

Drought and Outdoor Recreation: Impacts, Adaptation Strategies, and Information Gaps in the Intermountain West

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Foreword

The National Oceanic and Atmospheric Administration’s (NOAA) National Integrated Drought Information System (NIDIS) program was authorized by Congress in 2006 ([Public Law 109-430](#))—and reauthorized in 2014 and 2019—with an interagency mandate to coordinate and integrate drought research, building upon existing federal, tribal, state, and local partnerships in support of creating a national Drought Early Warning System (DEWS). A DEWS utilizes existing and new networks of researchers, academics, policymakers, resource managers, and other stakeholders to make climate and drought science readily available and relevant for decision makers in order to strengthen the nation’s drought resilience and to reduce the costs of drought. To establish a national DEWS, NIDIS created regional DEWS, where networks of partners support local stakeholders to monitor, forecast, plan for, and manage drought-related risks.

In 2019, NIDIS partnered with the University of Colorado’s Masters of the Environment Graduate Program to research drought information needs of the outdoor recreation industry in the Intermountain West DEWS (Arizona, Colorado, New Mexico, Utah, Wyoming), with the goal of addressing those information needs and strengthening the industry’s drought resilience.

Outdoor recreation is a major contributor to the Intermountain West’s economy, but the future viability of many businesses—particularly small businesses—in the industry is threatened by their drought vulnerabilities and the region’s projected increases in drought severity and frequency.

For this project, five Masters of the Environment graduate students worked with NIDIS to research drought impacts on and information needs of water-based outdoor recreation businesses, with a focus on the following subsectors: ski resorts; snow-based sports (e.g., dog sledding, Nordic skiing); lake-based sports (e.g., boating, paddle boarding); fishing; rafting, and small retailers. Between May and August 2019, 112 water-based outdoor recreation businesses (ski resorts, snow-based, fishing, rafting, lake-based, and small retailers) were interviewed and surveyed to determine how drought impacts their operations, adaptation strategies employed to mitigate negative drought impacts, and drought information needs to reduce the vulnerability of the industry.

This report presents the research methods and findings, including the following detailed information for each subsector:

- How drought impacts business operations
- Adaptation strategies of the businesses
- Current drought and weather information use
- Drought information needs.

This report seeks to provide NIDIS with recommendations for addressing drought information gaps of outdoor businesses with the aim of addressing those gaps and increasing the resilience of this industry in the Intermountain West. All information, material, and views presented in this report are those of the authors of the report. They do not necessarily reflect the opinions, views, or official policy or position of the National Integrated Drought Information System, NOAA, or any agency of the United States government.

Introduction

The outdoor recreation industry contributes 2.2% of the United States' national gross domestic product (GDP), making the sector larger than oil and gas extraction (1.4%), agriculture (1%), and utilities (1.6%) (U.S. Bureau of Economic Analysis, 2019; Mitka, 2018). Furthermore, the recent growth of the outdoor recreation industry has outpaced the growth rates of the national GDP, national real gross output, national average compensation, and national employment (U.S. Bureau of Economic Analysis, 2019). Depending on how broadly one defines its scope, the outdoor recreation industry contributes somewhere between \$427 and \$887 billion dollars annually to the US economy (U.S. Bureau of Economic Analysis, 2019; Outdoor Industry Association, 2017).

In addition to its significant economic contributions, outdoor recreation provides communities with a sense of collective identity and livelihood, sustainable sources of income, and a healthy way of life. Rural areas that have been supported in the past by extractive or agricultural industries are also increasingly leveraging outdoor recreation opportunities to bolster their local economy (Lawson, 2019). If successful, the outdoor recreation industry can provide a more robust and sustainable source of revenue compared to the boom-and-bust cycles of traditional economies (ibid.).

All forms of outdoor recreation depend either directly or indirectly on the availability and quality of water resources. This is immediately apparent for snowsports and activities which involve rivers or lakes, but even activities such as biking, hiking, and camping depend on a certain minimum quantity of water to exist. Meteorological drought can affect snowpack development and streamflows, increase the probability of wildfires, and modify the geographic range of critical species. These dynamics can affect both water-based and other forms of recreation, resulting in sub-par user experiences and lost revenue for businesses that serve these activities. However, drought is not the sole issue at hand, as precipitation variability has increased 10% since 1980 and will continue to pose serious challenges to long-term business planning (Lukas, 2019).

Due to global climate change, there is a strong consensus that droughts in the United States are projected to become more frequent and severe, compounding the aforementioned negative impacts (Seager et al., 2007; Dai, A., 2012; IPCC, 2013; Cook et al., 2014; Zhao et al., 2015). This is part of a trend of increasing aridification across the Rocky Mountain region. As a result, the Bureau of Reclamation forecasts that Colorado River flows could decline by 9% by 2060 (U.S. Bureau of Reclamation, 2012), driven by overall reductions in mountain snowpack development and snow residency time (USDA Office of Sustainability and Climate, 2017). Ultimately, the Intermountain West is becoming drier and warmer with shorter winters and longer summers.

Research Questions

These staggering changes to Earth's climate continue to create adverse conditions for outdoor recreationists, recreation businesses, public land agencies, and the communities who depend on income from tourism and recreation economies. This report examines the relationship between disruptive droughts and outdoor recreation businesses, and specifically details how businesses are vulnerable to the effects of drought, as well as strategies that business managers employ to increase the drought resilience of their business. Particular emphasis is placed on the use or unavailability of weather data to make business decisions, as well as adaptation strategies that can mitigate the negative impacts of drought.

Purpose and Goals

The purpose of this research is to provide NIDIS with recommendations and courses of action to increase the resilience of outdoor recreation businesses in the Intermountain West Drought Early Warning System (DEWS), comprising of Arizona, Colorado, New Mexico, Utah, and Wyoming. This project collected and synthesized data regarding the severity, extent, and impacts of drought on water-based outdoor recreation businesses in the Intermountain West DEWS region. Within this geographic area, the investigators scoped this research to the following activities and subsectors:

- Ski resorts
- Snow-based
- Lake-based
- Fishing
- Rafting
- Retail

Through this research, the investigators identify gaps in drought information that can improve the resilience of stakeholders in the industry in this region.

In order to determine these information gaps, this research investigates which weather and climate information outdoor recreation businesses are using to plan and conduct their operations, and what information is valued by the industry but is non-existent or undersupplied. Furthermore, this research seeks to summarize the strategies that businesses employ to mitigate the negative impacts of drought and maximize revenue regardless of environmental conditions. Ultimately, these data will inform recommendations for content that is disseminated via the U.S. Drought Portal website, which will help businesses increase their drought resilience.

Literature Review

The following literature review is subdivided into six subsections: Drought Types and Impacts, Winter Recreation, Summer Recreation, Adaptations, Inventory of Existing Drought Information Tools, and Gap Analysis. These sections have been ordered according to increasing level of specificity; the first section describes how drought affects outdoor recreation generally, while the following two sections go into greater detail on the differentiated impacts that are experienced by the industry seasonally. The final three sections explore the societal aspects of these drought impacts including potential adaptation measures, current sources of drought information, and which types of information are yet to be supplied. Together these sections provide a comprehensive overview of existing literature relating to the environmental and socioeconomic impacts of drought on the outdoor recreation industry.

Drought Types and Impacts

“Drought” is a deceptive term as it has no single agreed-upon definition. Many government agencies have proposed definitions for drought based on the types of resources that are impacted. Ultimately, all forms of drought are driven by climate variability but have different durations (McKee et al. 2000). Furthermore, all forms of drought have social, economic, and environmental impacts.

The three primary types of drought are meteorological, agricultural, and hydrological drought. Meteorological drought is the most immediate form and is marked by low precipitation, often in combination with high temperatures which exasperates aridity (McKee et al. 2000). Agricultural drought tends to persist for slightly longer durations and is characterized by low soil moisture (green water) and increased plant stress (McKee et al. 2000). Finally, hydrological drought lasts for the longest durations and is marked by low streamflows, low reservoir levels, and receding wetland areas (McKee et al. 2000).

Socioeconomic drought is distinct from these aforementioned types of drought, because it is a reflection of societal values rather than climate variability. Socioeconomic drought is based on meteorological, agricultural, and hydrological drought as they impact the supply and demand of economic goods. Socioeconomic drought begins when demand for a good exceeds supply due to weather-related shortages of water (McKee et al. 2000). For example, opportunities for whitewater rafting may be reduced during a hydrological drought, creating a socioeconomic drought due to the shortage of rafting experiences.

All of these types of drought result in direct and indirect impacts throughout multiple environmental domains. Direct effects of drought include reduced snowpack depth, earlier peak runoff, reduced streamflows, and lower water levels in lakes and reservoirs (Cutler et al., 2017). Indirect effects of drought include changes to site characteristics and environmental quality. These changes may include vegetation stress or die-off, disturbances such as wildfires and insect infestations, or the disappearance of unique features like glaciers or permanent snowfields (Cutler et al., 2017). Drought can also spatially or temporally redistribute resources which are integral to appreciative activities such as wildlife viewing or wildflower peeping (Colorado Drought Mitigation and Response Plan, 2013).

Taken as a whole, changing patterns of precipitation, temperature, and plant and wildlife distribution affects season lengths (Cutler et al. 2017). Winters are generally becoming shorter while summers are

extending in length (Fisichelli et al. 2015). This impacts outdoor recreators' demand for different areas and activities, leading to economic and social impacts (Cutler et al. 2017). For example, it is projected that peak visitation to national parks will begin earlier and last longer than it has in the past (Fisichelli et al. 2015). These visitors are also likely to seek out higher elevation areas in response to increasing aridification, posing additional management challenges (Gordon & Ojima 2015).

Changes in demand for outdoor recreation opportunities are not distributed equally across all outdoor recreation sub-sectors. Some forms of recreation (such as those based directly on water) are more sensitive than others (Thomas et al. 2013). Thomas et al. (2013) has laid out a "drought vulnerability framework" which analyzes vulnerability of different recreation providers as a function of drought exposure, sensitivity, and adaptive capacity. Providers in areas with environmental or climatic conditions that lend themselves to more frequent droughts are classified as highly exposed, and areas which are easily affected by drought due to land use, management, and policies are considered highly sensitive. Adaptive capacity reflects the potential for providers to change their operations in response to drought conditions. A rafting guide service may have some degree of adaptive capacity (by using smaller boats during lower flows) but is not highly adaptive because they are ultimately constrained by natural streamflows (Colorado Drought Mitigation and Response Plan 2013). These three factors combine to influence drought vulnerability, or general "susceptibility to harm" (Thomas et al. 2013).

Drought Impacts to Winter Recreation

Due to its dependency on snowpack and cooler temperatures, the outdoor winter recreation and tourism industry is directly impacted by drought. A 2011 study found that the winter recreation sector's total consumer spending is \$12.2 billion (Burakowski et al., 2011). Snowsports are the main attractions within this sector, including skiing, snowboarding, snowshoeing, and cross country skiing.

The ski and snowboard industry has transformed over the years, with large resort companies consolidating and acquiring smaller resorts. The two most competitive conglomerates, Vail Resorts and Alterra Mountain Company, recognize the growth and trajectory of this multi-billion dollar industry, and they are continuing to grow by purchasing additional ski resorts. While the industry has experienced significant recent growth, drought threatens the viability of the winter recreation sector as winters over the next century are projected to be warmer and drier (Colby & Frisvold, 2012). Within the Intermountain West DEWS region, there have been severe drought periods that have impacted snowsports industries. In October 2017, the Intermountain West entered a significant drought event, which was classified as a "severe drought" in January 2018 and then progressed into "extreme drought" by March 2018. The drought was categorized as an "exceptional drought" in May 2018, which severely affected the outdoor industry in the region, resulting in the early closure of ski resorts and other negative impacts to outdoor tourism (Burakowski et al., 2011).

In 2002, Colorado was impacted by a severe drought that disrupted the winter recreation industry and changed the perception of the future viability of the sport (Wilhelmi et al., 2008). Winter recreation has also experienced shortened seasons due to low snowpack. Starting in the 1980's, ski resorts began snowmaking operations which has been a viable adaptation strategy in response to intense drought periods. However, water rights throughout the Intermountain West are contentious, and as water resources become more scarce due to anthropogenic climate change, resorts are finding it more difficult to purchase water for snowmaking (Nelson, 2017).

Vulnerability varies throughout the winter recreation industry due to capital and location. Large conglomerates such as Vail Resorts and Alterra Mountain Company are less vulnerable to drought because they have successfully purchased many mountain resorts throughout the world, thereby ensuring that at least some of their resorts will be operable in drought years. Additionally, they have more capacity to invest in snowmaking technology to mitigate the negative impacts of drought on their resorts (Vail Resorts, 2017). Drought vulnerability is much greater for industry members that do not have the same level of financial security. Elevation also plays a significant role in the future outlook of a ski resort, as resorts at higher elevations are often less impacted during drought events. Colorado has an advantage since most of its ski resort base areas are located around 10,000 feet or higher, as compared to other states in the Intermountain West that have the majority of their ski resorts at lower elevations (On The Snow, North America Ski Resort Statistics, n.d.). In years of snow drought, resorts with other amenities such as restaurants, shopping centers, and summer recreation opportunities are more resilient (Klein & Travis, 2012). On the other hand, small winter recreation businesses that rely directly on natural snowpack and that have fewer alternative amenities are often severely impacted by drought.

Even with technological advancements, affluence, and geographical advantages, winter recreation and tourism is threatened by drought unpredictability and intensity, which is projected to increase in the future (Trenberth et al., 2014). Therefore, the winter recreation industry will progressively experience setbacks caused by drought which will require adaptations.

Drought Impacts to Summer Recreation

There are many recreational activities during the summer months that are water-based, such as fishing, rafting, boating, tubing, and stand up paddle boarding. In the Intermountain West, most of the water supply used for recreation originates from the mountain snowpack that has accumulated during the winter months. Therefore, a lack of precipitation during the winter months can directly affect recreation in the summer months (McKee et al. 2000). Drought impacts water-based activities through reduced streamflows and reservoir levels. In addition, drought in the spring can cause earlier runoff, reducing the length of a river recreation season (Cutler et al., 2017).

The ability for whitewater rafting outfitters to run a stretch of river depends on streamflows, which can fluctuate both early in the season—due to variable snowmelt timing—and later in the season—due to lack of summer precipitation (Truby & Boulas, 2013). Lower stream flows can force rafting outfitters to cancel trips and use smaller boats, thus resulting in less overall revenue. When misinformation regarding drought is publicized through the media, a negative public perception of drought can result in fewer rafting customers and/or more trip cancellations (Truby & Boulas, 2013). For recreational boating and fishing, lack of snowmelt and precipitation can impact reservoir and river levels. Higher-than-normal temperatures and lower precipitation in a spring or fall drought can also cause higher evaporation rates in reservoirs and cause water temperatures to increase (Truby & Boulas, 2013). This can directly impact aquatic life, which can also affect the quality of fishing.

In previous drought years, lower reservoir and lake levels have acted as a deterrent to potential boaters and have at times made boating impossible by rendering boat ramps unusable (Truby & Boulas, 2013). For example, in 2002, drought caused the closing of numerous Colorado State Park lakes and reservoirs, resulting in a \$140 million loss of revenue (Knight, 2018). According to the Colorado River Outfitters Association, the 2002 drought also resulted in a 39% drop in whitewater rafting days as compared to 2001 levels (Truby & Boulas, 2013). Unpredictable precipitation in

Colorado, especially if combined with drought, presents challenges for dealing with increasing numbers of water sport enthusiasts (Knight, 2018). Many Western Slope counties in Colorado, home of the state's year-round "playgrounds," are among the most vulnerable (Sibley, 2010).

There are also user-based conflicts when there is lack of water, especially during drought conditions. Water-based recreation can struggle in locations where most of the water has long been appropriated for more traditional agricultural, municipal and industrial uses. These uses are fundamentally at odds with recreation, because they take water out of the rivers, whereas water-based recreation depends on water remaining in rivers and reservoirs (Sibley, 2010). In Colorado, recreation is not a legislative purpose of the Colorado Water Conservation Board (CWCB) instream flow reservations program, and instream flows for the "natural environment" only considers aquatic life (Loomis, 2018). This can create river conditions where flows are not ideal for sustaining commercial whitewater businesses. The impacts to whitewater boating become particularly apparent on over-appropriated rivers that are sometimes dewatered for short periods of time (Loomis, 2018). Managing reservoirs to provide appropriate storage while also releasing adequate streamflows also becomes a significant challenge when dealing with drought. In the above examples, drought not only impacts water-based recreation, but it also influences water management decisions around recreation. In many states in the Intermountain West, it has become necessary to begin discussing water allocation during periods of drought to balance consumption needs with adventure tourism needs (Knight, 2018).

Outdoor Industry Adaptation Strategies

As drought impacts the amount of water and snow available to recreate, outdoor recreation companies will be forced to adapt to the changing environment. Research suggests potential adaptation suggestions, but these are generally geared towards ski resorts and are not plausible for all recreation areas (Cutler et al., 2017).

One of the major threats to the ski industry is shorter winter seasons, which can reduce the number of days that guests can recreate on the mountain. In order to bring in additional revenue to make up for fewer ski days, it is critical that ski resorts "diversify activities and/or tourist areas, as well as the seasonality of offerings" (Averyt et al., 2011). Introducing new activities like mountain biking, alpine coasters, high ropes courses, or other summer recreation options will draw visitors to the resorts during previously considered off-peak times. Ski resorts are also encouraged to join resort coalitions in order to offer multi-mountain lift passes, which will encourage more visitors regardless of snowfall and help diversify smaller resorts' financial portfolios (Cutler et al., 2017).

Snowfall during the shoulder seasons, as well as snowfall during peak season, is expected to become more scarce, and much of it will be rain instead of snow (Averyt et al., 2011). For resorts to be able to create enough snow to compensate, new snowmaking technology and careful water planning will be critical (Cutler et al., 2017). Another suggestion for overcoming low snowfall is to move to higher elevations when possible (Burakowski et al., 2018). This option is not feasible for many resorts that are located in lower elevation mountains, but when possible, this could improve the length of the ski season for many years to come (Averyt et al., 2011).

There are fewer adaptation strategies suggested for other water-based recreation businesses facing drought. One major strategy is to "use public relations to mitigate or prevent negative public perceptions of recreation during drought" (Averyt et al., 2011). If the public has a poor perception of recreation options during drought, even if those perceptions are not true, fewer people will choose to

participate in a particular type of recreation. Debunking myths publicly will encourage people to continue to recreate even when water levels are lower than average. Another potential adaptation strategy is for smaller recreation companies to “explore creative staffing and partnerships to accommodate changes in use due to drought” (Cutler et al., 2017). For example, a rafting outfitter could form a partnership with an outdoor retail store that would allow both companies to benefit from a more diverse customer base. None of the adaptation strategies for summer water based recreation offer much of a solution for immediate impacts of drought.

As drought intensifies and limits the amount of water available for any type of outdoor recreation, more robust adaptive measures will need to be taken. According to the research, if water based outfitters hope to stay in business, they will need to make significant changes to their business models. These changes may include providing new recreational activities that are not reliant on local water supplies. Diversifying activities is an example of a long-term adaptation, because it has the ability to reduce drought vulnerability on large time-scales. Short-term responses to an extant drought may be different than long-term strategies.

Inventory of Existing Drought Information Tools

A multitude of drought forecasting tools and resources currently exist. These can be broadly categorized into the areas of:

- US Drought Monitor and related products
- State-specific tools
- Drought indicators and indices
- Historic data and information
- Satellite, climate and biophysical data products
- Soil moisture detection
- Standardized precipitation index and related products
- Snow related datasets and tools.

While it is clear that these tools and indices may help the outdoor recreation industry better prepare for and adapt to drought, the vast majority of businesses do not specifically incorporate impacts on outdoor recreation or focus on long-term time ranges.

Gap Analysis of Drought Research and Conclusion

A number of under-investigated topics in drought-related studies relating to outdoor recreation have been identified. These gaps span two recurring themes: the impacts of drought on decision-making in the outdoor industry and lack of information for certain activity types. The identification of these gaps reveals deficits in current knowledge and opportunities for our project to fill some of these information needs.

Little information exists regarding how drought impacts decision-making in the outdoor recreation industry. There are many levels of decision making within the industry in which drought may influence decisions. These include:

- How businesses may change procurement, hiring, or other practices in response to drought
- The selection of drought mitigation or adaptation strategies

- How businesses process and integrate drought information into decisions
- The adaptive capacity of businesses
- How drought affects recreationists' and tourists' travel motivations and participation in activities
- If businesses in the outdoor industry are currently using drought information, and if so, what specific tools are being referenced

These encompass some of the essential questions that this project aims to answer. Gaps also exist in the predominant outdoor recreation activities researched. Previous investigations have focused primarily on skiing and golf, which leaves a majority of outdoor recreation activities under-researched (Verbos, 2016). While it is more clear how drought negatively impacts skiing and golf, there are a number of other activities also directly dependent on water availability and quality, such as rafting, fishing, boating, etc.

Methods

Stakeholder List Development

An iterative process was used to compile a comprehensive list of stakeholders in water-based outdoor tourism and recreation subsectors in the Intermountain West DEWS region (i.e., ski resort, snow-based, rafting, fishing, lake-based, and retail). This process occurred over a seven month time span between January 2019 and July 2019. The compilation of the stakeholder list involved leveraging investigators' existing contacts, internet searches, trade organization member directories, and snowball sampling methods (people recommending other people). The final master list consisted of 802 stakeholders from the study region.

These stakeholders were sorted by location, subsector, business type (guide, retail, rentals, resort, etc.), and stakeholder tier (Tier 1, Tier 2, and Tier 3; see "Stakeholder Prioritization"). While this stakeholder list serves as the basis for the project, it includes organizations and contacts who did not participate. Additionally, the stakeholder list is not comprehensive and does not include every water-based outdoor recreation business in the Intermountain West.

