

Montana Drought Vulnerability Assessment

Revised Full Draft

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Introduction

Overview of vulnerability assessments

Vulnerability is a multidimensional and complex term that can be operationalized in a variety of ways based on the social, economic, and ecological context in which it is being applied. The basic international agreed upon definition simply states that vulnerability to climate change is the “propensity or predisposition to be adversely affected” (Ara Begum et al., 2022). Often vulnerability is further subdivided into exposure, sensitivity, and adaptive capacity, but it is difficult to move from these general dimensions of vulnerability to consistent metrics or data that can capture the broad range of systems and elements of systems that might be vulnerable to climate change. Consequently, there is also no widely agreed upon methodology for conducting vulnerability assessments (Yu et al., 2021). The lack of a comprehensive, widely applicable theory or framework to guide analyses and programmatic efforts for vulnerability reduction has been a consistent challenge in the field of vulnerability research (Eakin and Luers, 2006; CGE, 2021; Ara Begum et al., 2022). Therefore, it is difficult to compare findings across studies and determine best practices or methodologies. This section will briefly discuss some of the key literature and approaches that have been used recently that helped guide the research approach undertaken in the Montana drought vulnerability assessment.

Early vulnerability research emerged from a shift in climate change research from an impacts-led approach that concentrated on the evolution of physical hazards associated with climate variability, to a vulnerability led approach that examines the underlying socio-economic, institutional, and political and cultural factors that determine how people respond to and cope with climate hazards (Adger et al., 2004; Ara Begum et al., 2022). Many studies have focused on vulnerability as it pertains to climate change risks and climate hazards. Sullivan and Meigh (2005) conducted a vulnerability assessment through an indicator-based approach called the climate vulnerability index (CVI), which they found can overcome some of the difficulties with combining different types of data and has the ability to be applied to a variety of scales. Cardona et al. (2012) characterized dimensions of exposure and vulnerability to climate and weather events, and also provide an assessment of changes in those dimensions, primarily through a review of literature related to the variety of different risk and vulnerability components. Chen et al. (2015) developed the ND-GAIN (the Notre Dame Climate Adaptation Initiative) index, which is an open-source index that shows a country’s current vulnerability to climate disruptions, as well as its readiness to leverage private and public investment for adaptation. Overall, the vulnerability of 192 countries is measured in the ND-GAIN index. This index provides a transparent and highly usable framework for conducting vulnerability assessments and contributes key information and methods to the Montana drought vulnerability assessment.

While many studies have focused on vulnerability from a global perspective, the framework of climate vulnerability can also be applied to local levels to assess variation in vulnerability within a country or locality. This is demonstrated through a study conducted in the small developing island country of Grenada, where socioeconomic vulnerability to flooding and climate events is spatially represented through GIS methods (Weis et al, 2016). The utility of vulnerability assessments is demonstrated here, as they find that vulnerability to flooding is not evenly distributed or even driven by the same factors across the country. Understanding vulnerability is key to effectively utilizing funds in order to reduce community vulnerability to hazards efficiently and effectively (Weis et al., 2016). Yu et al. (2021) expand on this concept through their research on vulnerability to climate change-related health hazards in 4188 Census dissemination areas in British Columbia, Canada. They computed overall vulnerability scores, as

well as exposure, sensitivity, and adaptive capacity sub-scores for each climate hazard (extreme heat, flooding, wildfire smoke, and ground level ozone).

Although the majority of vulnerability research focuses on climate change, there are some that specifically investigate vulnerability to drought. For example, some research focuses on agricultural and crop specific drought vulnerability and risk, using drought prone countries as case studies to demonstrate the utility of certain modeling techniques, such as the development of a spatial Agricultural Drought Risk Index (Kim et al., 2021) and principal component analysis (PCA) to understand the components of drought vulnerability (Alonso et al., 2019). It is notable that both of these studies analyze vulnerability yet define it in slightly different ways. Kim et al. (2021) define vulnerability as only sensitivity and adaptive capacity, while the terms of exposure and hazards were separate terms. Alternatively, Alonso et al. (2019) and Engstrom et al (2020) define vulnerability as containing all three terms of exposure, sensitivity, and adaptive capacity.

While the topic of vulnerability has been explored in the realm of climate change and to some extent with drought-focused vulnerability in agriculture, there are few statewide drought vulnerability assessments available to specifically inform this assessment. While not state specific, Engstrom et al (2020) conducted a drought vulnerability assessment for the United States as a whole, where they compared drought vulnerability from state to state based on quantitative metrics for each component of drought vulnerability. Although the methodology for state-by-state comparisons used by Engstrom et al (2020) is not directly applicable to the within state assessment being conducted for Montana, it provides validity for a quantitatively driven approach to compare vulnerability geospatially.

