizons, all of which can be impacted by both short-term weather and long-term climate trends. In most cases, however, **near-term decisions (from “In the Moment/On the Day” conditions out to “Tactical” time horizons)** take precedence, with on-the-ground conditions being the most critical factor in ensuring operational function and an exciting, fun, and safe guest experience. As a result, the vast majority of thought, energy, and decision-making occur within this time frame, even in organizations where long-term planning is an organizational goal.

In the **short to medium-term (“In-Season” and “Yearly Operational” time horizons)**, managers and critical support staff must look to issues regarding their infrastructure, their critical assets, and most importantly, their capital reserves. They must also decide when, where, and how to direct resources to ensure continuing and future operational viability. Planning for construction, forest management, training, and risk mitigation all fall within this range, and are all sensitive to both seasonal trends and short-term events. As such, knowledge of long-term weather and climate trends may be valuable assets, but require a scenario-based approach for maximum utility due to their inherently probabilistic nature.

Similarly, **long-term decisions (“Strategic” and “Legacy” time horizons)** must also take into account weather and climate risks, but do so only after considerations of profitability and feasibility are taken into account. Further, because resorts must focus on the near-term issues they continually face, the further out one looks from the present, the less time is spent planning, and the fewer resources are allocated. However, because resort operations are complex, even medium-term plans for expansion or investment may require taking into account long-term and or large scale impacts from resort activities, especially as relates to water and other common pool resource use. Increasingly, resorts may also concern themselves with how to protect their long-term legacies in the face of a changing climate.



What time horizons are relevant to ski area management and planning?

What type of questions do they need answered within these time frames?

“In the Moment/On the Day” (0 - 48 hours)			
What are current conditions, and what can the resort expect in the next 48 hours? Are the guests going to be safe and enjoy themselves? Are conditions right for snow-making, grooming, or avalanche blasting, and for how long? Are there weather risks imminent or on the horizon? Are there risks to snowpack or safety on the mountain due to weather conditions? Are there risks to my infrastructure or equipment due to wind, storms, or other weather?	Tactical (48 hrs – 1 week)		In-Season Operational (1 week – 5 months)
	Will storms, hot spells, rain, or other weather require interventions from crews? Will risks to safety emerge in the near-term that must be addressed by our mitigation teams? Is our equipment and infrastructure positioned to respond? Can we expect surges/declines in visitation due to changing local or regional conditions? When will conditions be right for interventions such as repairs, grooming, or training?	Will snowpack and landscape conditions conflict with our opening dates? Will conditions be right for snow-making and grooming leading up to our opening dates? Will we have the staff we need to meet resort demands? Are our supply lines and access to critical services likely to be affected by on-going conditions? How does this year compare to previous years where weather related issues emerged?	Yearly Operational (5 months – 1 yr.)
		Strategic (1 yr. – 5 yr. +)	
		Legacy (5 yrs +)	
		Can we integrate the lessons we learned over the last season into our future plans? What fire, landslide, or flooding risks might impact our off-season operations, maintenance, and expansion plans? How do we train next year’s staff to equip them for the weather they’ll face?	Where do we invest to maximize our ability to weather-proof operations? Will future droughts impact our critical water supply needs? What expansions, partnerships or programs do we need to build to achieve operational sustainability, given weather and other risks?
		How do we ensure our operation is doing what it can to reduce its long-term ecological and climate impacts? How do we ensure our resort can survive and thrive in the climate profile our mountain will see in the future?	

Barriers to Climate and Weather Data Usage

Although climate and weather factors play a critical role in nearly every level of operational success for ski resorts, not all resorts are equally positioned or equipped to utilize information on these topics. With each resort inhabiting a unique setting and weather positionality, even regional forecasts may miss the mark. Further, because decision making necessarily focuses on the “here and now”, it may not always be clear to managers which indicators have relevance to their day-to-day decision-making. And while all resorts collect extensive on-site

weather data as part of their snow-making operations, developing the ability to actively organize, analyze, and integrate this data may take low priority for all but the largest and most well-capitalized operations.

Across our interviews, we identified several key barriers to integrating weather and climate information into adaptive decision-making, including:

Limited Trust in Forecasts

Although all managers follow local near-term weather forecasts and monitoring information, the uniqueness of their resorts and the criticality of snow and safety management mean that their own senses and the instincts of their internal specialists play critical roles in their daily decision-making. Further, because the mountain valleys and parks they work in have notoriously dynamic weather patterns, forecasts beyond the 48 hour range are viewed with significant skepticism. This also holds true for seasonal or annual modeling outputs, which may have low or unknown reliability. Although information is valued and sought out, trust is carefully given.