Stakeholder Prioritization

Stakeholders were engaged using three primary methods: in-person interviews, phone interviews, and survey distribution. Given the short time frame of the project, it was not possible to physically visit and interview stakeholders in all five states within the Intermountain West. Stakeholders were prioritized for engagement using a dichotomous key (*Figure 1*). Tier 1 and Tier 2 stakeholders represent the key stakeholders for the project and include outdoor businesses (outfitters/guides, resorts, or retailers) that are water-based. In order for retailers to be categorized as Tier 1 or Tier 2 stakeholders, their entire company must offer products related to water-based activities that are exposed to drought. The only difference between Tier 1 and Tier 2 stakeholders is that Tier 1 stakeholders are located in the project's designated focusing locations, while Tier 2 are not. Tier 3 stakeholders are defined as trade or non-profit organizations focused on water-based outdoor recreation.

The investigators aimed to engage Tier 1 stakeholders primarily through in-person interviews, followed by phone interviews and then via survey for those that were unable to be interviewed. Tier 2 stakeholders were primarily engaged through phone interviews or via survey. Tier 3 were engaged via phone interviews or surveys.

"Focusing locations" were identified as priority locations the investigators visited over the summer of 2019 to conduct in-person interviews. These focusing locations were chosen based on their relative drought vulnerability, abundance of water-based outdoor businesses, the extent to which their economies depend on water-based outdoor recreation, and the feasibility with which they could be traveled to. These focusing locations were: Steamboat Springs, CO, Aspen, CO, Durango, CO, Taos, NM, Salt Lake City, UT, and Park City, UT. The propensity of locations within Colorado reflects the investigators' base location in Boulder, CO. In order to reach Tier 2 stakeholders (those outside of the above locations) and Tier 1 stakeholders in Arizona and Wyoming, interviews were conducted by phone. Tier 3 stakeholders—defined as trade or non-profit organizations focused on water-based outdoor recreation—were engaged via phone interviews or surveys.

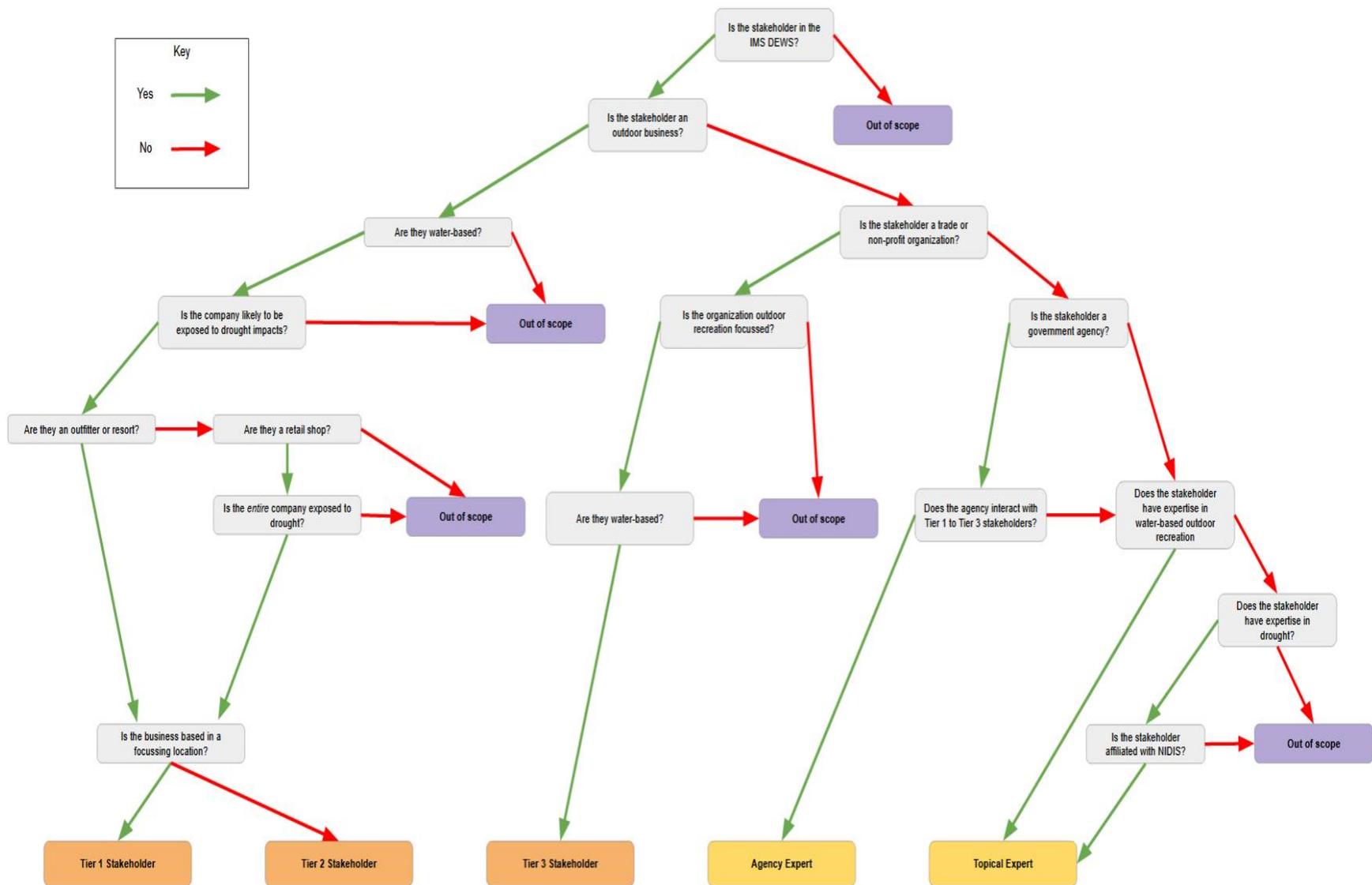


Figure 1. Criteria for prioritizing stakeholders to engage.

The last two categories of stakeholders within the scope of the project are agency experts and topical experts that specialize in drought or water-based outdoor recreation. Agency experts are defined as government agency representatives that directly interact with Tier 1–3 stakeholders. Specific stakeholders within the topical expert category include academic researchers, NIDIS partners, or other drought experts that are affiliated with NIDIS. Engagement with these stakeholders required personalized interview questions, as the questions for Tier 1–3 stakeholders are specific to outdoor businesses' drought vulnerability and information needs.

Interview Structure

The initial phase of data collection started by contacting Tier 1 stakeholders via email. If they did not respond, a follow-up email was sent one week after the initial date of contact. Appendix 1 represents the templates used for initial email communications. Stakeholders who did not respond to either emails were then contacted by phone. After a stakeholder agreed to be interviewed, a time, date, and location were arranged. In order to ensure that participants' consent was fully informed, stakeholders were offered a list of the themes to be covered in the interview.

Both in-person and phone interviews were conducted using a semi-structured interview protocol which consisted of open-ended questions (Appendix 2). A semi-structured interview protocol was chosen because it allowed research participants to expand on their comments when they felt it was relevant. The telephone-based interviewing was slightly different in that the investigators had to be more cognizant of being clear in articulating key concepts and ideas, since it was not possible to use non-verbal cues or gestures to assist in communication. The interview questions were the same for both in-person and phone interviews. The interviews were structured around six sets of questions relating to:

- Understanding outdoor business operations
- Perceptions of hydrologic and thermal shifts on outdoor recreation
- Impacts of these perceived shifts
- Adaptation strategies used to reduce the negative impacts of drought
- Assessing drought vulnerability
- Drought information needs

Depending on the type of organization interviewed (i.e., river-, lake-, or snow-based), drought events and conditions were defined as extreme low snow/water/streamflow and warm events. To avoid bias, the terms “climate change” and “global warming” were not mentioned by the investigators during interviews unless the interviewee brought those terms into the discussion. The interview questions were co-developed by the five primary investigators and were also reviewed by outdoor recreation management experts.

A total of 47 interviews were conducted; all interviews were recorded with permission from the research participant. Recorded interviews were transcribed using the Rev transcription platform and uploaded into the software Dedoose in order to analyze the data. The interviews ranged from 13.00 to 57.46 minutes in length, with an average duration of 32.21 minutes.

Survey Administration

The survey was administered between July 9, 2019 and August 27, 2019 using Qualtrics software. The questions contained in the survey were developed based on the interview questions in Appendix 4. The first round of invitations to participate in the survey were sent through Qualtrics to 580 organizations on July 9, 2019. A reminder email was sent on July 17, 2019 to those who had not completed the survey. On August 27, 2019, a third and final email was sent to 58 organizations that were categorized as Tier 1 stakeholders but had not yet been interviewed. At the end of the survey period, 65 organizations responded (a 10.1% response rate), however, only 51 of these responses were complete enough for use in the study. A breakdown of all stakeholders, both surveyed and interviewed, is shown in the map and chart in figures 2 and 3.

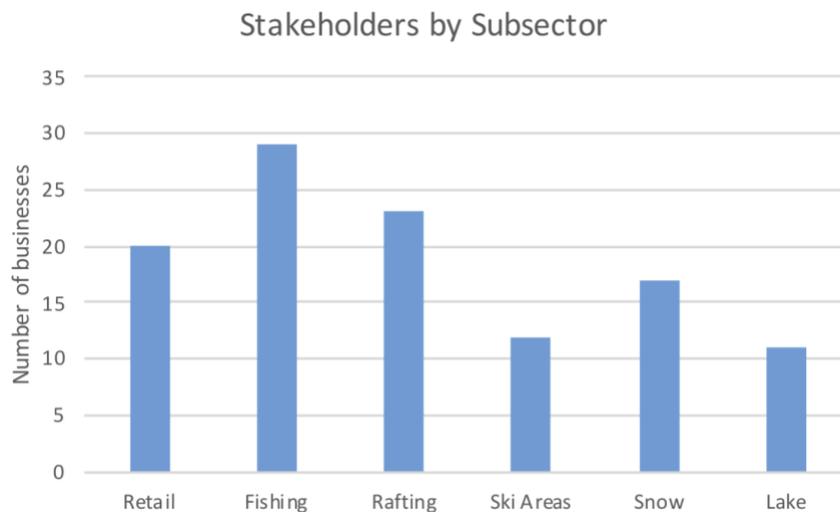


Figure 2: Stakeholders interviewed and surveyed by subsector.

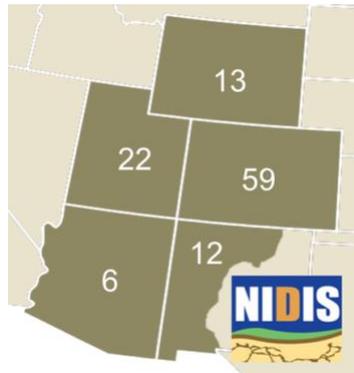


Figure 3: Number of stakeholders interviewed and surveyed by state in the NIDIS Intermountain West Drought Early Warning System (DEWS).

Interview and Survey Data Analysis

Transcribed interviews and survey data were analyzed using a combination of inductive and deductive coding as well as a thematic analysis approach. All coding and some analysis was completed using Dedoose software (Corbin and Strauss, 2008; Thomas, 2003). A project codebook was utilized for interview data analysis, which was developed primarily to match the interview questions

(Appendix 3). A deductive approach was used to analyze the codes that were developed based on the interview questions. Some of the codes were developed a priori, which allowed for a more organic exploration of the themes and relationships that came from these data. An inductive approach was used to analyze *a priori* codes.

Survey data were exported into an Excel spreadsheet and analyzed using deductive methods exclusively.

Categorization of Drought Forecasting Resources

To simplify our stakeholder engagement and analysis, drought forecasting resources were divided into 11 categories. Some of these categories are fairly well-known and discrete (i.e. USGS stream gauges) while others are broadly defined (i.e. “experiential monitoring”). Below is a brief overview of each category of forecasting resource:

NOAA Daily, Weekly, Long-Range, and Unspecified

NOAA “daily” forecasts consist of all short-term forecasts containing any weather variables (temperature, precipitation etc.) produced by NOAA and accessed via NOAA’s website. For the purpose of this research, NOAA “daily” is anywhere between 1 to 5 days out, NOAA “weekly” spans from 6 to 14 days out, and NOAA “long-range” is anything beyond that two-week span. Generally speaking, when business owners were referring to long-range forecasts, they were referencing the 3-month outlooks published by NOAA’s Climate Prediction Center. When the context of the interview answer did not reveal exactly which forecasting product was being used, the investigators filed it under NOAA Unspecified.

ENSO Advisory

El Niño and La Niña information was referenced by numerous businesses and sometimes considered in decision making. Regardless of how business owners heard about the presence of these phenomena, references to them were categorized as ENSO Advisories.

Experiential Monitoring

Experiential monitoring is perhaps the most broadly defined and varied category of information resources. This category encapsulates any individual’s contemporary observations or historical knowledge of a given geography. Experiential monitoring techniques were often innovative; a few notable techniques are summarized here:

- Watching the growth of a certain snowdrift on a nearby peak to determine snow amounts elsewhere, and eventually, river flows during the summer
- Driving a section of road which permits direct observation of the flow and turbidity of key tributaries
- Walking outside, sticking a finger in the air, and relying on intuition to predict future temperatures or precipitation
- Carrying a digital thermometer to measure river temperatures and sharing that information over social media
- Looking at highway cameras to monitor winter storms
- Monitoring upstream agricultural diversions to predict changes in streamflow

Third Party Forecasts

This category of information is also broadly defined. Third party forecasts can take the form of popular weather websites such as Weather Underground or Accuweather. Even though these sites are built around NOAA's data, they are still a distinct source because they feature additional tools and analyses. Also included in this category are forecasting services such as OpenSnow or Forecasts Unlimited. The latter service—retained primarily by ski resorts—provides clients with highly localized and frequent, e.g., hourly, forecasts.

SNOTEL

SNOTEL stands for “snow telemetry”. SNOTEL is a network of 730 automated stations operated by USDA's Natural Resources Conservation Service. SNOTEL sites provide fairly reliable information about meteorological conditions in remote mountain environments. SNOTEL sites are most often used to monitor snowpack development, which is valuable not only for winter activities but also as an indicator of spring runoff and summer streamflows.

USGS Stream Gauges

The United States Geological Survey (USGS) maintains a large network of automated stream gauges which measure hydrologic variables such as streamflow and temperature. These gauges are primarily used by rafting and fishing companies to monitor current river conditions.

Farmers' Almanac

There are two separate farmers' almanacs: the Old Farmer's Almanac and the Farmers' Almanac. These sources are unique from other weather forecasting resources in that they make forecasts between 16 and 18 months in advance. They both claim an 80% accuracy rate and make predictions using “secret formulas” that they claim account for solar magnetic storms, sunspots, astronomical factors and other factors. Independent verification indicates that these resources do not achieve their stated accuracy rates. Questionable claims and methodologies aside, the Farmers Almanacs are highly trusted sources for long range weather information for the outdoor recreation industry.

Other

The “other” category of information is a catch-all for resources that do not fit neatly into any other category. This category includes, but is not limited to:

- Roaring Fork Conservancy's weekly Snowpack and Streamflow Report
- Colorado Water Conservation Board data
- NOAA's Colorado Basin River Forecasting Center
- Colorado Avalanche Information Center forecasts and reports
- The U.S. Bureau of Reclamation scheduled dam releases
- Social media groups that share snow and weather observations

Ski Resort Subsector Overview

The ski resort subsector is comprised of ski resorts ranging from large multi-mountain ski resorts to smaller training facilities and local ski areas. While the target customer may differ for each resort, every ski resort is dependent on reliable natural snowfall and cold temperatures for a successful season. Because most ski resorts only offer skiing for a few months out of the year, it is critical for them to maximize their revenue during those months.

This analysis derives from eight ski resorts that were either interviewed or surveyed. Five of these resorts are located in Colorado, two are in New Mexico, and one is in Utah. All but one of these resorts stated that the majority of their revenue is generated between Thanksgiving and school spring break in March. This revenue stream is highly dependent on the sale of lift tickets. While most ski resorts have made major investments in hotels, restaurants, ski schools and other amenities, revenue generated from these services is still marginal in comparison to the revenue brought in by lift tickets.

Many ski resorts are built on a combination of both public and private land, with the US Forest Service managing the public land. This partnership is key to a successful subsector in the Intermountain West. Due to this public-private partnership, both parties must agree on any infrastructure changes before they are constructed. These infrastructure changes are proposed in ski resort Master Development Plans (MDPs). These MDPs are agreed upon by both the ski resort and the US Forest Service. In addition to new building proposals, general open and closing dates, water usage, and waste management are included in MDPs. Until the Ski Area Recreational Opportunity Enhancement Act of 2011 was passed, ski resorts built on US Forest Service land were highly constrained in their summertime operations. Even after the passing of this 2011 law, ski resorts still need to have summer operations approved by the US Forest Service. A common misconception is that the US Forest Service dictates when ski resorts will open and close, but resorts are able to make this decision based on their snowpack.

Ski Resort Drought Risk Assessment

Without natural snow on the ground or access to equipment and sufficient water to make artificial snow, the ski resort subsector will cease to exist in its current form. While national economic conditions play a role in visitation, ski resorts may experience revenue losses during a bad snow season in particular. Conversely, an exceptional snowfall year can mean major income for resorts. In Colorado, snowfall is so closely tied to people's desire to ski that if it snows in the Denver Broncos' stadium during a home game, there will be an uptick in skier days the following week. Three ski resorts located in Colorado independently shared this anecdote.

Geographic differences play a role in the vulnerability of different ski resorts throughout the Intermountain West. One ski resort in New Mexico explained that there is an advantage to being in close proximity to states such as Texas, because people are often trying to escape Texas' extreme heat. Because of this, visitation in New Mexico has the potential to increase during summer months as temperatures increase and/or drought expands. This was one example of the unexpected changes that have been observed by businesses in the snow-based subsector of outdoor recreation.

Aside from the risk of reduced natural snowfall, ski resorts are also vulnerable to the risk of warming temperatures. All eight of the interviewed ski resorts use artificial snowmaking to cover at least a portion of their ski runs during various times throughout the season. In order to make snow, air

temperatures need to be between 20–29 °F for three consecutive days with a fairly low relative air humidity. In order to obtain the forecast information needed to make snow, four resorts employ a private third party forecaster while the rest of the resorts rely on NOAA daily forecasts. The four resorts that pay this third party forecaster receive hourly forecasts specific to their coordinates and elevation bands during the ski season. The interviewees expressed that this allows them to make hourly decisions around snowmaking and lift operations. While snowmaking is a good option for larger resorts with substantial budgets, this is not always economically feasible for smaller resorts given the capital investment necessary for snowmaking equipment.

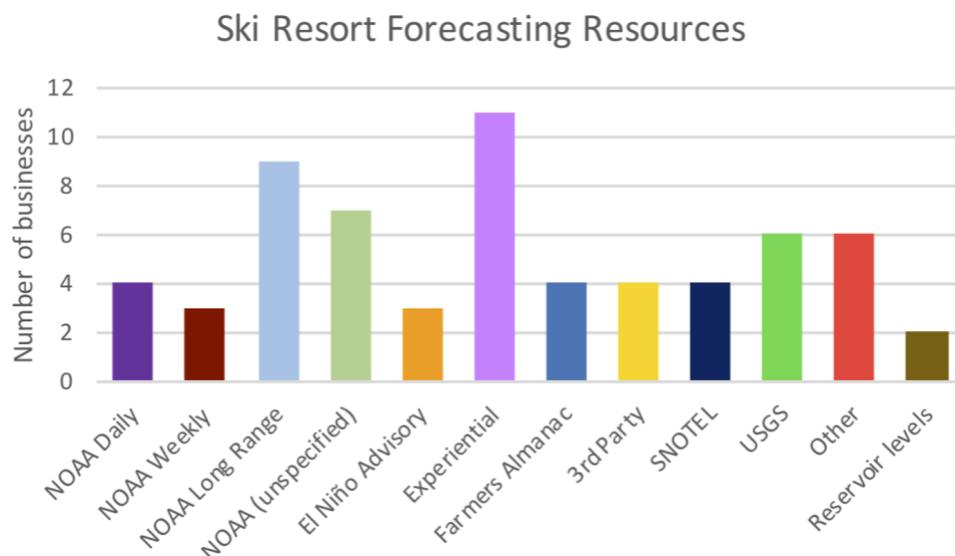


Figure 4: Weather and climate forecasting resources utilized by ski resorts.

In addition to vulnerability to temperature changes, most ski resort managers are aware of water limitations in the West and that water scarcity is projected to worsen. Most resorts hold water rights, and some have the most senior water right in their respective drainage area. Many resorts have invested in acquiring additional water rights in order to buffer themselves in lower snowfall years. The sole exception to this involves obtaining snowmaking water from the local utility, which means that a resort would be using potable water to make snow. Using treated water is both incredibly expensive for the ski resort as well as energy inefficient.

With increased variability in water supply, temperature, and precipitation, many ski resorts are concerned about how resulting snowfall reductions might impact customer visitation. While there does not seem to be a strong awareness of drought among destination ski resort visitors (i.e., someone staying overnight at the resort for three or more nights), most ski resorts believe that snow conditions from the previous year impact where someone might ski the following year. For example, Colorado had a very low snowpack during the 2017–2018 season, and that led to fewer out-of-town visitors in the 2018–2019 season, even though this latter season experienced exceptional snowfall.

In contrast to destination ski resort visitors, ski resorts believe that local skiers are very attuned to drought conditions. For local skiers, the decision of where and when to ski is primarily based on daily conditions. There is also a level of loyalty to certain ski resorts and specific areas within the mountains. As most out-of-town guests book trips several months in advance, local skier decision-

making mostly impacts smaller resorts that do not attract as many destination skiers. These smaller resorts view themselves as more vulnerable to drought, because a greater proportion of their revenue is generated from lift ticket sales. With fewer restaurants and hotels bringing in revenue, lift ticket sales become even more important for these small resorts.

Ski Resort Adaptation Strategies

Ski resorts employ a number of adaptation strategies to reduce the uncertainty of natural snowfall; the most important of these strategies is to increase snowmaking capacity. Other common adaptation strategies include geographic diversification, investments in summer recreation opportunities, altering marketing strategies, and joining a ski resort megapass.