Fontaine and Steinemann (2009) conducted a drought vulnerability assessment in Washington state, assessing the vulnerability of 34 separate subsectors. Their approach was driven by information gathered from stakeholder interviews, which contained both structured and semi-structured questions that were analyzed through sorting, coding, categorization, and consideration of causal relationships. While their approach has the advantage of revealing real world information and drought experiences directly from stakeholders, the quantitative aspect of their approach has the potential to introduce bias, as it is based on subjective factors, as mentioned by the authors. Specifically, they generate Likert scale rankings for drought exposure, sensitivity, and adaptive capacity based on their analysis from each interview. Their approach suggests value in stakeholder driven interviews to elicit useful qualitative information, however, the potential for bias in quantifying data from the interviews suggests an alternative approach for a quantitative analysis should be considered to supplement qualitative information.

Perhaps the most detailed drought vulnerability assessment comes from Colorado's Drought Vulnerability Assessment within the state's 2018 Drought Mitigation and Response Plan (Colorado Water Conservation Board et al., 2018). The Colorado drought vulnerability assessment uses a mixed-methods approach that combines quantitative and qualitative data to assess sector specific drought vulnerability across the state. Data were gathered through surveys, interviews, and a variety of other secondary sources such as business associations, agricultural extension agents, the U.S. Census, and state agencies with analysis performed at a county level scale. It was noted that with little work on drought vulnerability previously conducted, the integration of qualitative data and fairly broad definitions of drought impact and vulnerability were necessary to supplement quantitative data. Quantitative analysis was conducted where sound data existed and could be developed efficiently, with variation in data availability and use from sector to sector. Ultimately, data were organized and scaled into vulnerability scores as appropriate based on availability, uncertainty, and sector-specific information.

Overall, the vulnerability literature demonstrates that there is no well-defined methodology for conducting vulnerability assessments or even defining vulnerability, as it is clear the way in which it is framed, the geographical and socio-demographic makeup, and societal impacts are highly variable (Yu et al., 2021). This point is noted in many of the studies. Eakin and Luers (2006) note that vulnerability definitions and vulnerability assessment practices are indeed not well defined and have emerged from several broad intellectual lineages. Similarly, the Colorado Drought Vulnerability Assessment (2018) noted the importance of recognizing that a very small amount of work has been done for assessing drought vulnerability to date, thus necessitating the use of fairly broad definitions and a flexible framework. Despite the large variation in methodology, it has also been argued that the diverse approaches to studying vulnerability can be viewed as complementary and necessary to be able to address the full complexity of the concept and its relation to social-environmental systems (Eakin and Luers, 2006). Indeed, this mindset is embraced to incorporate methods from a variety of different research into the Montana vulnerability assessment.

It is also recognized that considerable overlap occurs and there are many similarities across the research methodology. First, the general definition of vulnerability is difficult to operationalize, but overall is fairly similar across research. Exposure, sensitivity, and adaptive capacity tend to be the core components; however, their definitions and inclusion within the term of vulnerability can vary based on context. For example, some studies define exposure separately, and only include sensitivity and adaptive capacity as components of vulnerability, as these two components better characterize the human impacts of hazards such as drought or climate change. Second, a mixed methods or hybrid approach with both quantitative and qualitative data is valuable. Many studies utilize both methods, which can complement each other in the face of scarce information. This approach is key to the Montana drought vulnerability assessment. Third, there is no clear scoring methodology that appears to be a standard in generating quantitative vulnerability scores or indices, with a variety of approaches appearing to provide a valid structure. Finally, many of the studies describe the usefulness of vulnerability assessments in providing a starting point for assessing risk and providing policy makers with actionable information to make decisions regarding hazard preparation and efficiently allocating resources. The Montana vulnerability assessment aims to provide the same utility to policymakers and stakeholders alike.

Defining drought vulnerability

As noted above, vulnerability is a multidimensional and complex term that can be defined in a variety of ways based on social, economic, and ecological context. The **three key components of vulnerability** are **exposure**, **sensitivity**, and **adaptive capacity**. Following much of the prior research, these three components are used as a starting point to frame drought vulnerability in Montana.