Lack of Data Management and Modeling Capacity

All resorts engage in some degree of on-resort monitoring of snowfall, snow depth, wind, temperature, humidity, and other critical variables. However, this data is often only utilized “on the day”, especially when deciding when and where to produce snow in the early season. Although often dating back decades or more, these records are seldom systematized or analyzed beyond comparing one year to the next. Further, modeling based on local scale data is beyond the capacity of all but the largest and most well-capitalized resorts.

Lack of Familiarity with Available Data and Indicators

Although nearly all of the managers and specialists we talked with are avid weather watchers and consumers of weather information, overall knowledge about the range of data products and analytical outputs provided by the meteorological and climatological community was mixed. In many cases, study participants noted that “they did not know if they were missing anything” when it came to using climate and weather data, especially in terms of medium- and long-term forecasting products and modeling outputs.

Lack of Understanding Regarding Local Climate Trends and Projections

Climate change, especially in terms of its potential effects on snowpack and seasonality, was widely recognized as a long-term risk for the industry. However, few of those interviewed felt that they had a good understanding of what actual climate models and projections might mean for their region. Moreover, because of the politicized nature of climate change in the United States, many expressed concern regarding their ability to effectively engage with the topic, especially when dealing with nearby community members, Federal partners, or representatives of the media.

How can NIDIS and the Meteorological Community Help?

The unique and iconic position of Intermountain West ski resorts places them at a nexus of social, economic, climate, weather, landscape, and dynamic (and not necessarily direct) drought processes. Understanding this confluence of factors is critical to the furtherance of NIDIS's core mission of enabling communities and decision-makers to make better informed and more timely decisions to reduce the impacts and costs of extreme hydrological conditions. By integrating ski area managers into existing climate and weather data development efforts, NIDIS and partnering programs across the meteorological community can further both their own operational goals and pave the way for a clearer understanding of how regional scale climatology is reflected in high-elevation, high-value sites.

Doing so, however, will require a multi-faceted approach, one that acknowledges the diversity and dynamism of the ski industry itself. Based on conversations with managers, we have identified

three main avenues of action to pursue in the coming years, each of which has been identified by managers as having the potential to improve both their operational effectiveness and their medium-to-long-term planning capacity. These include the development of data curation programs, such as online dashboards, which help managers to sift through and understand the vast and growing array of existing drought, weather, and climate data services. Similarly, in an effort to learn from and with ski resorts, the development of programs and partnerships to assist resorts in the management of their existing (often extremely high spatial and temporal resolution) datasets can help to build both trust and decision-making capacity. Finally, ski and recreation industry focused education and engagement efforts were identified as valuable. Including both direct value to existing operational information needs, such work might also allow for the emergence of new partnerships and modes of integrating climate information into the operations and plans of resorts and nearby resort towns.

Data Curation



Work in consultation with ski areas to develop a ski industry focused **data dashboard** that brings together a range of existing data sources including:

- Data feeds for up-to-the-minute weather information at the resort level, such as on-slope wet-bulb temperatures, wind speeds, and extreme event formation metrics.
- Medium-term, basin scale metrics for soil moisture, snowpack, streamflow, and rain-on-snow event tracking
- Long-term indices for drought conditions, year-to-year weather comparisons, long-term climatology, and ENSO dynamics.

Data Management



Develop mechanisms for the **sharing and management of data collected at the resort level**, which can often include records dating back 30 years or more in a variety of formats, including:

- Create systems for sharing, digitizing, and managing on-resort data
- Providing tailored analyses of on-resort data as relates to in-season and off-season performance metrics
- Build modeling tools for use by and with resort managers incorporating these datasets
- Integration of on-resort data gathering into dashboards and other publicly available tools.

Education and Engagement



Develop **programs that improve connections** between the meteorologists, climatologists, and other experts with ski resorts and the cities and towns they are a part of, including:

- In-person educational programming on climate change impacts in high elevation communities, drought and extreme weather event processes, and local ecosystem sensitivities.
- Improving the ability of ski resorts to communicate with residents and media outlets regarding climate-driven risks and responses.
- Working within existing industry events and outlets to disseminate weather info.