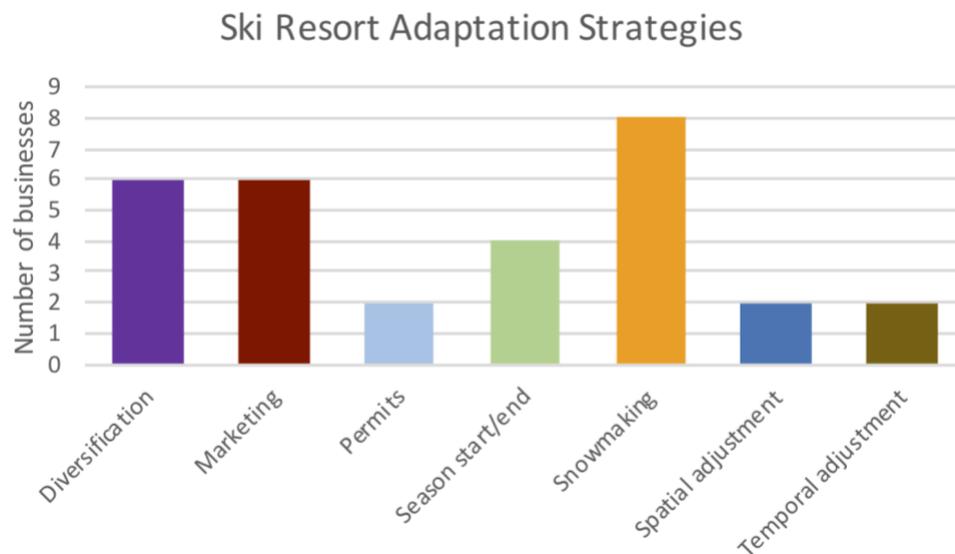


Figure 5: Drought adaptation strategies employed by ski resorts.

Snowmaking as a Ski Resort Adaptation Strategy

The most prevalent adaptation strategy adopted by ski resorts is snowmaking. Over the last few decades, snowmaking has become a critical part of ski resort operations in the West. One resort manager said, “I think everyone sees how critical it is, at this point, where that might not have been the case 10 or 20 years ago.” At this point, even some of the smallest mountains are making snow for their runs, and every ski resort credited snowmaking as being vital to their business operation.

While snowmaking is critical to opening terrain in the early season and extending it in the late season, it can be very expensive for resorts. Many of the resorts that were interviewed said that they are constantly working on acquiring more water rights and exploring ways to store water. Even the smallest mountain ski resort interviewed said: “We’re pulling a lot of water, so water rights are everything, really. You need that guarantee.” Another resort mentioned that they had recently built a pond on one of their properties in order to store water. Construction of these holding ponds is an expensive but necessary common practice in the subsector. The issue of water acquisition and storage will only become more pressing as water scarcity increases.

A much smaller piece of the conversation around snowmaking is cloud seeding in the hopes of producing more snow. Cloud seeding is the practice of dispersing atomized silver iodide into the air, which serves as condensation or ice nuclei. None of the ski resorts interviewed currently use cloud seeding technology, but about half of the resorts are interested in using it in the future. There are serious doubts about the effectiveness of cloud seeding, especially with regards to where the snow will fall after it has been seeded. As a result, individual resorts are hesitant to invest in cloud seeding as there is no guarantee that they will benefit, so deploying this technology may necessitate some type of group investment from a conglomerate of resorts. Despite doubts and issues, cloud seeding may be an effective adaptation strategy in response to drought in the ski resort subsector.

Megapasses and Geographic Diversification as a Ski Resort Adaptation Strategy

Ski megapasses have dramatically changed the ski resort subsector. There are two megapasses that most of the resorts are a part of: the Epic Pass, which is owned by Vail Resorts, and the Ikon Pass, owned by Alterra Mountain Company. Both of these passes give pass holders access to more than 20 ski resorts, and customers gain either unlimited ski days or a restricted number of days to each resort depending on which level of pass is purchased. Ski resorts join a megapass in order to guarantee lift ticket sales. For resorts on the Ikon Pass, Alterra Mountain Company gets paid for each day that a skier with a pass is on the mountain. At the time this report is written, the passes are priced competitively with only a \$10 price difference. With the exception of one, all of the ski resorts interviewed are part of either the Epic or Ikon pass. The one resort that is not part of these two megapasses is on a smaller, local conglomerate pass.

Over the last decade, Vail Resorts has acquired resorts all over North America and is continuing to expand further. This expansion has helped Vail adapt and geographically diversify in order to reduce their exposure to drought conditions. If there is a bad drought event in one part of the country, Vail Resorts will still make money from resorts in other parts of the country that are not experiencing a drought. Geographic diversification is not feasible for small resorts with little capital, which is why Vail Resorts has been targeting this specific type of resort to purchase.

Summer Recreation Opportunities as a Ski Resort Adaptation Strategy

After the Ski Area Recreational Opportunity Enhancement Act of 2011 was passed, ski resorts began investing in robust summer recreation experiences. Before 2011, portions of ski resorts on US Forest Service land would remain unused all summer. One resort said, "the only industry more capital-intensive than the ski industry is the airline industry." Continuing with this analogy, if an airline let their fleet sit grounded for a significant portion of a year, they would not only be losing money from foregone ticket sales but also wasting money on the upkeep for unused planes. The same can be said for a ski resort closed during the summer. With the 2011 change in law, many resorts have expanded their summer offerings. Activities such as mountain coasters, alpine slides, childrens' camps, mountain biking trails, adventure parks, high ropes courses, and disc golf have become common offerings at ski resorts in the summer. There is also a big push to host summer events such as corporate getaways or weddings.

Although resorts are investing in summer recreation opportunities, those summer options bring in very little revenue compared to winter activities. Most of the ski resorts interviewed

said that they considered their summer season to be a success if they broke even, with the few successful resorts bringing in just 15% of their revenue during the summer months. This number may seem low, but any buffer from a slow ski season is an improvement for resorts.

In addition, multiple subsectors within the outdoor recreation industry are interconnected, so when ski resorts attract more summer customers, other businesses adjacent to the resorts experience an increase in summer revenue. Thus, an entire region benefits from a year round increase in ski resort customers. However, given the relatively small financial contribution of summer activities to resorts' overall annual revenue, summer recreation will not be enough to keep the vast majority of resorts in business in the face of climate change or extensive drought.

Marketing as a Ski Resort Adaptation Strategy

Every resort has brand marketing that they generally use year after year. One marketing strategy that some resorts employ is to be the first to open at the start of the ski season. Being the first resort to open for the season gains media attention for the resort, and according to one interview, leads customers to believe that they have the most snow. While this is only a theory, resorts compete to be the first open in order to gain media attention each season.

Barriers to Ski Resort Adaptation

Based on the interviews conducted, ski resorts believe they are doing everything they can to adapt to drought. The major barrier to ski resort adaptation is that there is simply not enough water or cold enough temperatures to produce artificial snow necessary to create quality ski conditions during severe drought events. Each resort desires additional water rights in order to make more artificial snow, but that is not possible in most cases. One of the resorts interviewed feels that the subsector is not doing nearly enough to influence climate policy and that this is the missing puzzle piece for the ski resort industry and drought risk mitigation. This resort feels that if ski resorts used their financial influence, especially in western states, to push renewable energy policy, they might collectively influence policy change.

Information Gaps for Ski Resorts

Generally, ski resorts desire more specific forecasts for their geographic location. Most decisions tied to forecasts involve snowmaking, which requires temperature, humidity, and wind predictions. As stated above, the bigger resorts pay a private forecaster to give the most specific and up-to-date predictions as possible. This private hire provides the majority of short-term forecasts that the ski resorts seek.

Across the entire subsector, there is a desire for accurate long-term snowfall forecasts, but there is an understanding that this is most likely not possible at this time. In an ideal world, an accurate snowfall forecast would exist for each month of the ski season. This would allow for better operational decisions, allowing ski resorts to plan the ideal time to make snow. Preventing unnecessary snowmaking would conserve water and reduce energy consumption. It would also be helpful to have these long-term forecasts in order to better predict resort opening and closing dates.

Ski Resort Forecasting Information Gaps

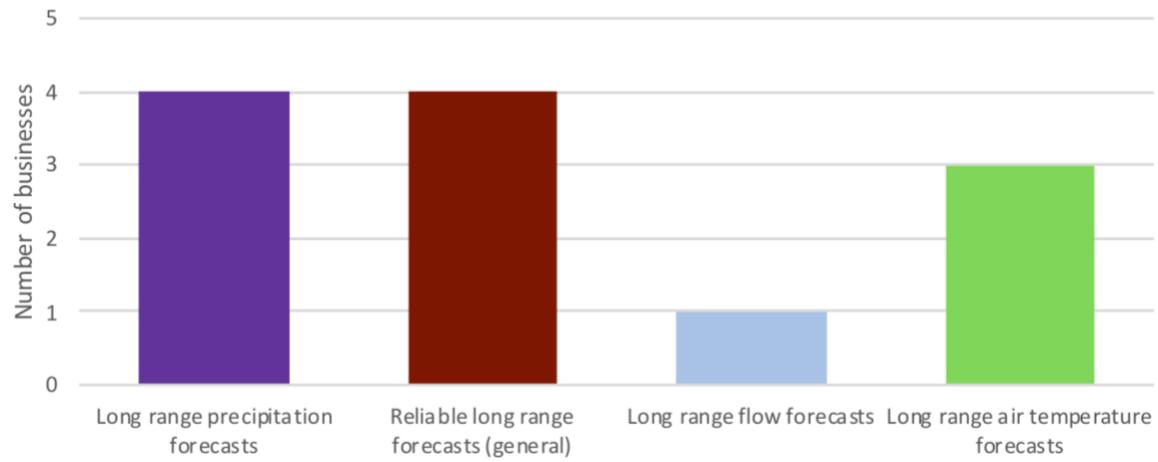


Figure 6: Weather and climate information gaps within the ski resort subsector.

Snow-based Subsector Overview

Although many subsectors rely on water, snowsports and snow-based activities can only occur when there is sufficient snowpack and reliable snowfall. This subsector includes, but is not limited to, snowmobiling, cross-country and Nordic skiing, snowshoeing, dog sledding, snowsport rentals, and snow-based fat biking.

Interviews were conducted with twelve businesses in this subsector that offer snowsports and snow activities as part of their main activity offerings. Most of the businesses interviewed in the snow-based subsector also provide activities not dependent on snow in order to buffer the business from low snow years.

According to the interview subjects, a variety of activities are offered during the winter months. Two of the twelve businesses provide some form of snowmobiling to their customers; seven of the companies have some form of ski-related offering (e.g., cross country); two companies offer dog sledding as a winter activity; two businesses provide avalanche courses; and some businesses rent different equipment for snow-related activities.

During the interview process, the investigators asked each subject to explain when peak revenue occurred. Of the 12 different businesses, three owners said that their peak revenue occurred in December and March. Four of the owners stated that peak revenue normally occurs evenly throughout the winter season.

There have been some trends and changes within the subsector that the interviewees collectively noted. Six out of the twelve businesses spoke about visitation and how it has increased over the past few years due to many factors, including leaf peeping, increased activities offered, and diverse family activities. An increase in internet activity and marketing has also changed visitation patterns, because it has allowed more people to discover certain businesses and activities offered. On the other hand, access to the internet can also negatively impact visitation for businesses, because visitors now have the ability to make last-minute travel decisions based on snow reports published online.

Within this subsector, procurement of gear or a rental fleet is vital to business operations. During the interviews, stakeholders were asked to explain timing and strategies around purchasing decisions for the winter season. A minority of the businesses said that they have some flexibility in procurement timing, but the majority feel that they do not have the power to significantly change orders that have already been made. A majority of the businesses also mentioned that they have to place equipment orders for the winter season approximately one year in advance.

Snow-based Subsector Drought Risk Assessment

Five of the businesses interviewed identified the 2017–2018 season to be a drought year that negatively impacted their businesses. One stakeholder told the investigators that the loss of business due to low snowpack was difficult, “both probably mentally and physically, it was just a hardship. I had to refinance my house. I had to get a bank loan to pay for all the equipment and product that we didn't sell. And then just a ton of stress going forward knowing that I had that and I still had to pre-book all of my orders for the following year. It's scary.” This illustrates that uncertainty in future conditions is affecting business owners' livelihoods and mental health.

A majority of the interviewees demonstrated that their businesses were impacted by a lack of snow. Some of the businesses elaborated, explaining that, due to the lack of snow, they had to cancel certain activities that they normally offer during the winter months. In drought years, some of the shops that rent equipment stated that they had to purchase new gear and equipment more frequently due to very rough, rocky, and icy snow conditions, causing gear to wear down quickly. This could negatively impact their net revenue and spending for the season.

Because snow-based recreation is reliant on a certain amount of snowfall and cold temperatures, drought can have serious impacts that can be detrimental to the overall business and reduce revenue. One interviewee said “I feel like our summer activities aren't nearly as susceptible to drought as winter and that's also an elevation thing. More and more we're seeing [that] we may have a wet winter but it might be rainy.” This interviewee makes the important point that elevation is a vital aspect for the subsector's survival and low elevation could pose a threat to the current or future success of a business. If businesses are located at lower elevations, they often are more vulnerable to the negative impacts of drought, because they receive less snowfall. This is another way in which the industry can differ by geographic location, as some areas are at a higher elevation than others. States like Colorado and Utah will be less vulnerable than states like Arizona and New Mexico because their high elevations buffer them from the impact of drought conditions.

Public perception is becoming increasingly important in understanding the vulnerability of businesses within the snow-based subsector. Tourism has changed throughout the past 30 years as technological improvements including the internet enable marketing opportunities for outdoor recreation businesses. During the interview process, more than half of the businesses stated that public perception could pose a threat to the viability of their business due to misinformation. One business said that customers learned that, “... it's been such a dry year”. “Oh we heard it's been really rough up there for a season.” Once there is word of a dry season, it is often difficult to show customers that not every mountain or business has been impacted.” Some of the businesses also stated that due to the increased use of technology and internet, customers have the option to make last-minute decisions to cancel or change a vacation.

Snow-based Subsector Adaptation Strategies

One way in which the snow-based subsector can manage drought conditions is to identify and implement adaptation strategies. There are many different types of adaptation strategies that businesses in the sector employ based on their access to capital, access to marketing, geographic location, spatial opportunities, and access to new technologies. This ability to adapt is a determinant of whether or not a business will have future success.

During stakeholder interviews, some of the business owners identified certain strategies that they have been using in order to adapt to changing climate and weather conditions. Those that are flexible in their decision making were often less vulnerable than other businesses. One stakeholder also mentioned that when there is extremely low visitation, they will actually take other jobs in order to make up for lost revenue.

Adaptation can also refer to the purchasing strategies of certain businesses. Two of the interviewees identified the purchase of fat bikes, which are mountain bikes with larger wheels and tires that can be used on snow. This has become a popular, widespread activity in the winter, because the quality of the snow does not need to be at the same standards as for skiing or other more traditional

snowsports. Four of the businesses interviewed stated that they base their decision-making on previous years' decisions and they consider different trends and changes that they witness over time. This included, for example, data-based decisions or trends in visitation and general tourism. Of these businesses, most of them said that they tend to scale back their purchases relative to previous years in case of a low snow year.

Though adaptation is one of the best ways for a business to increase its probability for success, there are some serious barriers to adaptation that impact stakeholders differently throughout the Intermountain West. These barriers are often the defining factors that make a business more vulnerable than others. Some of the stakeholders identified climate change as one of the main barriers to adaptation, because the variability and predicted changes brought on by a changing climate will impact their businesses. Another barrier that multiple businesses spoke about was that because people have more internet access and choices, this could lead to last minute changes and cancellations. This unpredictable change causes the business to not only lose revenue from that specific trip, but also lose the opportunity to rebook. One of the final barriers that creates vulnerability for a snow-based business is the lack of a reliable labor force during the winter season. Because these businesses are often located in affluent areas that are difficult to access, employees often have trouble finding housing in close proximity. As a result, business owners may face challenges in hiring employees and/or, during extreme weather, employees may not have access to roads and transportation.

One final barrier that a stakeholder identified was that higher elevation is vital for the future success of certain snow-based businesses. They stated, "... might not be rhetoric, but in 2025 you're not going to be able to ski unless you're over 9,800 feet, right, there will be no snow on the ground". The inability for certain businesses to adapt to adverse drought events will pose a serious threat as future climate variability increases.

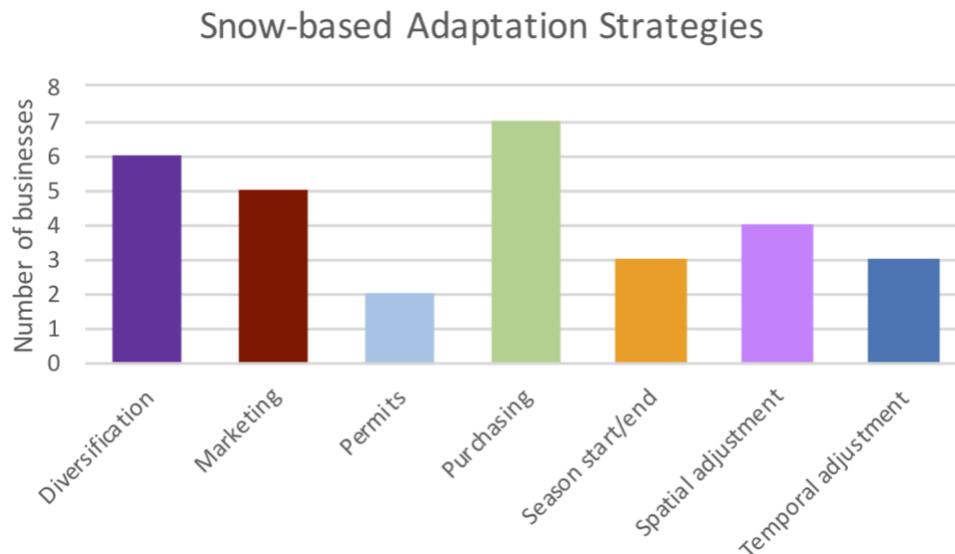


Figure 7: Drought adaptation strategies employed by the snow subsector.

Drought Information and Current Weather Forecasting for the Snow-Based Subsector

Within the snow-based subsector, the majority of businesses responded that they are currently checking NOAA long-range forecasting to inform their businesses. The next most utilized tools were the El Niño Advisory, experiential drought monitoring, and the farmers’ almanac. About half of the interviewees stated that they refer to NOAA daily forecasting, USGS stream gauges, SNOTEL, and third party forecasting.

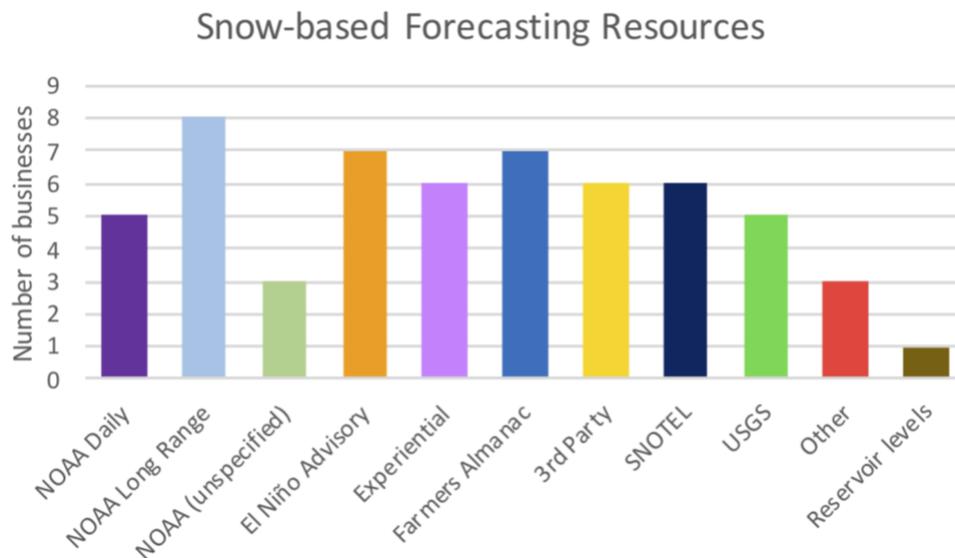


Figure 8: Weather and climate forecasting resources utilized by the snow subsector.

Within the snow-based subsector, there is significant distrust of scientific forecasting, so many businesses rely on experiential drought and weather monitoring. These businesses said that they perform a “rain dance”, have a “sixth sense”, make educated guesses, and base their day-to-day decision-making on looking outside to check the current weather. One interviewee said, “how can you predict what’s going to happen? The only way you can predict that is watch the volcanoes. It super heats that water and of course the cold water flowing from whoever where collides with that and it creates all these weather patterns. And so if you can predict that, you can predict that, you can probably predict when there’s going to be a drought or not.” This illustrates some of the disconnect between portions of the industry and science-based approaches to forecasting.

Short- and long-term decision-making is partially based on information that stakeholders receive from forecasting resources and tools. Some businesses refer to the conditions of the previous year, in combination with some type of tool to inform their equipment purchasing and planning decisions for the upcoming season. This can change when there is a serious drought year, like in 2017–2018, which forces owners to rethink their strategies. Some of the decisions that businesses must make include equipment procurement, activity offerings based on snow conditions, and hiring.

Information Gaps for the Snow-based Subsector

Some of the businesses said that receiving even general knowledge about how many inches of snow they may receive throughout the season would be highly beneficial for preparing for the upcoming season. One interviewee detailed that having this information before November would be most

helpful. A majority of interviewees in this subsector expressed that having access to more accurate short- and long-range weather and climate forecasting would greatly aid in decision-making for the upcoming season. Some of the businesses want more detailed information and forecasting within their specific region. Overall, the snow-based subsector wants more access to information about the mid- to long-range weather and climate predictions within their area, so they can have ample time to prepare and adapt to the future conditions.