Before defining drought vulnerability, understanding, and defining the concept of drought is also important. While the broad definition of drought is “a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area,” there are actually **four different types of drought**: **Meteorological**, which is a change from normal precipitation; **Agricultural**, which is characterized by low soil moisture; **Hydrological**; which is when surface and sub-surface water levels are below normal; and **Socioeconomic**; which is when water shortages affect people. The four types of drought are not independent of each other, and often times can compound one another, such as when prolonged periods of meteorological drought lead to larger agricultural or hydrological drought as soils dry up and reservoirs and aquifers are not able to recharge. Ultimately, the combination of the different types of drought will eventually lead to socioeconomic drought and substantial multidimensional impacts on society. Additionally, the ways in which humans use and manage water resources can also impact the severity of drought. The Montana drought vulnerability assessment is

focused primarily on these societal impacts of drought, and how it impacts different water use sectors and regions across the state.

Defining drought vulnerability in Montana closely follows how the previous research defines vulnerability by using the three key components of exposure, sensitivity, and adaptive capacity (Table 1). Because the primary interest is in examining the societal and socioeconomic impacts of drought, the focus of this vulnerability assessment is on sensitivity and adaptive capacity. These two terms characterize the sensitivity of society to a variety of drought impacts and, equally as important, society’s ability to adapt based specifically on how drought impacts individuals and water use sectors. Exposure is the bio-physical side of drought, or more simply, measurements of the presence of meteorological, agricultural, and hydrological drought. Drought vulnerability and its components are defined in the table below.

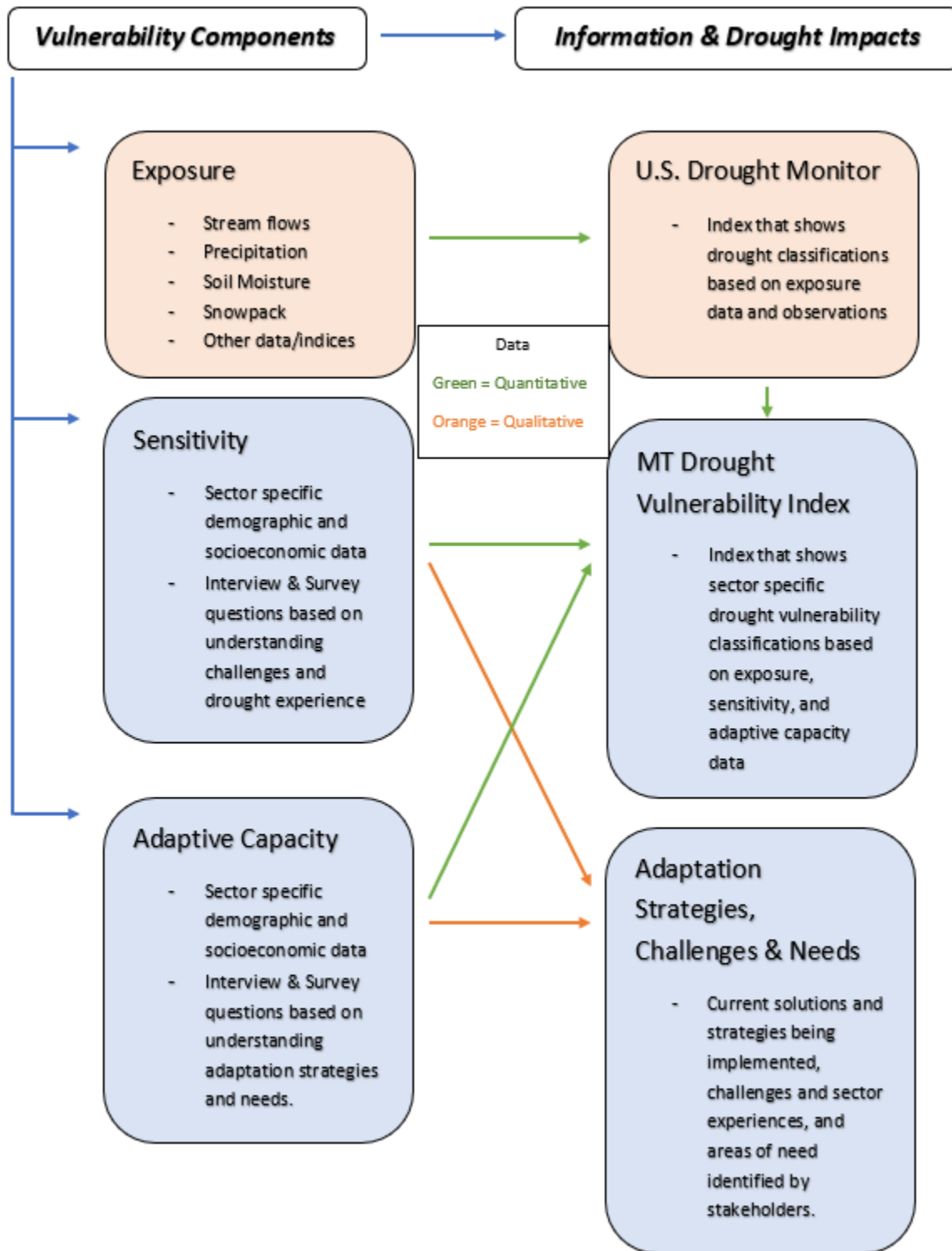
Table 1. Drought vulnerability definitions