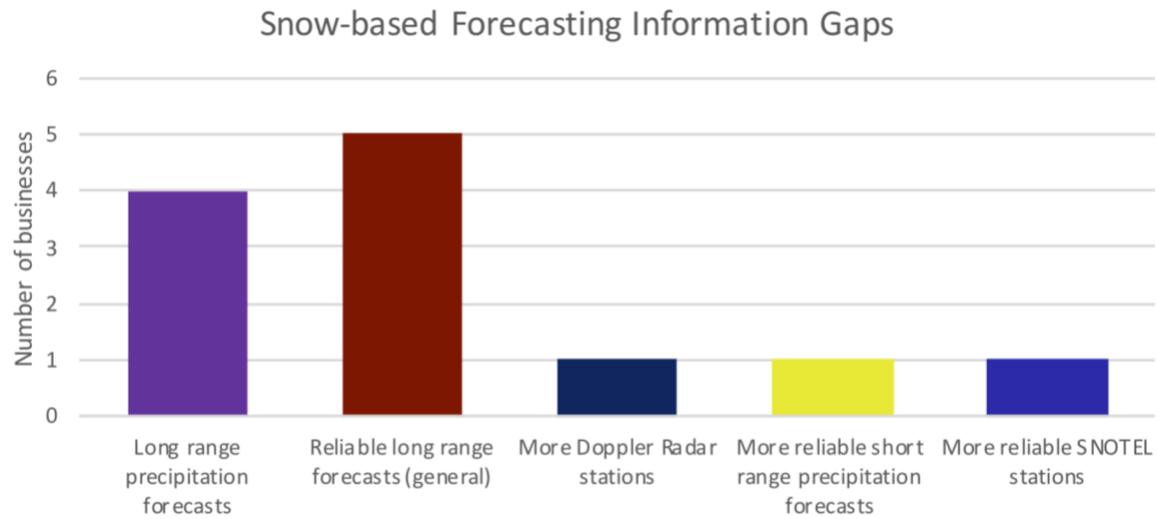


Figure 9: Weather and climate information gaps within the snow subsector.

Lake-based Subsector Overview

The lake-based subsector includes activities such as lake-boating and paddle boarding. This is a unique industry, because while drought is becoming more frequent and severe throughout the Intermountain West, the recreation that occurs on lakes and reservoirs is often buffered from negative impacts. This is partially due to mandatory agricultural dam releases as well as general characteristics of water storage systems. Some of these businesses are fed by tailwaters and may experience a positive impact during a drought year, because the agricultural sector will often demand more water during these times, thereby benefiting some businesses. The investigators experienced difficulty contacting the businesses and companies that fell within this category and conducting comprehensive interviews with the few that were willing to partake in the process.

The investigators were able to conduct one successful interview and received 10 responses from the survey. According to the survey and interview results, all 11 businesses stated that their peak revenue occurred within the months of June and July. A majority of these businesses also included August as a month of peak revenue. More than half of the businesses also included May as one of the highest periods of revenue generation.

Eight of the 11 businesses noted that they offer some form of lake-boating experience, while three specifically offered paddle boarding. The stakeholder that was interviewed stated that the most revenue came from retail and equipment rentals. This industry is very seasonal and only has a short window of time to provide lake-based offerings but is still able to thrive because many lakes and reservoirs are partially protected from drought and climate variability due to their own water storage potential.

Lake-based Subsector Drought Risk Assessment

As mentioned above, many of the businesses that the investigators contacted explained that they are not impacted by drought and were not interested in being interviewed. Even though drought is increasing in severity and frequency, these specific businesses did not experience decreased visitation or loss of revenue. This confidence in the future outlook of lake-based recreation stems from historical evidence that during drought years (for example, in 2017–2018), certain businesses did not report any losses.

Though some businesses were unaffected, other businesses owners within this industry expressed that they experience negative drought impacts. Some examples that were identified by stakeholders included lower lake and reservoir levels, increased chances of wildfires, and higher water temperatures. As a result of these impacts, there were many compounding factors that created problems for lake-based business owners. Lower lake levels make it difficult to launch boats from the docks, the overall season is shortened, and there is a need for more infrastructure that allows for lake access during drought years.

All 11 stakeholders that the investigators interviewed stated that they were in some way vulnerable to drought. Geographic location plays a particularly interesting role in whether or not a business is directly impacted by the negative effects of drought. For example, if there is a drought in an area such as Lake Powell, which is located at the bottom of the Upper Colorado River Basin, the reservoir will not necessarily be impacted, since most of its inflows originate as mountain snowpack hundreds of miles away. The reservoir will only be impacted if there is low water or drought that severely impacts

the upstream region. Because of this, many potential stakeholders located downstream are not likely to experience the impacts of drought. One stakeholder in Arizona said, “drought in our area doesn't affect the water level in the lake. Flash floods from local rains in the canyons doesn't even affect the lake at all.” Of the stakeholders, about half responded stating that they experienced drought in 2018.

Public perception of drought often plays a role in whether or not a business will have a successful season. A majority of the businesses stated that public perception does impact their revenue and visitation. Though most found tourists and customers have some awareness of drought conditions, a few business owners stated that they do not believe that public perception impacts them. One interviewee said this was a non-issue, stating, “99% of them don't know anything about a drought. No concept whether it's wet or dry.”

Adaptation Strategies of the Lake-based Subsector

In order to combat negative public perception about drought as well as other negative drought impacts, businesses often employ adaptation strategies. Some of these include building better access roads to the lake or reservoir, updating and reviewing drought contingency plans, constant maintenance around the marinas, staying updated on weather reports (short- and long-term), and marketing smaller boats and watercrafts.

There are also some barriers to adaptation that the stakeholders explained in their survey and interview results. A few of the subjects stated that they have little to no capacity to adapt due to financial constraints, size, geographics, or other reasons, and a majority explained that they have limited access to accurate and accessible forecasting tools. These factors, combined with the projected increase in drought severity and prevalence, create potential future vulnerabilities for the lake-based subsector.

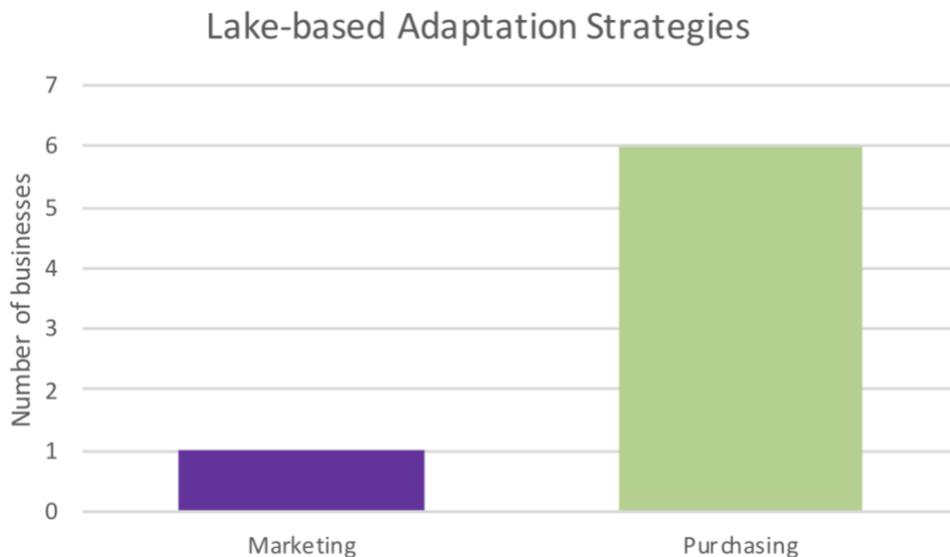


Figure 10: Drought adaptation strategies employed by the lake subsector.

Drought Information and Current Weather Forecasting for the Lake-Based Subsector

All businesses within the lake-based subsector stated that they use different forecasting tools to help them make data-based decisions. Most businesses utilize experiential drought monitoring and reservoir levels to make decisions. Less than half of those interviewed stated that they use NOAA forecasting, SNOTEL, USGS, and third party forecasting. This could demonstrate the lack of trust in the reliability of scientific forecasting tools.

Some of the decisions that these data inform include hiring, operating hours, opening and closing dates, and permitting. The interviewees reported that for hiring, they need three month forecasts, while a minority stated that they need longer outlooks. For operating hours, the majority wrote that three month forecasts were the desired forecasting resource, while one stated they needed a climate prediction one year in advance. Closing and opening dates are often determined four to six months in advance for the lake-based subsector, therefore there is a need for this length of forecasting.

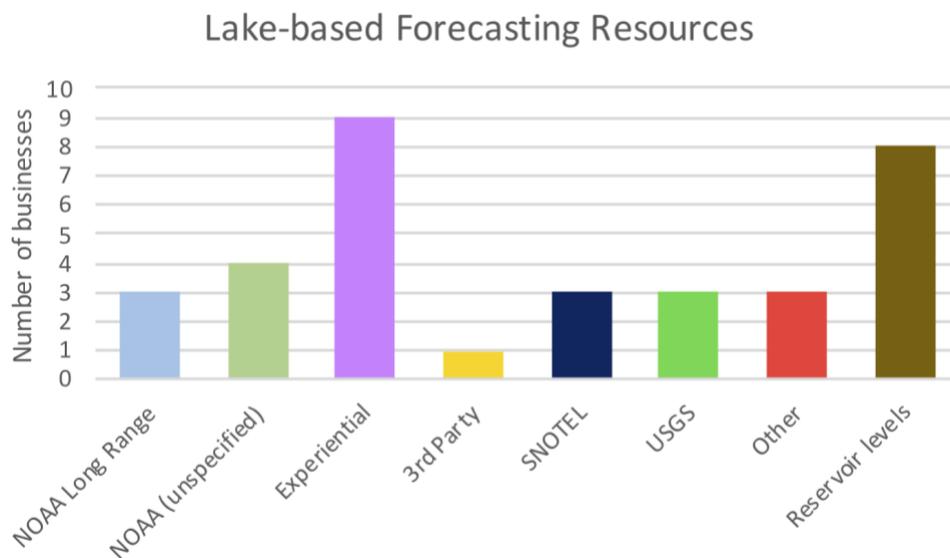


Figure 11: Weather and climate forecasting resources utilized by the lake subsector.

Information Gaps for the Lake-based Subsector

Overall, there was some expression of distrust within the industry when discussing forecasting and other scientific tools for weather and climate predictions. Many stakeholders stated that they base their business decisions on word of mouth weather and climate information, with one interviewee saying that they did not use any type of forecasting tool. On the other hand, members of the lake-based subsector also said that they would benefit from improved tools and information. There was a collective response that the most useful type of information would be more accurate and reliable forecasts in order to make better decisions.

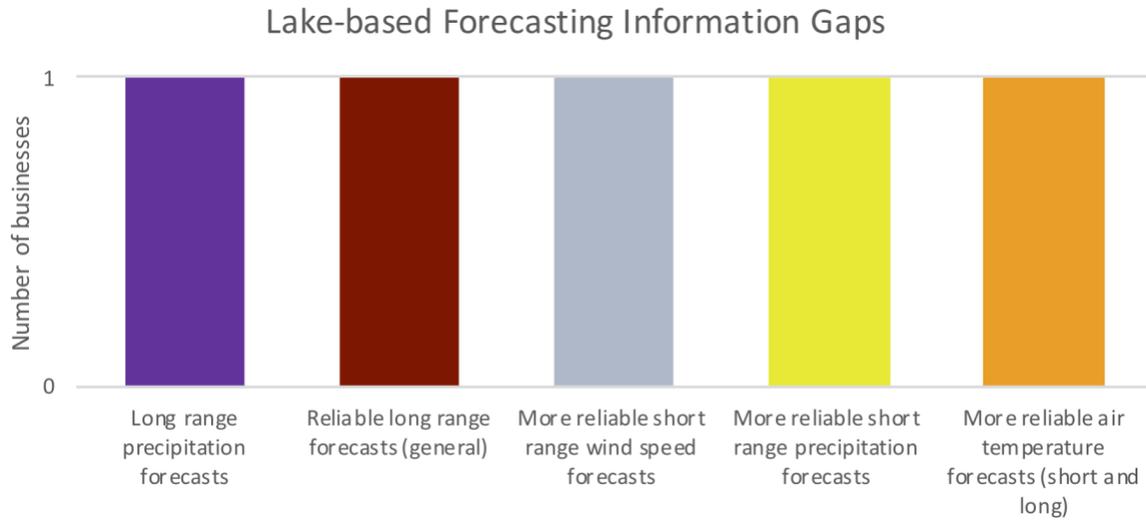


Figure 12: Weather and climate information gaps for the lake-based subsector.

Fishing Subsector Overview

For the purposes of this project, the fishing subsector comprises businesses that offer fly fishing guiding, outfitting, and retail services to clients. Fly fishing entails using a light-weight lure (artificial fly), which is cast using a fly rod, reel, and a weighted line. Within fly fishing, there are a number of specific methods and techniques that outfitters and guides offer to customers, including wading, floating, Tenkara, and ice fishing. The ability of guides to offer these types of activities depends on the guide's experience and the available fishing habitat (e.g., small streams, large rivers, lakes and ponds).

Wade fly fishing is the most simplistic method of fly fishing and involves wading in a section of a stream or river and casting a line. Advantages of wade fishing include that it is beginner-friendly, provides an intimate angling experience, and it can be done in lower water conditions. Offering wade trips can therefore be advantageous to angling businesses during drought years.

Tenkara fly fishing is a Japanese method of fly fishing, and differs from wade fishing in that it uses a long rod and a line, but no reel. It is primarily used on small creeks, streams, and alpine ponds and lakes to catch trout. Tenkara is fairly niche in the United States; only one of the angling businesses that participated in this research provided Tenkara trips.

Float fly fishing utilizes drift boats, which are specially designed for fishing on rivers. Float fishing offers a number of advantages compared to wading, including: it allows anglers to cover larger sections of river, fish in deeper waters, get into positions that are inaccessible when wading, take more gear, and can be less physically strenuous than wading. Angling businesses can charge significantly more for float trips as opposed to wade trips due to the increased equipment requirements.

This analysis is based on interviews and surveys with 28 fishing businesses. While some businesses specialize in a particular type of fishing (e.g., Tenkara, ice fishing), most fishing guides and outfitters offer several trip options, with the primary ones being guided wade fly fishing and float fly fishing trips. Many businesses offer morning, afternoon, and full-day guided trips. Most fishing businesses also operate a retail line of business, which can range from selling t-shirts, hats, and souvenirs to technical gear and equipment. In addition to guided fishing trips and retail, a few businesses offer instructional courses, destination trips to international locations, or non-angling activities (e.g., target shooting, bird hunting) to diversify their offered activities.

The majority of fishing businesses are relatively small, with one to six permanent employees. Most business owners either guide or are ex-guides. Although fishing businesses are open year-round, there are seasonal fluctuations in the number of staff due to the seasonal nature of tourism and ideal fishing conditions. Businesses often have a longstanding core team of one to four guides, and they hire five to twenty subcontractor guides during the peak season depending on customer demand. Businesses that have more robust retail lines of business hire additional shop employees on a seasonal basis.

Even though angling can take place year-round, the vast majority of fishing businesses generate the most revenue between mid-June and mid-September. Within this period, many businesses emphasized the eight-week window between mid-June and mid-August as the most critical to their operations. One business owner stated that they generate 70% of their annual revenue during this time. The peak fishing season is determined partially by ideal fishing conditions as this period

correlates with the back end of the spring runoff. However, the majority of businesses attribute this period the highest revenue generator because it coincides with the summer tourist season. The exception to this paradigm is ice fishing, which requires eight inches of ice coverage on a reservoir, and therefore generates revenue during the winter months.

Many businesses described a shift over the last twenty years in their customers, which transitioned from predominantly experienced anglers who booked full-day trips to novices who are looking for a half-day activity during a family vacation. This is especially true in resort towns such as Aspen, CO and Park City, UT, where fishing is a secondary activity rather than the primary draw to the area. Many novice customers are directed towards particular fishing businesses by hotel concierges, thus many fishing business owners in resort towns emphasized the importance of developing relationships with concierges. Since many tourists plan their vacation far in advance, the changing customer base towards novices is manifested in fishing trip reservation bookings made, on average, eight to twelve months in advance.

Fishing Subsector Drought Risk Assessment

Since the health and behavior of fish is directly dependent on the water resources they occupy, drought significantly impacts fishing businesses in the Intermountain West. Every business identified the calendar year of 2018 as the most recent drought event that they experienced and some described it as “the driest year of [their] lifetime” and “the most severe drought year [they had] experienced as a fly fishing guide”. Other years businesses recalled as impacted by drought include 2002, 2012, and 2014/2015, in order of most to fewest citations.

Depending on its severity, drought can have positive, negative, or neutral effects on fishing businesses, which creates challenges for determining the subsector’s precise vulnerabilities to drought. From a high-level perspective, the fact that angling can still take place in lower water conditions buffers fishing businesses during drought events. However, once the severity of a drought reaches a certain threshold, businesses are negatively impacted.

Negative Drought Impacts on the Fishing Subsector

During drought events, angling businesses are primarily concerned about water conditions that are too low and too warm. This often occurs during the later summer months, which can shorten the fishing season during drought years. When water levels are too low, fishing becomes more technical or even impossible. In low water conditions, drift boats may be unable to navigate waterways, resulting in businesses cancelling float trips. In 2018, several businesses noted that while the total number of trips they provided did not drastically change, the percentage of wade versus float trips did. In a normal year, approximately 70% of a guide’s annual trips are float trips and the remaining 30% are wade trips. In 2018, angling businesses stated that this flipped because rivers became un-floatable due to low water levels. Switching from float trips to wade trips negatively impacts a business’s bottom line because they charge substantially more for float trips than they do for wade trips.

Water temperature has critical implications for the physiological processes of fish: temperatures that are too warm (68°F or greater) due to drought can induce stress in fish. Cold water can hold higher concentrations of dissolved oxygen than warm water, so fish can become stressed in warmer water temperatures when they do not get sufficient dissolved oxygen. When fish are stressed, they become increasingly susceptible to fungus and other

diseases. For example, in September and October of 2018, guides in Aspen were catching brown trout that had white fungus in the shape of human handprints. Stress on fish is further compounded by the concentration of fishing to certain sections of rivers that have enough water to remain fishable. The fish tend to congregate in the same spots that have enough water, and the increased competition for food resources can place additional stress on fish. Finally, the shift in the customer base of fishing businesses from expert anglers to first-timers can result in novice anglers playing a fish longer than necessary, which places even more stress on fish.

Fish kills can occur when a certain threshold of stress is reached. In 2018, angling businesses in Glenwood Springs, CO, Carbondale, CO, and Durango, CO all noticed fish kills in local rivers. This is detrimental to the longevity of the fishing industry in these regions, as it depletes the reproducing stock. Fish kills also result in a negative customer experience. A guide in Glenwood Springs described that, on one of their trips in summer 2018, “it was just white, white, white belly up fish in the bottom...[they] tr[ie]d to keep the conversation going with customers, and [were] rowing through like, ‘don’t look down’”. The same guide in Glenwood Springs explained that although they knew that they “shouldn’t be fishing...[they had] to pay the bills”, and thus continued to fish that summer even though they knew it was harming the resource. This exemplifies the dilemma that angling businesses may find themselves in during severe drought events. The majority of their revenue is made during the summer months when water temperatures are warmest and fish stress levels are likely to be highest. Despite these adverse conditions, businesses may be unable to make up that revenue during other parts of the year, so they fish in spite of the conditions.

Severe drought events can result in voluntary or mandatory fishing restrictions or closures. In the summer of 2018, Colorado Parks and Wildlife (CPW) issued a mandatory ban on fishing on a sixth-tenth of mile stretch on the Yampa River. During this same summer, the Roaring Fork Conservancy, local fishing groups, and CPW put a voluntary river restriction in place after 2 p.m. on the Roaring Fork River near Aspen. As a result of these closures, fishing businesses had to cancel a significant number of trips, which had substantial negative economic impacts. Businesses impacted by fishing restrictions in 2018 reported economic losses ranging from 20%-50% of the revenue they usually generate during this period.

Although not a direct impact of drought, wildfire can significantly impact the operations of fishing businesses. Guides in Aspen, CO, Durango, CO, and Park City, UT all reported being adversely impacted by wildfires that occurred in summer 2018. In Aspen, the airport was shut down over the July 4th holiday as a result of the wildfire in the Roaring Fork Valley. A guide in Aspen reported that during this time, they “didn’t do a trip for a solid five, maybe ten days”. Even though water resources were still fishable, smoke, burning sensations, haziness, and views of helicopters and fire retardant discouraged people from spending time outside. In Park City, a wildfire destroyed summer fishing opportunities on the Strawberry River by depositing ash in the river that could not be flushed out for three to four months. Wildfires in Durango resulted in National Forest closures, which restricted the resources where angling businesses could operate. Rains following the wildfires resulted in severe mudslides and ash flow, which had serious repercussions for fishing resources on the Animas River. For these reasons, while business owners felt that drought significantly impacted their businesses and revenue, they felt that “wildfire is much more significant of a problem for revenue”.

Angling businesses are particularly concerned about the effects that the public perception of wildfire has on their business. Given that the majority of customers are novices, most guides felt that their average client was not well informed enough to know that drought conditions cause stress on fish, and therefore the public perception of drought did not usually deter customers. However, because wildfires receive substantial media coverage, businesses feel that wildfire much more significantly impacts their visitation. One guide stated that “the media destroyed [their business] during drought years...[with] statements like “the whole state is on fire” and “fish are dying all over the state””.

Finally, drought conditions can negatively impact the mental health of angling business owners. Several business owners described feeling increased stress during drought years, because they are “scrambling and trying to move customers [at the] last minute” due to their usual locations being unfishable. A guide in Durango said that “a lot of times what severe drought years mean is that [they] have to borrow more money to bridge the gap.” A guide in Aspen described many sleepless nights during the summer of 2018 where he would question the viability of his business. While this research does not aim to quantify the mental health impacts of drought on business owners, there is evidence that the uncertainty regarding how drought may impact businesses and their revenue can cause stress in fishing business owners.

Neutral Drought Impacts on the Fishing Subsector

A few angling businesses noticed shifting fish habitat during drought events. For example, a guide in New Mexico observed that, in consecutive drought years, cold-water species such as trout are moving further upstream to chase colder temperatures, and warm-water species such as bass are moving into historic trout habitat. Another example is in exceptionally dry years such as 2018 and 2002, guides on the Animas River in Durango have observed smallmouth bass. This species typically lives further downstream where the river transitions from a cold water to a warm water fishery.

Some businesses also reported that their recommendations regarding optimal times to fish have changed in the last ten years in response to fluctuating snowpack and runoff trends. In general, businesses have seen that snowpacks have been smaller than the historical norm and that snowpacks tend to melt earlier than they have in the past. A guide in Durango used to recommend the last week of June as the best time to fish on freestone rivers but now recommends a week or two earlier due to these shifts in snowpack and streamflows.

Positive Drought Impacts on the Fishing Subsector

Despite the many ways in which drought can negatively impact angling businesses, the majority of fishing operations said that their businesses benefited from drought up to a certain threshold of drought severity. Since high water levels and stream flows can make angling conditions more difficult and dangerous, anglers generally prefer lower water conditions. Considering the shifting customer base of angling businesses to novices and families, lower water conditions pose less risk to clients, especially younger children. Many businesses stated that drought lengthens their business season, since ideal fishing conditions start earlier in the year. Some businesses also observed that drought could extend the winter season well into November and December.

In addition, drought’s severe impacts on the quality of or ability to do other outdoor activities may drive customers to fishing, benefitting angling businesses. During the 2017/2018 winter snow drought, angling businesses in Aspen saw more winter business because tourists were looking for alternatives to skiing, which suffered due to the lack of natural snowfall. One business owner stated that during “that low snow year [the business] did better activity-wise than [they] expected to do”, and that they were “really, really busy, which is kind of a silver lining to being in such a scary drought situation.” During the 2018 summer drought, some angling businesses noted that they experienced a boost in customers since water conditions were too low to support rafting operations. Drought events may also benefit reservoir fishing; for example, fishing increased on the Stagecoach Reservoir in Steamboat Springs in summer 2018 in response to fly fishing bans on the Yampa River.

Finally, drought may benefit angling businesses that fish primarily on tail water streams in the lower Colorado River basin states due to increased reservoir releases. During drought years, farmers in the lower basin states have increased irrigation water needs, and thus more water is released from reservoirs to meet those demands. As a result, tail water streams actually have higher flows during drought events in order to supply farmers with the water they need.

Adaptation Strategies of the Fishing Subsector

Angling businesses reported a number of different strategies that they employ to adapt to drought conditions. Many businesses attributed their ability to remain financially successful during the 2018 drought to a variety of adaptation strategies. No single adaptation strategy is perfect and businesses often use a combination of strategies during drought events.

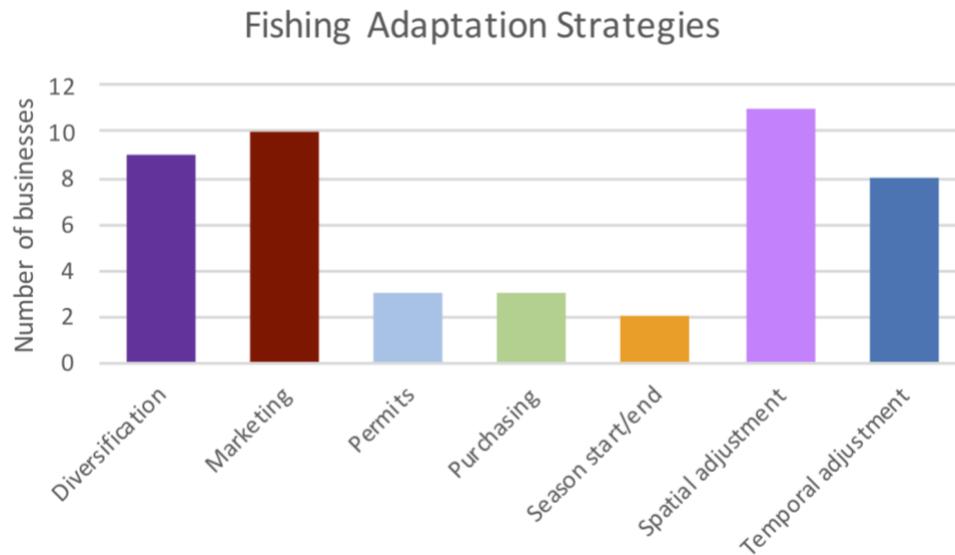


Figure 13: Drought adaptation strategies utilized by the fishing subsector.

Temporally Shift Trips

Since guides are primarily concerned about the stress-inducing impacts of warm water on fish, many angling businesses take clients out to fish earlier in the day when water temperatures are coolest. In a normal year, a guide may take clients out to fish at 10 a.m and return around 7 p.m., but in drought years, guides may take clients out at dawn and fish until 2

p.m., before water temperatures reach their peak. This helps alleviate additional pressure on fish, ultimately preserving the stock.

Spatially Shift Trips

Guides may also spatially shift their trips to higher elevation areas where water temperatures are cooler. Many guides emphasized the importance of having permits on a variety of water resources at different elevations in order to spatially shift trips depending on conditions. In Lower Colorado River Basin states, guides may switch from fishing on freestone rivers to tailwaters in order to avoid hot and low water conditions. Some guides do more trips on still waters and reservoirs during drought events, and target warm water species such as smallmouth bass or northern pike.

Altering Catch-and-release Practices

Although most guides still fish during low and warm flows, they employ more cautious catch-and-release practices in order to reduce stress on the fish. Some of the strategies businesses mentioned include keeping fish in the water, discouraging clients from taking pictures with the fish, limiting how long clients fight with a fish, and releasing the fish quickly.

Set Client Expectations

In order to combat any negative public perceptions of drought or wildfire, angling businesses often call customers the day before in order to educate them and set expectations. While some clients are disappointed that they cannot fish a certain river or section of the river, they are generally understanding regarding changing trips temporally and/or spatially, and are open to a different kind of experience. Calling customers in advance allows guides to assure their customers that they can still have a good experience, albeit a different one. In resort towns, fishing businesses indicated that it was also important to get this message to hotel concierges, who play a critical role in booking trips. One guide in Aspen reported that they took temperature readings three times a day with a digital thermometer and posted them on social media in order to reassure customers that the fishing conditions were still viable.

Drought Anticipation

Every angling operator interviewed or surveyed indicated that they had experienced a drought in their lifetime, and many said that they perceived a drying trend over time. As such, many guides stay informed of conditions in order to schedule trips when water conditions are going to be the most conducive to fishing. A few businesses also stated that the skill of their guides has increased due to a greater frequency of drought conditions over the last thirty years.

Activity Diversification

Some fishing operations maintain other lines of business to bring in customers when fishing conditions are not ideal. One business owner stated that “the businesses that are successful now are the businesses like [theirs] that do retail, guide services, classes, travel, international travel, and that really offer a whole picture.” In addition to the above activities, some businesses also offer duckie trips, inner tube floats, and rafting trips in order to capitalize on both low and high water conditions.

Fishing Subsector Barriers to Drought Adaptation

Even with a variety of adaptation measures available, angling businesses identified a number of barriers that make overcoming drought a challenge.

Considering that the majority of angling businesses' customers are novices, some do not want to wake up at dawn to fish on their vacation. Several guides noted that "it's surprisingly difficult to get people to meet you before 9 a.m.", which is important in order to avoid warm water temperatures during a drought. Although guides try to minimize additional stress placed on fish, new anglers often play a fish longer than necessary because they are less skilled. In the age of social media, clients often want pictures with the fish they catch, which can further stress fish. While guides want to preserve the fishing resource, they also need to balance the expectations of novice customers, and those two objectives can be at odds with each other.

While spatially shifting trips is one of the primary adaptation strategies available to guides, some clients have specific rivers in mind that they want to fish, and are not willing to fish on a different river. Spatial diversification often translates into more time traveling in a car, which may be unappealing for customers looking for a half-day trip. There are further limitations to spatial adaptation, because guides can only go so far upstream or in elevation before the fish become too small and the water too narrow to provide a quality fishing experience.

Low certainty forecasting makes it difficult to manage clients' expectations. The majority of customers book trips in early spring; they want to know at that time when is the best time to fish between June through August. However, from early spring, snowpack conditions can change, which affects fishing conditions in the summer. Guides feel a lot of pressure giving recommendations for the summer, because they are often helping the client plan their vacation. Although businesses use forecasts to inform customers as best as they can, forecasts are not accurate this far in advance, which can leave clients disappointed.

As was previously mentioned, many businesses provide substantially more wade trips in drought years than float trips because wade trips are more feasible. However, guides can charge significantly more for float trips than they can for wade trips. Even though angling businesses may not see a substantial difference in the total number of trips booked during drought years, they often see a drop in revenue because they are booking the same amount of less expensive trips.

Finally, fishing businesses are highly dependent on the summer tourist season, which is the most vulnerable to drought. Several businesses specifically identified July as the most crucial month for revenue, because that is when the most tourists are visiting. However, July is also the most variable: in wet years, rivers may be too muddy to fish; in drought years, rivers may be too low and warm. Many guides expressed that even though they knew that fishing was detrimental to fish in drought conditions, they could not afford to cancel trips. One guide stated that "at the end of the day, you've got to pay the bills...I think the noble thing would have been no trips at all but you can't afford that." An extreme drought year may result in severe damage to fishing stocks due to a combination of environmental and anthropogenic factors, which may threaten the future viability of the resource.

Drought Information and Current Weather Forecasting for the Fishing Subsector

Angling businesses use a variety of weather and climate forecasting resources to plan their operations. The tools most utilized by guides are short- and long-term weather forecasts, USGS stream gauges, SNOTEL sites, reservoir levels, and experiential monitoring.

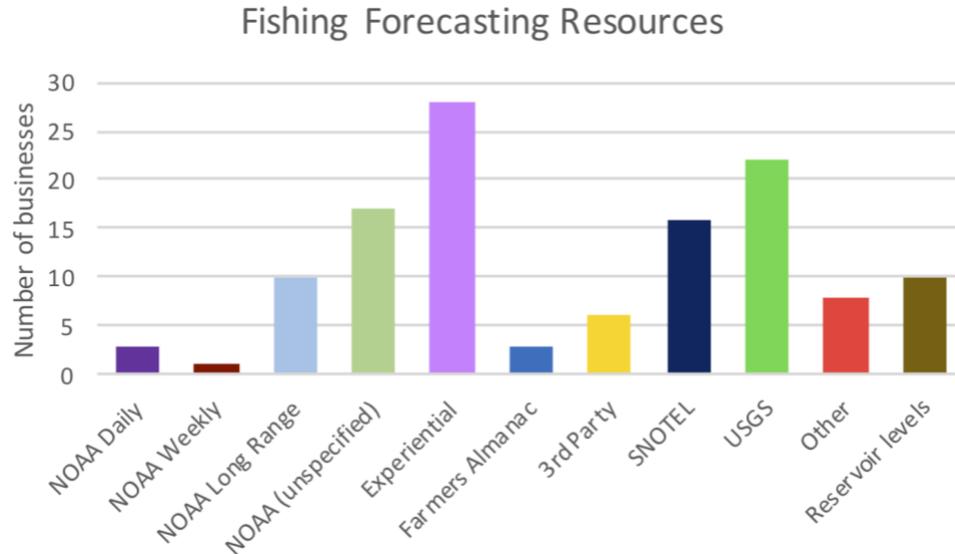


Figure 14: Weather and climate forecasting resources utilized by the fishing subsector.

Since the behavior of fish is highly dependent on weather, fishing businesses use short-term weather forecasts for deciding when the best time to fish is on any given day. Guides are often particularly interested in temperature. Specific weather forecasts that businesses use include NOAA’s point forecasts, Weather Underground, and My Radar.

Guides rely heavily on USGS stream gauges and reservoir levels for deciding which streams, rivers, and reservoirs to operate on. Businesses often look at stream gauges every day, especially on unusual years (ie., high water or drought years). If flows are too high, then rivers can become “blown out”, meaning that there is too much sediment in the river to make it fishable. Alternatively, too low conditions can make it impossible to run float trips. If spatial diversification is not an option, then guides use stream flow conditions to decide whether or not to cancel trips.

SNOTEL sites are primarily used by angling businesses to monitor snowpack throughout the spring. Guides primarily look at SNOTEL sites in February, March, and April to inform their summer bookings and estimate the best time to fish. Fishing businesses often couple SNOTEL site data with experiential monitoring to make these recommendations. For example, a guide that has been guiding for over twenty five years stated that because he had “been in this a long time, it’s pretty easy to tell what’s going to happen based on snowpack levels.”

Finally, guides use personal observations or word of mouth to monitor environmental conditions. Older guides are often more wary of using technology to make decisions than younger guides, and instead prefer to rely on instinct and experience more than anything else. Some guides will look at the river while they are driving to the shop headquarters to determine the relative clarity of the river.

Others report that forecasts cannot make up for simply being out on the river for four to five days a week, and that this prevents “get[ting] blindsided when you don’t do a trip for a week.”

Information Gaps for the Fishing Subsector

The vast majority of angling businesses want more accurate forecasts of snowpack, stream flows, water temperatures, and reservoir levels when they are booking trips from February through April. Knowing the date of peak runoff for rivers and all of the tributaries that fishing businesses operate on would be the most helpful, as it would allow guides to adequately prepare for the season. Many guides found the USGS stream gauges to be challenging to interpret, therefore, making them more user-friendly would be a helpful first step. In order for this information to be usable to the subsector, it needs to be regionally specific, at the scale of individual tributaries.

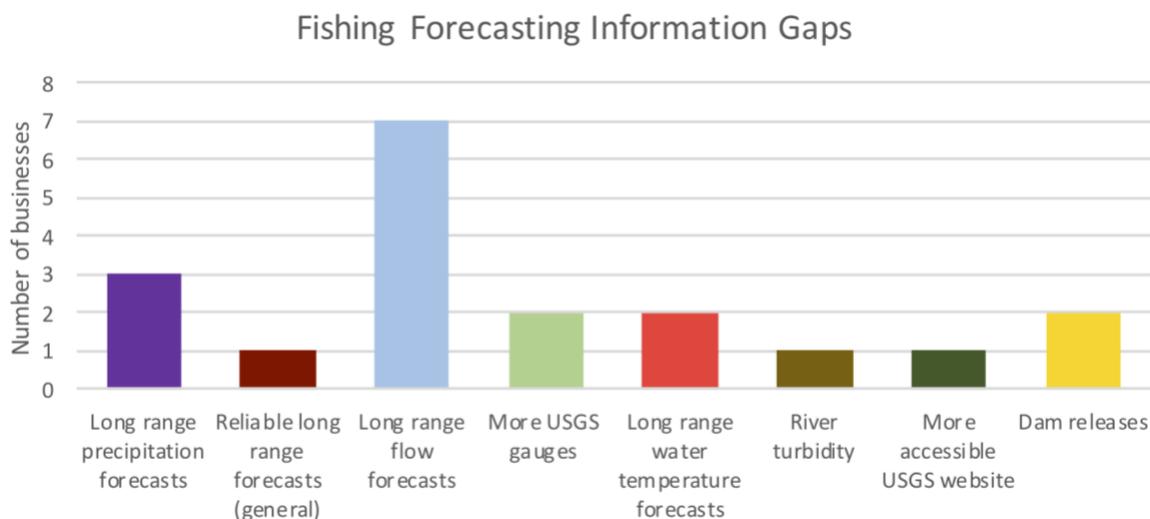


Figure 15: Weather and climate information gaps for the fishing subsector.

Several businesses found it challenging to gather data from numerous disparate sources, and expressed that having a dashboard specific to angling would be helpful. Having a user-friendly and streamlined clearing house where guides could access weather, stream flow, reservoir, and snowpack data would make it easier to plan day-to-day operations.

In the Lower Colorado River Basin states, several guides expressed the need for stream flow forecasts that take into account dam releases and irrigation diversions. Guides are currently often unaware when these occur, which make it challenging to plan trips. Increased communication between irrigators, dam operators and guides about scheduled releases would allow for better planning in the subsector.

Rafting Subsector Overview

The rafting subsector of the outdoor industry consists of guiding companies, outfitters, and retail shops that focus on river recreation. Twenty-two businesses that focus on or provide river recreation services were interviewed and surveyed for this project. These businesses provide services ranging from offering guided single-day whitewater rafting trips, multi-day rafting trips, tube rentals, raft rentals, and paddling gear retail services. Ten out of the 12 businesses interviewed within this subsector focus on whitewater rafting, which consists of guiding customers down class II-V whitewater rivers and creeks. The other two businesses focus mainly on retail for general river recreation. In the Intermountain West, a majority of the whitewater rafting businesses interviewed operate primarily during the summer months, between June and August, due to seasonal conditions. These rafting businesses are heavily reliant on adequate streamflows in order to provide a quality customer experience. River and stream flows are directly related to the winter snowpack, since the melting snowpack in the spring months causes the rivers and creeks to rise. Therefore, rafting businesses are also very dependent on the winter snowpack to ensure that their business can operate during the summer months.

Within this subsector, regional and geographic differences play a large role in the operations and management of rafting businesses. Considering that the Intermountain West includes a variety of landscapes, there can be major differences in how businesses in certain regions operate. In New Mexico and Arizona, the peak season may begin in the spring, as early as March, while in Colorado the peak season may not begin until June. Additionally, each river basin has a variety of characteristics that affect the streamflows and water availability. In mountainous regions such as Colorado, rivers may be free-flowing, relying on melting snow to increase stream flows required for rafting. In other regions, especially in Arizona, New Mexico, and Utah, dams and reservoirs may hold back the melting snowpack, creating different flow regimes and altering seasonality. In New Mexico, rafting companies can also be very reliant on summer monsoons.

Rafting Subsector Drought Risk Assessment

The rafting subsector in the Intermountain West is highly vulnerable to drought. This is especially the case if a drought causes decreased winter precipitation, reducing snowpack in the mountains. Reduced snowpack results in less water in the rivers and creeks that rely on the snowpack to feed them. This can drastically shorten the length of the rafting season, since the rivers will not flow at raftable levels for quite as long. As an example, a river may normally have raftable flows from June through August, but in a drought year, flows may drop below raftable levels by early July, significantly shortening the rafting season. Low stream flows and shortened river seasons accounted for the majority of major drought impacts affecting the rafting subsector. Since rafting businesses rely on stream flows to provide a quality customer experience, low flows can negatively impact that experience or make it impossible to offer rafting trips at all. When some rivers get too low, they become more rocky and technical, eliminating much of the excitement that customers expect when whitewater rafting. Many businesses stated that when river flows get too low, they can't operate on a specific river or section of river and customer booking levels drop. In one interview, a business stated that in a drought year, their revenues could drop 40% due to cancelled trips related to low river flows. When this occurs, the impacts from a drought forces businesses to either operate while losing revenue, lay off employees since there is little to no work available, or shut down for the season.

While all rafting businesses can be impacted by drought, exposure to these drought impacts can differ regionally and within watersheds. If reservoirs or dams are located above the raftable sections of a river, this can greatly limit a business' exposure to low stream flows. For businesses operating on specific rivers in Arizona and Utah, such as the Colorado River or Green River, droughts can have little to no impact, since river flows remain consistent throughout the year due to the reservoirs upstream. However, for businesses operating on free-flowing rivers in other states, droughts and associated low river flows have significant negative impacts.

Rafting businesses can also see impacts due to the public's perception of a drought. A low snow year followed by low river flows can affect customer demand for rafting trips. A few businesses stated that many customers aren't interested in rafting when river levels are low. Part of this reduction of customer demand is due to media coverage surrounding droughts and current conditions. Media headlines, especially when referring to snowpacks and river flows, can create a public perception that is unvalidated. In particular regions, many customers book rafting trips through concierge services at their hotels, and the concierge often conveys this media coverage. Many businesses are able to offer their usual rafting trips for part of the summer, transitioning to different types of trips as the river flows drop to levels that no longer support rafting. When the media and news coverage of a particular drought reaches potential customers, the customers often assume that rafting opportunities do not exist for that season. While it is true that the rafting season may be shorter in a drought year, businesses are usually able to provide a quality experience for a portion of the season. Therefore, an altered public perception can reduce visitation even when rafting businesses are fully operational and conditions are ideal.

Adaptation Strategies of the Rafting Subsector

In order to maintain a viable and profitable business during drought years, many rafting businesses have implemented adaptation strategies to mitigate the risk of drought negatively impacting their business. The rafting businesses that were interviewed and surveyed tended to have similar strategies for dealing with the uncertainty surrounding future conditions. Many businesses operate on multiple rivers or sections of rivers, hoping to reduce exposure to low river flows. A majority of businesses also offer additional activities to complement or substitute for rafting trips, such as bike rentals, hiking trips, or Jeep tours.

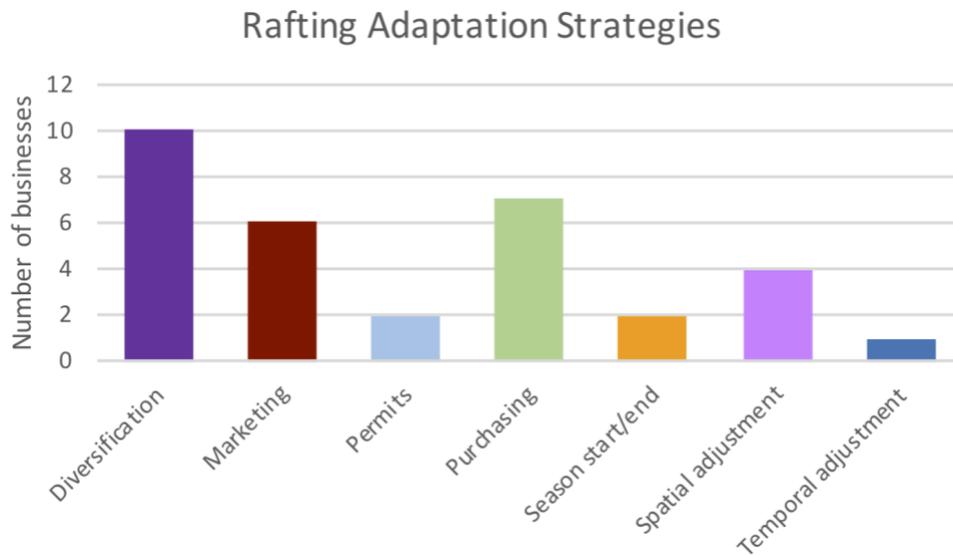


Figure 16: Drought adaptation strategies utilized by the rafting subsector.

Spatial Diversification

Spatial diversification is one of the most cited adaptation strategies used by rafting businesses to mitigate the risk of low stream flows on any given year. While it is common for some rafting businesses to operate on a single river, many businesses provide trips on a variety of rivers or sections of rivers. This allows them to adjust trip location based on stream flows in order to obtain a quality customer experience. If one river becomes too low to maintain an exciting rafting experience, a business can take their customers to another river that still has adequate flows. One business went so far as to purchase rafting companies on different rivers in order to expand its trip offerings.

Equipment Changes

Since river flows are not consistent throughout the season and can vary greatly each year, at least four rafting businesses routinely use different types of rafts and equipment depending on river flows. One business discussed this strategy in depth. In a normal water year, they use rafts that can carry six customers. In high water years, larger rafts are used to carry up to eight customers, increasing the revenue per trip. However, if it is a low water year, they must switch to smaller boats, carrying only four customers and losing revenue. While this company is able to adapt to a variety of river conditions, it can be difficult to forecast and predict the upcoming season's revenue.

Marketing Adjustment and Customer Service Strategies

Since rafting businesses face risks associated with the negative public perception of drought, many businesses are changing the way that they advertise and are working to better prepare customers for rafting conditions. When an area is in a drought, there can be a public perception that the rivers are too low for rafting. However, river flows may be adequate for rafting during a drought, albeit for a shorter operating season. In this case, businesses are finding new ways to advertise, via social media and other outlets, to inform potential customers that rafting is possible on certain rivers. In addition, if a river has a low flow but is still raftable, businesses may reach out to customers to discuss conditions and activity offerings and to set expectations before customers arrive. This helps maintain a quality

customer experience, especially if conditions are different than what the customer expects. Finally, some rafting businesses educate guests on climate issues while on rafting trips, hoping that better informed customers will return in the future regardless of the conditions.

Activity Diversification

In order to generate additional revenue during drought years, some rafting businesses offer non-rafting activities to their customers. Many businesses that were interviewed recently began offering mountain biking tours, Jeep tours, inflatable kayak tours, and hiking tours to offset the reduced demand for rafting trips in low water years. While these tend to be secondary activity offerings, it has allowed businesses to continue generating revenue when river flows are too low. It also provides opportunities for employees to continue to work a full season. Another added benefit is that offering alternate activities can extend the operating season for seasonal businesses. As an example, by offering mountain biking when the river flows are low in the spring and fall, revenue generating opportunities extend beyond the typical rafting season.

Other

Additional adaptation strategies were also mentioned that were very unique to specific businesses. One business was working to create an endowment fund with community stakeholders to purchase water rights from the local reservoir. This water would be drawn from the reservoir in drought years to extend the rafting season and reduce drought risk. Another example included delaying investments and owner payouts in drought years, increasing the long-term viability of the company.

Rafting Subsector Barriers to Drought Adaptation

Many rafting businesses have been able to find solutions to adapt to risks associated with drought and climate variability. However, there are barriers to adaptation, since there are certain things that businesses cannot readily adjust. The most challenging barrier is the physical location of the business. Rafting businesses tend to operate in specific regions and on specific rivers. If there is a significant drought in the area, rafting businesses will inevitably be impacted, except those operating below reservoirs with adequate storage. In addition, while businesses can adapt to generate other sources of revenue, decreased water levels due to drought are out of their control.

The peak rafting and summer tourist seasons also tend to be the same months year after year, and there is little that rafting businesses can change with regards to the timing of the peak season. If a drought impacts river levels during the peak season, businesses are limited in their ability to adapt. Lastly, successful adaptation strategies rely on customer visitation and demand. If customers do not travel to these regions to recreate, whether due to drought or economic factors, it will be more difficult for adaptation strategies to be successful.

Drought Information and Current Weather Forecasting for the Rafting Subsector

Rafting businesses that were interviewed reported using ten different sources of weather forecasts and information to help plan business operations. The most popular information sources were USGS Stream Gauges, SNOTEL, NOAA weekly, third party weather, El Nino/La Nina Advisories, Experiential, NOAA monthly, NOAA daily, and the Farmers' Almanac.

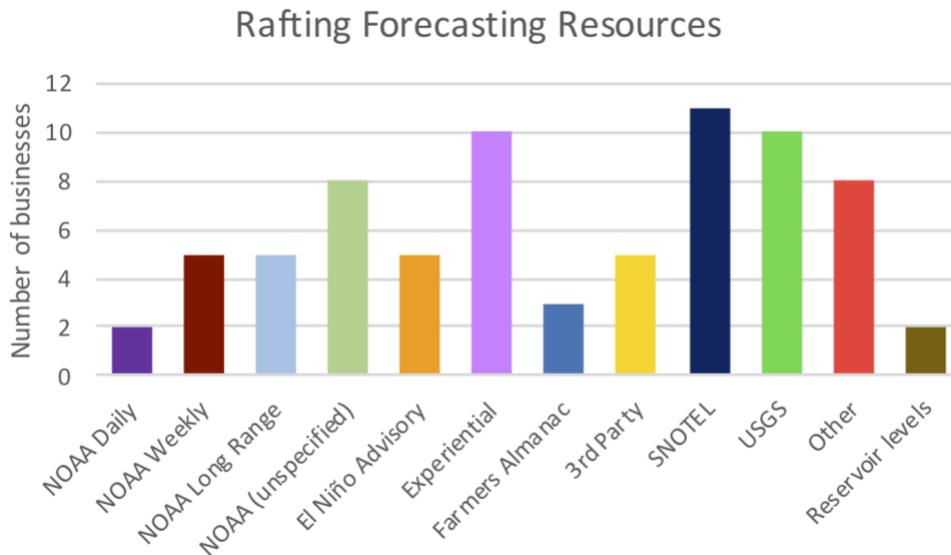


Figure 17: Weather and climate forecasting resources utilized by the rafting subsector.

USGS Stream Gauges are used heavily by the rafting subsector to monitor current river flows in order to make operational decisions about rafting trips. By using current streamflow data, businesses can decide which rivers are at adequate flows needed for a quality rafting experience. Rafting businesses in mountainous regions also relied on SNOTEL data to estimate future runoff. SNOTEL sites monitor the level of the snowpack, which eventually melts and feeds rivers and creeks that are used by businesses to take rafting trips. Monitoring SNOTEL sites allows businesses to forecast the timing of runoff as well as the remaining length of the season.

In addition, weekly NOAA forecasts and third party weather forecasts offer insights into upcoming weather patterns, so that businesses can properly schedule trips and activities. Third party weather forecasts include a variety of weather providers who distribute their own versions of daily, weekly, and monthly weather forecasts. Rafting businesses also use resources such as the Colorado Basin River Forecast Center (CBRFC), American Whitewater, Reclamation Management, and River Brain. When businesses want a long-range forecast, they use NOAA Monthly forecasts, El Nino/La Nina Advisories, and the Farmers’ Almanac. The NOAA Monthly forecast provides forecasted weather patterns and trends, allowing businesses to make preliminary estimates on snowfall and precipitation. The El Nino/La Nina Advisories also provide a long-range forecast by predicting seasonal patterns of precipitation. Since the Intermountain West includes a large geographic area, businesses located in different regions were impacted differently by both El Nino and La Nina. The Farmers’ Almanac was also mentioned a couple of times by interviewees for its long-range forecasts. These long-term forecasts were used by businesses to make decisions about investing in new equipment and creating marketing strategies.

The last significant information resource was experiential, and this includes manual monitoring of conditions, personal experience, and community networking to obtain accurate information about current river conditions. While most of the resources above proved to be helpful in planning business operations, there was an element of distrust when using long-term forecasts and SNOTEL sites to predict river conditions. Businesses often cited that the reliability of long-term forecasts was minimal, and that it was difficult to make business decisions around uncertainty. Businesses stated that SNOTEL sites, while useful during the river season to estimate the remaining water stored as

mountain snowpack, were a difficult way to measure the timing of runoff before the start of the season.

Information Gaps for the Rafting Subsector

When asked to identify information that would be most useful to rafting businesses, the overwhelming majority of respondents stated that more accurate, long-term forecasts are needed. Most businesses are specifically interested in forecasted river flows, including the timing of peak runoff as well as the total length of expected runoff. The timing of the forecast needs ranged from November of the year prior to the rafting season all the way to a few weeks in advance. Businesses also mentioned that estimated snowpack would be valuable, especially if there were tools available that could translate the snowpack levels into estimated runoff. Additionally, rafting businesses are looking for a better, easier way to collect all of the information that they need. This could be as simple as a dashboard with current and forecasted conditions. In general, businesses want earlier, more accurate forecasts. All of the forecast tools mentioned above would give businesses better visibility into estimated river conditions, allowing them to better plan their operations, hiring, marketing, and equipment needs.

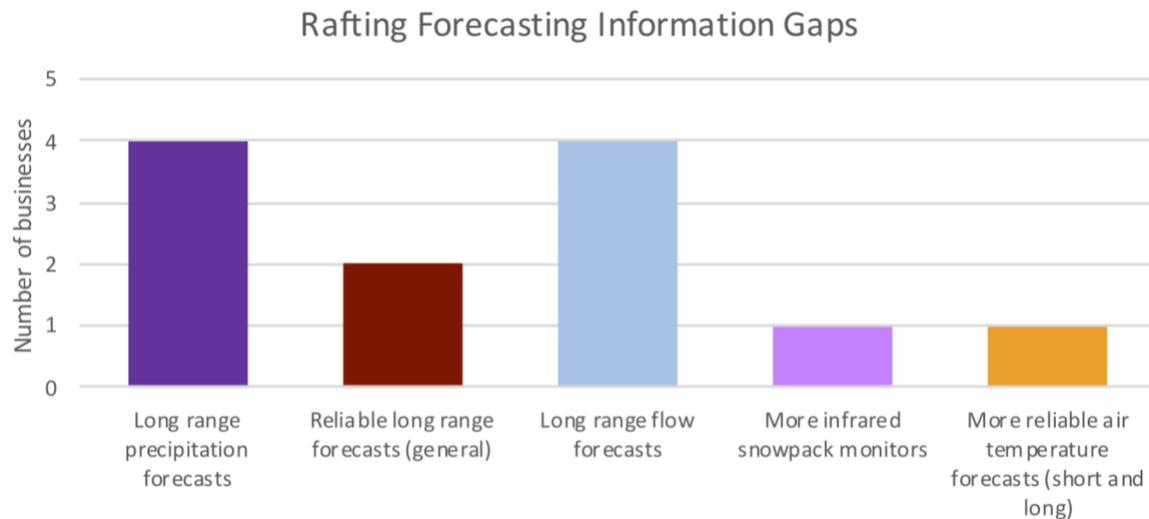


Figure 18: Weather and climate information gaps for the rafting subsector.

Retail Subsector Overview

The retail subsector of the outdoor recreation industry consists of a diversity of businesses that provide goods and services to customers participating in all of the activities described in this report. Some retail shops specialize in a few activities while others take a more generalist approach and serve many different subsectors. Because many forms of outdoor recreation are season-specific, some retail shops provide one set of products and services during winter and then transition to a summer operation and provide different products and services.

Some retail stores are coupled with an outfitting and guiding operation administered by the same business owner. These “hybrid businesses” are generally limited to the fishing subsector, but not exclusively. These businesses reported that the retail component accounts for 50% to 70% of their total revenue. For the purposes of this analysis, only the retail component of these hybrid businesses has been considered.

In total, this analysis is based on interviews and surveys with 20 businesses that fit into the definition of a pure retail shop or a hybrid business. A majority of these businesses had at least one or two previous owners. These stores have between two to 15 staff at any given time, which highlights a unique feature of this subsector: intra-annual changes in staffing are extreme. Due to the seasonality of many outdoor recreation activities, the number of employees at a given store may change by 200% to 500% within a year.

Many shops stated that certain product categories drive the bulk of their revenue. For stores primarily serving winter sports, ski sales and rentals are the most lucrative product category, followed by ski boots and rentals. Stores primarily serving summer activities are less dependent on a single product category. One shop owner stated that the majority of their revenue was derived from renting inner-tubes for floating the local river, while others said that the largest revenue generator was selling a large volume of high-end hiking socks. Rafts, kayaks, wetsuits and other “exposure gear” were often the most lucrative products for stores specializing in riversports. Further, these stores have relatively predictable periods of peak revenue. Retail shops serving summer activities make the majority of their money between June and August with the 4th of July weekend being a common peak. Shops serving winter activities generally make most of their money between Christmas and March, with peaks occurring during Christmas and Spring Break.

Retail Subsector Drought Risk Assessment

Environmental conditions, including snowfall or streamflows, impact retail shop sales, affecting the bottom line of businesses. While economic conditions play a role in sales, the success of most retail shops is largely weather-dependent. Lack of snow, low water in rivers, high temperatures, wildfires, and other drought impacts directly and indirectly deter tourists and local customers from visiting a recreation site or patronizing an outdoor retail shop. As a result, the success of these businesses is partially a function of weather and climate.

This introduces significant uncertainty for business managers who make important business decisions up to a year in advance. Herein lies the key to how outdoor recreation retail shops may be vulnerable to drought: these businesses regularly expose themselves to risk by making decisions about hiring and procurement with few meaningful forecasting resources to inform these decisions. Business managers are placed in a challenging situation where manufacturers need orders finalized between

nine to 12 months before shipment, but current long-range forecasting products are not accurate enough to inform these orders.

Many business managers reported “buying blind” because they could not base their orders off of trustworthy data. One reported that, “when we make these purchasing decisions, again, we’re making these so far out in advance that it’s just impossible to find any kind of a forecast that’s going to be accurate enough that far out to make a viable decision.” Others echoed this sentiment by saying: “You just have to take a leap of faith,” and “You really are blind [when making] these orders.” Some business managers cited using the Farmers’ Almanac to help inform decision-making, but the utility of that resource is limited as well.

This exposure to risk caused by making financial commitments in an increasingly variable climate is compounded by different managers’ purchasing philosophies. Managers with a more conservative approach minimize their risk by making conservative sales estimates, purchasing less inventory, and attempting to source additional inventory as needed. This shields the business from being overstocked, but also means that potential sales may never occur because the store is understocked. Similarly, managers with more aggressive purchasing philosophies purchase inventory liberally and hope they can sell their large stock. This strategy is beneficial in wet years, but may result in losses when demand wanes due to poor environmental conditions such as drought. At least one retail store manager reported having to take out loans and rent a storage unit to store excess inventory after the 2018 drought. Others reported losing 20% to 35% of their average annual revenue during the same drought event.

Regardless of purchasing philosophy, one thing in common among retail shops is the criticality of certain times of the year. The bulk of these stores’ revenue is generated in an extremely short period of time. As such, adverse environmental conditions including drought can severely hurt businesses’ bottom line. One shop owner stated that, “June, July, and August...that eight-week window in there literally makes our whole year.” Another affirms just how essential the summer peak season is by saying, “It’s the season that is most important to us because it’s when everybody’s coming, the money is coming in...that’s the hardest one, and the most important one.”

Similar risks are introduced when hiring staff, which occurs frequently due to the seasonal nature of certain stores. While staff can be hired rather quickly, the decision of how many employees to have in a shop remains a delicate balance. If a shop hires too many people, it will lose money in paying people to be idle. Hiring too few staff may result in poor customer service. The issue of staffing is further complicated by the fact that reducing employees’ hours or firing them only serves to transfer the financial risk on to those employees. Furthermore, it can be challenging to add additional staff mid-season when people seeking seasonal employment have already accepted jobs elsewhere.

The presence of wildfire highlights an important point about the vulnerability of retail shops to drought: public perception about an area appears to be equally important to that area’s outdoor economy as its natural assets and environmental conditions. If a customer believes that a certain area has poor recreational opportunities, due to drought or other reasons, they will likely choose to visit a different area and patronize different retail stores. The flip side of this dynamic is that moisture drives sales. Shop owners cited this repeatedly, sharing anecdotes such as “I’m a snow farmer. If it rains for three days in a row in August and let’s say the temperature drops to low 60s high 50s, we’ll start selling

skis. It's the craziest thing. Weather drives people in my door for sure. They just smell the moisture in the air and they come in and buy skis. It's crazy.”

Unfortunately, if a locality has a bad snow year or low rivers, that event will create a public perception of low quality recreational opportunities that persists in the future. This is a “lag effect” in which, even if the next year has excellent environmental conditions, customers will remember the prior year’s dryness and choose to visit other areas. One shop owner described this as “when we have a bad year, that particular year is usually not terrible, but it usually affects the year going forward. People are more hesitant to book vacations and make their reservations for rentals.”

Awareness of environmental conditions, and the resulting changes in public perception, appears to be intensifying as well. With the advent of social media networks, smartphones, and other internet technology, consumers are becoming more and more sophisticated. Customers have become noticeably better at following favorable conditions rather than blindly booking trips to a set destination. One shop owner summarized this effect: “The lack of snow has a major impact on us and has changed over the years due to...the internet. People used to plan ski trips...well in advance and book it. They're coming, they're hoping the weather's there, it's all good. Now people are much more “last minute”. They watch who's got the best snow, who's got the most terrain open and may decide to go somewhere else...because the snow is so bad.”

Adaptation Strategies of the Retail Subsector

For the retail subsector, adaptation strategies range from simple solutions, e.g., conducting more market research to inform purchasing decisions, to more complex interventions that include offering incentives for online reviews and introducing new products to the shop. While no adaptation strategy is a silver bullet capable of mitigating all drought-associated risk, combinations of these strategies have been effective in improving businesses’ drought resilience.

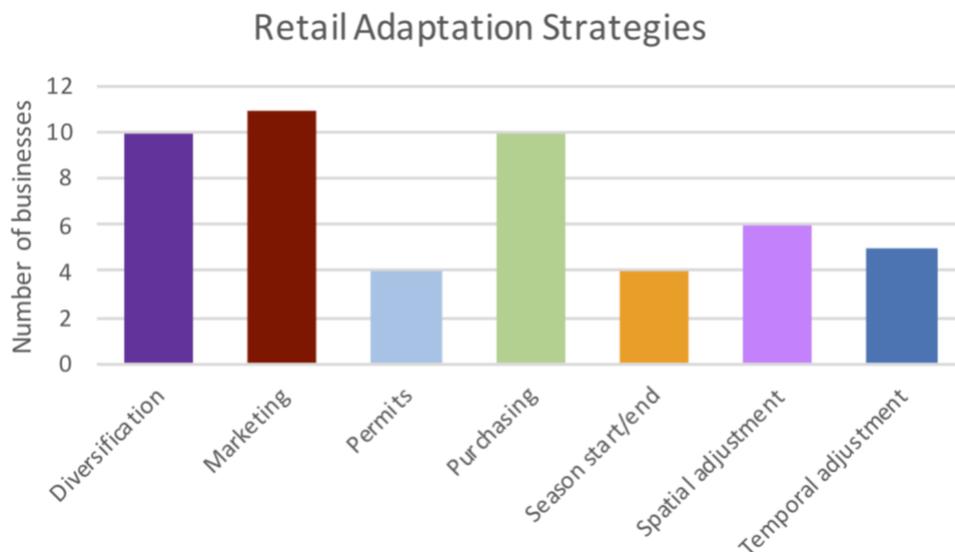


Figure 19: Drought adaptation strategies utilized by the retail subsector.

The most commonly-cited adaptation strategies for retail stores are: increased marketing, procurement strategy adjustment, and hiring practice adjustments. Marketing can take the form of traditional advertising via radio, online channels, social media, and newsprint. Discounts and special

offers proved valuable for driving more customers through a shop's doors, and in some cases, generating revenue despite marginal conditions. One shop owner shared that "last year we didn't have a lot of snow for Thanksgiving, I think they had two or three manmade runs open. I ran a special on the radio that basically gave you two for one ski rentals...we made the rental so cheap that we were just like, 'not only can you keep them today, you can keep them Friday and they're two for one,' that's what I changed because there was no snow."

Marketing is not foolproof, however. In some areas, marketing efforts by small businesses have minimal effect compared to the marketing power of larger neighbors. One salient example of this is in Jackson, Wyoming. The primary attraction in town is Jackson Hole Ski Resort; retail shops in the area are essentially bound to the marketing success of this ski area. Potential customers are primarily interested in visiting the ski area, and any discounts or deals offered by local shops will be secondary to that interest. As one business said, "we're left to the power of what the resort does for marketing to get people to come here first before they even think about renting from us."

Many businesses were skeptical of the power of marketing altogether. A common adage repeated in interviews was: "fifty percent of our marketing doesn't yield results, but we never know which fifty percent it is." While this statement may not be entirely accurate, it points at a real challenge for businesses: there is little feedback about exactly how a customer heard about the store. Uncertainty is a key characteristic of the outdoor recreation retail subsector.

In the face of uncertainty, retail store managers must order the right amount of the right products and have them delivered at the right time to make sales. All of those variables must all line up to ensure success. Procurement strategy adjustment provides ample opportunity to mitigate the risk faced by outdoor retailers. Part of the challenge of procurement can be attributed to how consumers' purchasing behaviors change in response to environmental conditions. In dry years, certain product categories are less popular than in wet years. Fat powder skis, rafts, and high volume kayaks are generally purchased at higher rates in wet years while narrower skis, stand-up paddleboards, and lake-fishing gear are more popular in dry years. Most gear manufacturers have ordering deadlines up to a year in advance, and some business managers discussed their ability to tweak and adjust orders leading up a cutoff date. Manufacturers have a penalty for cancelling an order altogether, but making adjustments in the quantity and variety of products until the last cutoff date appears to benefit businesses.

Changing climatic conditions also influence business strategies. As winter shortens and warm-weather begins earlier in the spring and lasts later into the fall, adjustments to the timing of deliveries and inventory transitions (when a shop exchanges winter products for summer ones, or vice versa) can aid businesses. For example, businesses may shift the delivery time of next season's gear or shift the transition time of their multi-season store. These shifts were reported to generally match the transition of seasons and runoff. Doing so enabled these businesses to respond more rapidly to changing environmental conditions and to capitalize on climate variability.

The aforementioned adaptation strategies were most frequently referenced by businesses in this study, however, a few businesses reported other, less common strategies which are notable for their efficacy and novelty, as described below.

Rent-to-Buy Programs

One ski shop featured a unique program which helped them liquidate stock and prepare the store for a new shipment of skis. This shop owner described the program as “rent-to-buy.” For this program, customers could rent any ski in the shop for an entire season. They could pay about half of the purchase price at the beginning of the season, and when the rental period is near its end, the customer has the option to return the skis or pay the remainder of the purchase price and keep the skis. This program helped to catalyze ski sales because the customers had the opportunity to thoroughly test skis before buying. Two years of rental fees is equivalent to buying skis, so many customers took advantage of this program.

Attract Value-Driven Customers

One large retail store discussed an interesting set of partnerships which helped them generate business during the 2018 drought. By sponsoring the town’s public radio and dedicating a percentage of sales to a local environmental non-profit organization, this business was able to attract more customers who were coming through the door because they believed in the mission of the non-profit or loved to listen to public radio. These initiatives increased the brand value of the store and attracted loyal customers for the duration of the season.

Leverage the Review Websites

A few shops were confident that review websites such as Yelp or TripAdvisor were responsible for driving a lot of their business. As one shop owner put it, “In today’s world, the power of the review is impressive.” In response to this, a handful of shops had programs to incentivize their staff to solicit customer reviews on these websites. In these businesses’ judgement, such a program has a sufficient return on investment to justify.

Collaborate with Hotels

Tourists often plan minimally for their travels, e.g., booking flights and a hotel, and then finalize the details of their trip upon arrival. This provides an advantage to retail stores because the local accommodations can provide insight about potential visitation in the upcoming tourism season. By asking local hotels to divulge how many rooms they have booked in a given season, businesses can gain a better idea of how much product may need to be purchased for that inflow of customers. The power of this strategy may be diminishing, however, as the advent of online travel agencies such as Airbnb or Vrbo is decentralizing lodging in tourism and recreation towns.

Use Education to Attract New Customers

A particularly innovative retail shop mentioned how it offered a free, women-only fly fishing class. People were encouraged (via marketing) to show up and were provided gear and instruction for free. Such an offering not only serves to introduce more female participants into a historically male activity, but also has the potential to create new local customers. It is unclear if this strategy was producing any return on investment, but nevertheless it is valuable as it fortifies the customer base.

Drought Information and Current Weather Forecasting for the Retail Subsector

Business owners cumulatively reported using at least 15 different sources of weather forecasts and information in planning their business operations. In order of prevalence, or how many businesses

referenced these sources, the most popular weather information sources are experiential monitoring, USGS stream gages, SNOTEL, the Farmers’ Almanac, Other, and third party weather websites.

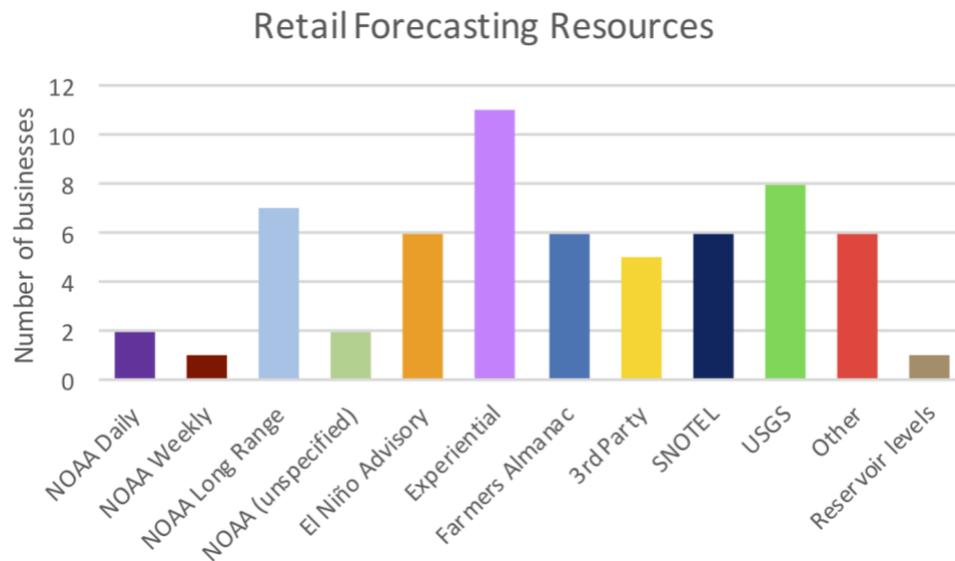


Figure 20: Weather and climate forecasting resources utilized by the retail subsector.

What is notable about this list is that the top three most common sources are actually just forms of real-time monitoring, and the next three sources are the first bona-fide forecasts. Experiential monitoring is a broad category that combines an individual’s contemporary observations and historical knowledge of a given geography. Given the diversity of experiential monitoring techniques, it is challenging to summarize how this category of information is used among retail business managers. Over time, some people had developed a form of intuition about their area that was used in making procurement and hiring decisions. Beyond this, experiential monitoring cannot be taught or provisioned in any meaningful way.

Services such as the USGS stream gages and SNOTEL are more concrete data sources useful in planning business operations. SNOTEL sites can provide insight about the upcoming season’s runoff and river levels. This information can then be used by businesses to adjust how much inventory to purchase and what product categories may be in greater demand. The stream gages provide less foresight as they reflect current river conditions, but are nonetheless useful to fishing and rafting stores that often post daily streamflow data in stores for customers’ reference.

The Farmers Almanac is a unique resource for retail managers because of its long-range predictions. This resource makes forecasts 16 to 18 months in advance, providing shop managers with some indication of conditions in the upcoming season. This information is valuable in making hiring and procurement decisions, but it is never the sole determinant of decisions. As one owner put it, the Farmers’ Almanac is, “the furthest one out that we could... glean information from.” The Almanac is also perceived as accurate and relatively trustworthy, which is significant because 9 out of 16 retail businesses expressed distrust of NOAA’s long-range forecasts.

One of NOAA’s forecasts that is highly trusted is the El Niño and La Niña advisories, or ENSO Advisories. Shop owners who referenced these advisories said that they understand the relationship between the El Niño phenomenon and wet years. Unfortunately, this phenomenon was sometimes

referred to binarily—many people were not aware of El Niño’s scalar properties (i.e. strong versus weak El Niño). Nevertheless, ENSO Advisories are factors in some stores’ decisionmaking on procurement.

Information Gaps for the Retail Subsector

Unsurprisingly, most retail store managers want trustworthy, long-range forecasts which would be valuable in making consequential hiring and procurement decisions. Most managers were rightfully skeptical of NOAA’s 3-month temperature and precipitation outlooks—one even joked that they might as well “bring out the dartboard.” Even if the 3-month outlooks were more accurate, they still wouldn’t be much value for purchasing decisions which are made farther in advance. If accurate, long-range forecasts were technically feasible and made available 9 to 12 months in advance, this resource would help reduce exposure to risk inherent in the process of purchasing inventory and hiring staff.

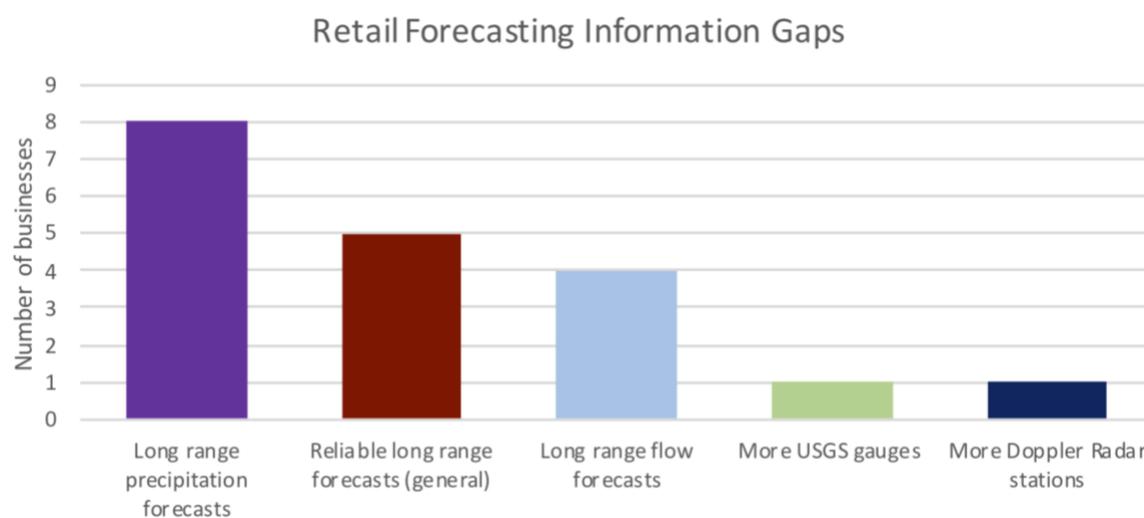


Figure 21: Weather and climate forecasting information gaps for retail subsectors.

One of the most desired components of a long-range forecast is information about snowpack development. Knowing the season’s snowfall in advance would not only help managers decide how much equipment to order, but also what varieties of equipment. As previously stated, certain product categories sell better than others in dry versus wet years and knowing about snowpack could help in deciding which products to purchase. For the same reasons, long-range streamflow forecasting is highly desired as well.

This research sought to determine during which times of year these forecasts would be most valuable. Answers to this question varied widely, leading to the conclusion that long-range forecasting is valuable year-round. Retail store owners reported that purchasing for river gear takes place in June or July, fishing gear is purchased between October and January, and ski gear is ordered early to mid-winter for the following season. As a result, there is no “ideal timing” to publish forecasts.

Conclusion

Social, Environmental, and Economic Impacts of Drought

As discussed in the literature review and verified in the field, drought creates substantial environmental impacts. These impacts are both positive and negative, as well as direct and indirect in nature. Low streamflows, reduced snowpack development, and warming temperatures are all directly degrading water resources integral to the outdoor recreation industry. Taken as a whole, the window of opportunity for outdoor recreation activities is becoming shorter and shorter. Reduced snowpack is limiting the length of the ski or snow-based seasons and low flows limit the length of the riversport season as well as reservoir levels needed for lake-based recreation. In the case of the fishing subsector, extreme low flows and high temperatures are also harming fish species essential to anglers.

Wildfires, fueled by hot and dry conditions, are also having direct and indirect impacts on outdoor recreation businesses. In some cases, fires directly affect the regions where businesses operate and may prevent access for recreation or result in National Forest closures. In other cases, the public's perception of regional wildfires drives customers to other areas. In this latter category of cases, the wildfire may not actually be impacting a customer's chosen recreational activity, but nevertheless acts as a deterrent.

These environmental impacts of drought generally serve to reduce visitation and sales in the subsectors analyzed in this report, with a few exceptions. Low streamflows benefit fly fishing companies to an extent, until water temperatures begin to affect the wellbeing of the fish. Low snowpack in one region may also drive snowsport enthusiasts to higher elevations, benefiting those areas to an extent. Across the industry, businesses have reported 20% to 50% reductions in annual revenue during drought years. These losses are not evenly distributed across the various subsectors and further study is required to determine which subsectors are the most sensitive to drought.

Under drought conditions, all supply-side participants in the outdoor recreation retail subsector are acting to minimize their risk. This has precipitated a "transfer of risk" from manufacturers down to the individual. Manufacturers might seek to protect themselves from potential losses by moving their ordering deadlines up in time. This forces retail stores to make earlier purchases, locking in revenue early. Those same stores, faced with below-average sales during a drought year, may choose to recoup their losses by laying off employees. This approach effectively transfers the financial burden of the drought onto individuals who may be poorly situated to manage the burden because there are fewer employment opportunities mid-season.

One final theme which emerged in the field was that drought creates significant mental health challenges for business owners. As the viability of a business is threatened by drought, business owners are forced to work harder, make riskier choices, and generally expose themselves to severe financial consequences in order to stay afloat. Particularly distressed owners reported refinancing their homes for extra money, renting storage units to hold overstock, and generally losing sleep. Ultimately, this is creating unquantified economic and public health impacts which are fruitful areas of future study.

Adaptation Strategies

Most businesses in the outdoor recreation industry have found ways to adapt in order to partially mitigate the risk of negative drought impacts on their business.

- Diversification
 - This was the most common adaptation strategy, and businesses used this strategy to enter other markets and minimize drought exposure. Diversification can be broken down into the following categories:
 - Activity diversification
 - This was used by businesses to offer additional activities to their customers, reducing their reliance on snow and water. Offering additional activities also extends their operating seasons and brings in additional revenue. Examples are ski resorts that offer summer activities like ziplines or alpine slides and rafting companies that offer mountain biking trips.
 - Spatial diversification
 - This is when businesses operate in multiple geographic locations. Examples of this would be ski resorts that consolidate across regions and sell megapasses or fishing and rafting businesses that run trips on different rivers. This diversification strategy reduces the risk of encountering drought conditions in a specific area.
 - Temporal diversification
 - This is when businesses change the timing of their services. This has been highly successful for fishing outfitters, and during drought years, many outfitters change the timing of their trips to account for warmer river conditions in the afternoon that can harm fish.
- Marketing
 - Businesses are using social media and other outlets to reach out to customers ahead of their trips to adjust expectations during drought years. This keeps customers informed and updated on current conditions, especially when drought is in the news.
 - Marketing can also be helpful to fight any negative public perception of drought.
- Purchasing strategy adjustments
 - Most retailers that were interviewed also adjust their purchasing strategies, which often led to buying less or different inventory in case it happens to be a bad snow or water year.
- Snowmaking
 - Every ski resort has invested in snowmaking equipment and capacity in order to maintain a quality customer experience and provide a full length ski season.

Barriers to Drought Adaptation

Despite a number of adaptation strategies available to the outdoor recreation industry, there are still barriers that make it difficult or impossible to adapt during drought events. Barriers that have been identified in our research are described below in no particular order.

- Capacity
 - In most cases, diversification requires additional capital and resources, thus it may be harder for smaller businesses to diversify their activities offered or areas of operation.
- Fixed customer expectations
 - While an outfitter may be able to provide a different experience to a customer, sometimes customers have fixed expectations and are hesitant or unwilling to accept changes to their expected experience. For example, although fishing outfitters can adapt to drought conditions by starting earlier in the day or shifting to higher elevation rivers, customers may not want to start fishing at dawn or spend additional time in a car on their family vacation.
- Geographic location
 - As drought is expected to increase in both frequency and severity, particularly in the southwest, businesses located in the Intermountain West will be increasingly impacted by drought unless they move their operations from the region.
- Distrust of forecasts
 - Several businesses said that although they are looking at forecasting resources, they do not trust their accuracy enough to plan their business around them.
- Drought knowledge
 - Many business owners did not see the clear linkages between drought and their businesses—i.e., they recognized the impacts of low flows and low snowfall, but were hesitant to say that it was caused by drought. This makes it challenging for business owners in the outdoor industry to plan for drought.

Drought Risk Themes

Within the foreseeable future, drought is predicted to increase in severity and frequency in the region. This increase will affect specific industries that are already experiencing these impacts, including the outdoor recreation industry. The findings detailed throughout this report highlight the current status of the outdoor recreation industry throughout the Intermountain West DEWS, illustrating that the subsectors analyzed in this report are negatively impacted by drought. Though there are a few exceptions, most of the businesses are in some way vulnerable to drought. This vulnerability originates from an overall uncertainty about the future of moisture and precipitation conditions which then creates financial risk for business owners. After compiling and analyzing the results of the stakeholder engagement, there were five main themes regarding drought risk and vulnerability consistent across the majority of the subsectors. These are summarized below and include: the size of business; elevation levels; the distinction between businesses operating on free-flowing rivers versus tailwaters; decision calendars; and length of season.

Size of the business

Though most of the businesses interviewed for this project were small to medium in size (with the exception of ski resorts), the final results of this project illustrated that the smaller the operation, the more vulnerable they were to the negative impacts of drought. An example of this is a one-person operation that does not have the capacity to adapt due to limited capital and resources.

Elevation levels

Elevation levels relate to the fishing, snow-based, and ski resort subsectors. Snow-based businesses and ski resorts operating at lower elevations are often more vulnerable in a drought year due to less precipitation and warmer temperatures reducing the overall snowpack levels. For the fishing subsector, low elevation streams tend to heat up faster, increasing fish mortality. This creates less than ideal conditions for completing snow activities, often reducing visitation within the area and in turn, negatively impacting revenue.

Free-flowing rivers versus tailwaters

Businesses that operate on free-flowing waters are often more vulnerable to the negative impacts of drought because they are directly reliant on precipitation and snowpack runoff. During a drought year, there is a decrease in moisture and runoff which affects the overall viability of the operations that depend on free-flowing waters. On the other hand, operations located on or fed by tailwaters are often less vulnerable to drought because of mandatory dam releases for agricultural users throughout the year. These businesses can even benefit from drought years because often the agricultural sector will request higher volume releases to make up for the limited precipitation which in turn provides water for outdoor recreation.

Decision calendars

Weather and climate variability make it difficult for business owners to accurately make procurement and hiring decisions for the upcoming season, predict future visitation numbers, and employ certain adaptation measures. Businesses often expressed difficulty in decision-making for the upcoming season because of the uncertainty around future conditions. For example, interviewees in the retail subsector said that they were “buying blind” which impacted the future of their business as well as their mental wellbeing as it often led to increased stress.

Length of the season

The final drought risk and vulnerability theme refers to the length that a business operates throughout the year. Members of the industry that were able to operate year-round were often less vulnerable to the negative impacts of drought because they had the ability to make up for lost revenue during different times of the year. If drought impacted their winter activities, there is potential to recover this loss during other times of the year. Businesses that have a short peak season experience more potential risk because if there is a drought during the span of time in which they operate, there is no possibility to make up for lost revenue in the off season.

Forecasting Resources

The most popular forecasting resource across the outdoor recreation industry is “experiential monitoring.” This category is unique in that it relies on an individual’s historic knowledge and contemporary observations to inform their personal intuition. While this form of forecasting is highly valuable, it is not necessarily transferable to other people or businesses. Following this, the next most popular resources are real-time monitoring services: the USGS stream gauges and the SNOTEL system. These services are especially valuable for ascertaining current conditions and using that information to inform trip planning. Real-time monitoring systems can also provide insight into future conditions, e.g., snowpack depth suggests the potential magnitude of the upcoming spring runoff and upstream streamflow can suggest future streamflow changes that have yet to reach a certain area.

Considering the decision calendar of most outdoor recreation businesses, short- and medium-range forecasts published by NOAA are useful only to businesses offering guided trips. This category of forecasts is also quite popular, as are the long-range climate outlooks published by NOAA's Climate Prediction Center. Unfortunately, even though one in three business owners are checking this resource, many have expressed distrust in it. Common complaints include the outlooks not being accurate enough or not looking far enough into the future to inform decision-making. This may explain why one in five businesses use the farmers' almanacs. The farmers almanacs provide long-range predictions that are perceived to be accurate enough to support decision-making. This perception, however, may not correspond with reality, and trust in the farmers almanacs may be misplaced.

About one in five businesses use some form of third party forecasting service. These services, described in the methods section, essentially provide businesses with repackaged forms of NOAA's forecasting products. In some cases, useful narrative forecasts and analyses are included as well. One notable provider in this arena is a company called Forecasts Unlimited (FU). FU was referenced by a handful of ski resorts as an invaluable resource. For about \$10,000 annually, FU will provide point forecasts at multiple elevation bands on the hour for the entire season. It's a premium service, and its high price makes it inaccessible for smaller outdoor recreation businesses.

Information Needs

Common feedback from businesses that were interviewed is that they want more accurate long-range forecasts. This will help businesses with procurement, trip planning, hiring, and equipment needs. For ski resorts and snow sports, better snowpack forecasting for the upcoming season is critical. River-based and rafting businesses would also like better snowpack forecasts, but they are more interested in better tools to translate the existing snowpack into runoff quantity and timing. Retail businesses need enhanced long-term forecasts to help them with procurement decisions, which often have to be made 9–12 months in advance.

ROARING FORK CONSERVANCY
Snowpack & Stream Flow Report

Date: May 14, 2015 Time: 11:00 am

Summary: At this time of the year, the average snowpack levels are dropping considerably. This is a trend which can be observed in many graphs tracking such data. Combine that with the recent precipitation and the Roaring Fork basin snowpack levels are now at 76% of average, compared to last week's 58%. All streams are flowing over 60% of normal and Ruedi Reservoir is 77% full.

Current Snow Water Equivalent % of Normal in Colorado

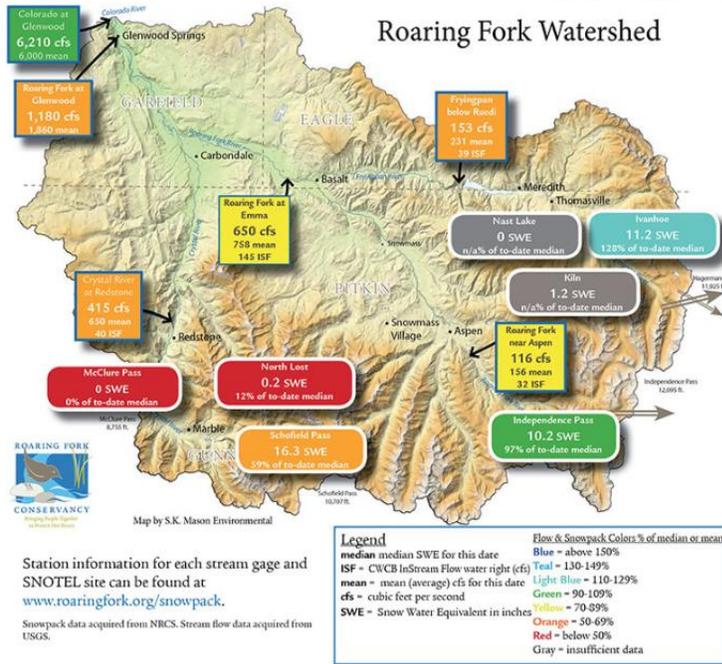
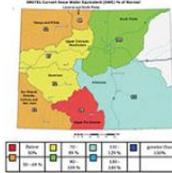


Figure 22: Roaring Fork Conservancy Snowpack and Streamflow Report.

Many businesses also mentioned that current monitoring resources can be very complicated and difficult to navigate, and they're looking for more user-friendly ways to gather data about current conditions. Since many of these monitoring resources are located in various locations, they can be hard to find and interpret. A great example of a user-friendly resource is the Weekly Snowpack and Streamflow Report published by the Roaring Fork Conservancy in Aspen, CO. This report combines multiple data sources and presents those in a very usable format, and it is used by all of the fishing and rafting outfitters in the area to stay updated and informed on current conditions.

Recommendations for NIDIS

One of the information needs that was identified in our stakeholder engagement was for a dashboard that consolidates popular forecasting resources. Since different subsectors in the industry reference different resources, having a specific dashboard for each of the subsectors would be most useful for business owners so that they do not have to access a variety of different resources on their various platforms. These subsector-specific dashboards could be featured on the Outdoor Recreation Industry portal on drought.gov, and would enable NIDIS to fill an immediate information need. The dashboards could also be a place to share popular adaptation strategies, so that businesses can learn best practices for mitigating drought risks. To create this dashboard, the information needs of each subsector have been discussed in depth in this report and are summarized below:

- Retail
 - Forecasting is perhaps the least useful to this subsector given their need for long lead times in procurement.
 - SNOTEL sites can provide stores with limited insights about the magnitude of spring runoff and summer streamflows, which may aid in procurement decision making.
 - Long-range outlooks published by NOAA’s Climate Prediction Office do not forecast far enough into the future at sufficient accuracy. Nevertheless, retail store managers check this resource and it should be included in a dashboard.
 - The Farmers’ Almanac may not be sufficiently accurate either, but it is perceived as trustworthy. It exists only in hard copy and cannot be shared via the portal, but a discussion on its merits and constraints is valuable.
- Rafting
 - Rafting outfitters are primarily interested in more accurate runoff and streamflow forecasts. Being able to estimate runoff based off of SNOTEL site data was cited as important.
 - Some use NOAA’s Colorado Basin River Forecasting Center, while others were not aware of this resource and would benefit from better access to it.
 - This subsector also noted that both the SNOTEL website and the USGS stream gauge database are difficult to understand. The subsector would benefit from a feature that consolidates and simplifies this resource on a watershed basis.
- Ski Resorts
 - The ski resort subsector is most interested in localized, highly accurate, frequent weather forecasts.
 - There was also interest in long-term accurate forecasts that predict the cumulative snowfall of the entire ski season.
- Fly Fishing
 - Fishing guides and outfitters articulated the need for more USGS stream gauges on tributaries.
 - This subsector is interested in incorporating dam releases and irrigation diversions into stream flow modeling.

- Businesses interviewed seek more user-friendly data, such as dashboards that aggregate data sources (USGS stream gauges, SNOTEL sites, water temperatures).
- Snow-based recreation
 - Snow-based business owners said that having a general understanding about the amount of snowfall for the upcoming season would be beneficial to their overall decision making.
 - This subsector expressed that accurate, region-specific mid- to long- range forecasting would be very helpful to their businesses.
- Lake-based recreation
 - The businesses within this subsector expressed interest in strengthening relationships with dam operators in order to have accurate information about future flow releases.
 - There was also an interest in more accurate longer term forecasting specific to a certain region

The proposed dashboard for the outdoor recreation industry presents a unique opportunity to aggregate different forecasting resources, adaptation strategies, and best practices for each subsector. In doing so, NIDIS can ensure that business owners have access to and are using the most high quality, up-to-date information. The dashboard will also help educate business owners about forecasting resources that they may not have previously been aware of.

The dashboard cannot stand on its own however. A concerted effort to market the dashboard and increase awareness around them is critical too. In order to reach the widest possible audience, NIDIS should schedule webinars with the National Governors Association Outdoor Recreation Learning Network to deliver key findings to the state outdoor recreation offices. These offices are strategically positioned to help in raising awareness about drought planning for the industry and can serve as a liaison between NIDIS and each state’s outdoor business community.

In addition to this, it is recommended that NIDIS establish working groups with the outdoor recreation industry to serve as a conduit for sharing drought information and services and as a means for the industry to provide regular feedback regarding drought support needs. In order to form these working groups, requests may be emailed to the businesses and seminar attendees whose contact information is included in a supplementary spreadsheet. Various non-profit organizations, trade associations, and coalitions may also be helpful to continue to engage the industry. These groups are organized below by subsector, and some are relevant to all forms of recreation:

- Universally relevant groups
 - Outdoor Alliance and Grassroots Outdoor Alliance
 - America Outdoors
 - Outdoor Industry Association
 - State outdoor recreation offices
 - State outdoor business alliances
 - National Governors Association
 - Outdoor Retailer Trade Show
 - Local chambers of commerce

- Small Business Association
- Recreation subsector groups
 - Fishing
 - Trout Unlimited
 - Backcountry Hunters & Anglers
 - Rafting
 - Colorado River Outfitters Association
 - American Whitewater
 - American Rivers
 - Ski Areas
 - National Ski Area Association
 - Snowsports Industries America
 - Protect Our Winters (POW)
 - Snow-based recreation (see universally relevant groups above)
 - Lake-based recreation (see universally relevant groups above)
 - Retail (see universally relevant groups above)

The investigators also highlight important gaps to address through future research. Expanding the research to focus on other regions outside of the Intermountain West should be a top priority. Understanding how businesses adapt and mitigate drought risks in other regions may be helpful. Expanding the geographic scope of this research may also yield lessons which may be applicable across all DEWS regions. It is also important to expand the focus of this research to understand the relationship between drought severity and economic impacts. If NIDIS could model the relationship between drought and weather-related revenue losses, business owners may be able to adopt better drought planning practices because they understand how drought will financially affect their business. Finally, there is widespread demand for more reliable and longer-range forecasting. While this type of forecasting may not be feasible currently, the investigators feel it is crucial to underscore this point. The ultimate defense against drought is the ability to see it coming and proactively plan for it.

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Appendix

Appendix 1: Interview Protocols

INTERVIEW REQUEST EMAIL PROTOCOL

- 1) After a stakeholder is assigned to a team member, they will be in charge of all proceeding communications
- 2) Initial emails will be sent using the following templates, and will be tagged in the group email with the team member name and location
- 3) If the stakeholder does not respond, one week after the initial email they will be sent a follow-up email as a response to the initial email
- 4) If the stakeholder does not respond to the second email, then we will call them 3 days after
- 5) When someone agrees to participate, we will:
 - a) arrange the time and location of the meeting
 - b) ask them if they would like the topics that will be covered in the interview (this will allow us to receive more fully informed consent from participants)

INTERVIEW PROTOCOL

- 1) Interviews will always be conducted by at least 2 team members; one will be in charge of taking notes, someone will be the designated question prompter
- 2) Informal questions relating to business' background will be asked first to develop trust and leverage expert knowledge.
- 3) Interviewees will then be asked if the remaining portion of the interview can be recorded, reiterating that all responses are anonymous and recording is primarily meant for coding purposes. These will then be transcribed for coding.
- 4) A general set of interview questions will be asked first for all interviewees, and then a set specific to their type of business (ie., ski resort, rafting guide, fly fishing shop). All interviews will be concluded with a series of wrap up questions.
- 5) Interview data will be summarized into a google sheet (Interview Notes → Interview Results).
- 6) Recorded interviews will be transcribed using Rev. Transcribed interviews will then be converted into a Word document, and then uploaded into Nvivo to be inductively coded.

Appendix 2: Content and intent of interview questions

Table 1. Content and intent of interview questions

Question	Intent
Are there any patterns (seasonal/annual) to business visitation, have they changed at all in the recent past?	To understand how drought may affect outdoor recreation businesses, and what other conditions/phenomena influence visitation.
What drives the bulk of your revenue during different times of the year? When do you generate the most revenue?	To determine if businesses may be economically vulnerable to the negative impacts of drought.
What does drought mean for your business? During which years has drought impacted your business?	Since drought is a locally-defined event, this question aims to determine how businesses define drought and which drought conditions are important to them. Additionally, we can assess their recollection of historic drought events and their impacts.
2018, 2012, and 2002 were severe drought years according to NIDIS. Did drought conditions affect your business revenue or practices? How so?	To assess NIDIS' definition of drought years against that of outdoor recreation businesses. In the event that the stakeholder perhaps forgot about a drought event, this question may remind them, and glean information about how businesses are impacted by drought.
Do you think that the public perception of drought has impacted your business?	To determine the extent to which the public perception of drought has impacted the outdoor recreation industry.
Were there any lessons learned from past drought events?	To understand how outdoor businesses have historically responded to drought events.
Do you currently use weather forecasts, information, tools, or indices? If so, which ones? If not, why not?	To assess the use of drought monitoring products and other forecasting data. Since drought is a locally-defined event, this question gets at the conditions and information that is important to decision makers and business owners.
What business decisions do these data inform? And when are these made? How frequently are these resources consulted?	To understand how drought information is integrated into business decisions in the outdoor industry. Additionally, this question

Question	Intent
	gets at understanding the decision calendars of businesses, which will be helpful for determining what temporal scales drought information will be most helpful.
What operational decision-making do you make that may be impacted by drought (day-to-day, week-to-week, and month-to-month)?	To determine the impacts of drought on decision-making in the outdoor industry, and to assess the vulnerability of a business.
Have you made any adaptations to your business practices based on drought conditions? If not, are you able to?	To understand how businesses reduce their vulnerability to drought. This question also aims to assess the adaptive capacity of the business, which is a component of vulnerability.
What determines your start and end (or opening and closing) dates?	To determine if drought influences start and end dates (or opening and closing times).
When do you make hiring decisions? What informs that decision?	To determine if drought influences hiring practices.
What other entities influence your planning process and timeline (i.e., government agencies, school calendar/summer vacations)?	This question aims to understand how the outdoor industry interacts with outside entities, as well as assess adaptive capacity.
What drought information <i>would be helpful</i> for your business? At what point in the year would it be most helpful and at what temporal scale(s)?	To determine the drought information needs of the industry.

Appendix 3: Project codebook

Table 1: The codes developed for data analysis designed to match the research questions.

Code name	Description
(Parent) Drought impacts	What are the general and observed effects of drought on the business (1 is negative, 5 is positive, 3 is anticode, 1 is default)
(Parent) Recent drought events	When has the business been affected by drought, when was the timing and onset (weight: 1960–2019)
(Parent) Forecasting Resources (Child) USGS streamflows, SNOTEL, third party weather resources, Farmers Almanac, El Niño/La Niña, Experiential drought monitoring, NOAA (daily, weekly, monthly)	What resources business owners/managers consult to find information about weather, climate, and drought conditions, or the trends over time
(Parent) Data-based decisions	What decisions are informed by the consulted forecasting resources
(Parent) Adaptation strategies (Child) Barriers to adapt, hiring, snowmaking, permits, season boundaries, purchasing, spatial adjustment, temporal adjustment, business diversification, marketing	Any actions that a business has taken in response to drought to mitigate negative impacts
Public perception	How the research participant believes that the public perception of drought may impact their business (1 is bad for business, 5 is good for business, 3 is anticode, 1 is default)
Visitation	What are the patterns (seasonal/annual) of visitation to the business, and have they changed in the recent past
Peak revenue	When the business generates the most revenue and what activities are responsible for that revenue—this may be important for determining exposure and subsequently vulnerability
Procurement	When procurement decisions are made

Code name	Description
Ideal drought information	Drought information gaps that when filled, would reduce the drought vulnerability of the organization
NIDIS (Child: yes, no)	Assessment of whether or not stakeholders have heard of NIDIS
Business background Child: Recurring permits, external entities, planning	General background on business—how long has the business been operating, where the business operates, how many employees the business has, etc.
Drought Foresight	Thinking about future impacts of drought and/or the potential for more drought conditions/events
Experiential drought monitoring	Phrases interview participants use to refer to first hand monitoring of weather or drought
Networks (Child: Connectivity of the industry)	Relationships within the community (and community drought impacts) or between different businesses/organizations in the industry
Weather Dependent Revenue	Any discernible commonalities or occurrences in the business based on weather or climate events (1 is negative, 5 is beneficial, 3 is anticode, 1 is default)
Distrust of forecasts	Any indication that government entities or federal information is inaccurate (1 is distrust, 5 is trust, 3 is null, 1 is d)

Appendix 4: Survey

The purpose of this project is to better understand the drought information needs of the outdoor recreation industry, in order to provide tools and resources to help the industry adapt and respond to drought events. This study is being conducted through a partnership between the University of Colorado Boulder's Masters of the Environment Program and the National Oceanic and Atmospheric Administration (NOAA)'s National Integrated Drought Information System (NIDIS).

You are being asked to participate in this study because of your affiliation with a water-based outdoor recreation business in the Intermountain West (Arizona, Colorado, New Mexico, Wyoming, Utah). The results will help record, analyze, and track the way the outdoor recreation industry is affected by drought, and what the drought information needs for the industry are.

This survey should take approximately 10-15 minutes to complete.

Risk to participants is minimal, as this is not a study of individual views or perceptions, but rather about businesses and drought planning. Every effort will be made to protect you and your organization's privacy and confidentiality by exclusion of personal identifiers from analyzed and reported data. **We will not reveal that you participated in this study.** Your participation in this survey is completely voluntary.

If you have any questions about this research or want to contact the investigators, please email outdoor.rec@colorado.edu.

What is the name of your organization?

What type of organization do you represent?

	Summer	Winter
Outfitting and Guiding	<input type="checkbox"/>	<input type="checkbox"/>
Retail	<input type="checkbox"/>	<input type="checkbox"/>
Rentals	<input type="checkbox"/>	<input type="checkbox"/>
Ski Resort & Ski Area	<input type="checkbox"/>	<input type="checkbox"/>
Other <input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>

What activities does your business focus on?

Skiing/Snowboarding	<input type="checkbox"/>
Fishing	<input type="checkbox"/>
Rafting	<input type="checkbox"/>
Whitewater Kayaking	<input type="checkbox"/>
Snowmobiling	<input type="checkbox"/>
Snowshoeing	<input type="checkbox"/>
Nordic Skiing	<input type="checkbox"/>
Dog Sledding	<input type="checkbox"/>
Lake Boating	<input type="checkbox"/>
Other	<input type="checkbox"/>

Where is your organization's headquarters located (i.e. Durango, CO)?

In which specific geographic areas does your organization operate (i.e. Yampa River, White River National Forest, Lake Powell, Tenmile Range, etc.)?

In which month(s) does your organization generate the most revenue?

January	<input type="checkbox"/>
February	<input type="checkbox"/>
March	<input type="checkbox"/>
April	<input type="checkbox"/>
May	<input type="checkbox"/>
June	<input type="checkbox"/>
July	<input type="checkbox"/>
August	<input type="checkbox"/>
September	<input type="checkbox"/>
October	<input type="checkbox"/>
November	<input type="checkbox"/>
December	<input type="checkbox"/>

Are you familiar with the National Integrated Drought Information System (NIDIS)?

Yes	<input type="radio"/>
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No	<input type="radio"/>
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What does drought mean for your business?

Low streamflows	<input type="checkbox"/>
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Low snowfall	<input type="checkbox"/>
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Low reservoir/lake levels	<input type="checkbox"/>
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High water temperatures	<input type="checkbox"/>
-------------------------	--------------------------

Wildfire risk	<input type="checkbox"/>
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None	<input type="checkbox"/>
------	--------------------------

Other	<input type="checkbox"/>
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Please indicate which best describes your organization's experience with drought.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Drought has impacted my organization's operations in the past.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drought will impact my organization's operations in the future.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My organization's revenue is dependent on water availability.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

During which years, if any, has drought impacted your business?

What ways, if any, has drought impacted your business revenue, operations, practices, etc.?

Describe any actions or adaptation strategies that your organization has taken in response to drought. If not, why not?

Has the public perception of drought impacted your business, and if so, how?

Which, if any, does your organization use regularly for monitoring drought conditions?

Weather forecasts	<input type="checkbox"/>
Long-term weather outlooks	<input type="checkbox"/>
USGS streamflow data	<input type="checkbox"/>
Reservoir levels	<input type="checkbox"/>
SNOTEL (Snow Telemetry) sites	<input type="checkbox"/>
SNODAS (Snow Data Assimilation System)	<input type="checkbox"/>
Surface Water Supply Index (SWSI)	<input type="checkbox"/>
Standardized Precipitation Index (SPI)	<input type="checkbox"/>
U.S. Drought Monitor	<input type="checkbox"/>
U.S. Seasonal Drought Outlook	<input type="checkbox"/>
Farmers Almanac	<input type="checkbox"/>
Historical norms	<input type="checkbox"/>
Rain gauge sites	<input type="checkbox"/>
Personal observations or word of mouth	<input type="checkbox"/>
I don't use any drought information tools	<input type="checkbox"/>
Other	<input type="checkbox"/>

How frequently are these resources consulted?

Daily	<input type="checkbox"/>
Weekly	<input type="checkbox"/>
Monthly	<input type="checkbox"/>
Annually	<input type="checkbox"/>
Never	<input type="checkbox"/>
Other	<input type="checkbox"/>

What business decisions do these data inform (if any), and when are they made?

	0-3 Months out	4-6 months out	7-9 months out	10-12 months out	Over 12 months out	Not Applicable
Procurement	<input type="checkbox"/>	<input type="checkbox"/>				
Hiring	<input type="checkbox"/>	<input type="checkbox"/>				
Operating hours	<input type="checkbox"/>	<input type="checkbox"/>				
Opening and closing dates	<input type="checkbox"/>	<input type="checkbox"/>				
Permitting	<input type="checkbox"/>	<input type="checkbox"/>				
Other <input style="width: 50px; height: 20px;" type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>				

What barriers exist that prevent your organization from effectively preparing for or responding to drought?

Low certainty forecasting	<input type="checkbox"/>
No capacity to prepare	<input type="checkbox"/>
No capital to respond/prepare	<input type="checkbox"/>
Insufficient knowledge to act	<input type="checkbox"/>
Have not considered it	<input type="checkbox"/>
Other	<input type="checkbox"/>

Are there associations, professional organizations, and/or regional networks that are useful to your organization for drought planning? If so, please list them.

--

What drought resources (information, networks, guidelines) which are not yet available would be valuable to your business? At what point in the year would it be most helpful?

Drought resources:

--

At what point in the year:

--

Please enter your name and email so that we can follow up with you in the future.

Name

Email

Would you be interested in learning more about drought data, resources, and tools?

 Yes No

May we contact you with further questions?

 Yes No

We thank you for your time spent taking this survey. Your response has been recorded.

If you have any questions about this research or want to contact the researchers, please email outdoor.rec@colorado.edu.

For more information please see:
[US Drought Portal](#) or [University of Colorado Boulder](#)

Appendix 5: Survey Administration

INITIAL MESSAGE SENT:

Subject: Drought Planning Survey Request

Body:

Dear ORGANIZATION,

We are a team of graduate students at the University of Colorado Boulder conducting research on the impacts of drought on water-based outdoor recreation businesses. The purpose of this project is to help the outdoor recreation industry adapt and respond to drought conditions. We are partnering with the National Oceanic and Atmospheric Administration (NOAA) and the National Integrated Drought Information System (NIDIS) to incorporate the outdoor recreation industry's needs into current drought forecasting tools.

You are being asked to be in this study because of your affiliation as a water-based outdoor recreation business.

The results will help record, analyze, and track the way the outdoor recreation industry is affected by drought, and what the drought information needs for the industry are. The idea of local capacity in drought management is increasingly important, and the responses to this survey when analyzed together, will provide some insights into organizational needs and capacity in the Intermountain West (Arizona, Colorado, New Mexico, Wyoming, Utah) region. The findings have implications beyond this region and can suggest recommendations that could apply elsewhere.

The benefits of participating in this survey include:

- A review of needs and opportunities for drought planning into the future
- An understanding of what type of organizational relationships might contribute to capacity in drought planning, and what datasets and indicators are the most valuable in this process.

This survey should take approximately 15–20 minutes to complete.

Risk to participants is minimal, as this is not a study of individual views or perceptions, but rather about organizations and drought planning. Every effort will be made to protect your privacy and confidentiality by exclusion of personal identifiers from analyzed and reported data. We will not reveal that you participated in this study. You have a choice about being in this study and you do not have to participate in this study if you are not interested. Your participation in this survey is completely voluntary.

Feel free to reach out with any questions, for more information please see:

<https://www.colorado.edu/menv/drought-impacts-outdoor-recreation-industry>
<https://www.drought.gov/drought/>

REMINDER #1

Subject: Drought Planning Survey Request

Body:

Dear ORGANIZATION,

We know that you are extremely busy, but hope that given your expertise and involvement in water based outdoor recreation, you can take approximately 1–0 minutes to answer this survey on how businesses in this industry plan for, and respond to drought. We thank you in advance for your time!

Here is a link to the survey:

LINK TO SURVEY

REMINDER #2

Subject: Drought Planning

Body:

Dear ORGANIZATION,

We previously sent you a request for you to participate in the drought planning survey; we have elected to keep the survey open to try to garner the widest possible set of views and perspectives. As such, we hope that you would be willing to take a few minutes and complete the survey. You are being asked to take the survey because of your affiliation with the outdoor recreation industry.

Thank you in advance for your time and participation!

Here is a link to the survey:

LINK TO SURVEY

The results will help record, analyze, and track the way the outdoor recreation industry is affected by drought, and what the drought information needs for the industry are. The idea of local capacity in drought management is increasingly important, and the responses to this survey when analyzed together, will provide some insights into organizational needs and capacity in the Intermountain West (Arizona, Colorado, New Mexico, Wyoming, Utah) region. The findings have implications beyond this region and can suggest recommendations that could apply elsewhere.

The benefits of participating in this survey include:

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