Drought vulnerability: the propensity for society and individuals to be affected by drought. The term includes three components (exposure, sensitivity, and adaptive capacity) that can be split into two subgroups: Drought presence (exposure) and societal impacts (sensitivity and adaptive capacity).	
Component 1: Exposure	The presence of meteorological, agricultural, and/or hydrological drought. Exposure is measured through data, monitoring tools, and other measurable indicators that characterize the presence or absence of different types of drought.
Component 2: Sensitivity	The degree to which a region or water use sector may be impacted by drought, as defined by socioeconomic and demographic data that characterize that sector or region. A greater degree of water dependency, such as a higher population or more irrigated land, will lead to higher sensitivity to drought, depending on the water use sector.
Component 3: Adaptive Capacity	The presence of drought planning, availability and effectiveness of resources, and water use practices or policies that minimize the impact of drought. The ability to adapt may also be influenced by the willingness of a sector to adjust and the availability of information to make informed decisions.
Notes: Exposure is highlighted in orange to indicate a drought presence component. Sensitivity and adaptive capacity are highlighted blue to indicate societal impact components.	

Structure of the drought vulnerability assessment

With drought vulnerability thus defined, the concepts that structure the research design, data collection, and analysis efforts of this vulnerability assessment will now be explained. Defining and understanding vulnerability was vital to the framing of the research approach and helping to identify interview questions, survey design, and quantitative data sources. The information and analyses reported in the vulnerability assessment are intended to be clear, easy to understand, and easily translatable to a broad audience. The translation of the vulnerability components defined above into the information and drought vulnerability indices that are included in the report is shown in Figure 1, and further explained below.

Figure 1. Structure of the vulnerability assessment



Exposure, as it is defined in this report, simply indicates the presence of bio-physical drought, and can be measured and characterized using a broad range of data, indicators, and indices (e.g., precipitation,

temperature, stream flows, soil moisture, snowpack and standardized precipitation index). These data are available in various formats, spatial densities, and locations, and are often quite technical to use and interpret. Alternatively, the U.S. Drought Monitor is an index released weekly that shows drought classifications across the United States. There are five classifications, ranked from abnormally dry (D0) to exceptional drought (D4). Unlike the multitude of data sources listed above that could characterize isolated pieces of drought exposure, the U.S. Drought Monitor is a simple tool that integrates multiple dimensions of biophysical drought in a way that is clear and well understood. The scientists who maintain the U.S. Drought Monitor evaluate multiple data sources and indices, as well as reports and observations from observers across the country, to classify drought conditions. The output is an accessible and easy to understand drought map.

Sensitivity and adaptive capacity, as they are defined, represent the vulnerability components of drought that characterize how drought impacts society and water use sectors, and consequently, how society and water users are able to respond to and adapt to drought. There is substantial publicly available secondary data, mostly quantitative, that measures individual aspects of sensitivity and adaptive capacity for specific economic sectors. In this assessment, these data are used in conjunction with U.S. Drought Monitor data to generate overall and sector-specific drought vulnerability indices. In addition to the quantitative indices, individual interviews and an online survey were also utilized to gain an understanding of the components of drought vulnerability, with a focus on sensitivity and adaptive capacity, from stakeholders across the state. Findings from these interviews and survey responses complement the drought vulnerability indices by providing important information about the challenges and experiences of drought, current solutions to drought already happening, and what types of resources are needed to help water users across sectors handle drought moving forward.

This report is organized in the following manner. First, a methodology section that describes the mixed-methods approach, interview and survey design, and analysis will be presented. Following the methodology section are results, with subsections focusing on findings related to the vulnerability components. First, drought exposure is characterized through data from the U.S. Drought Monitor as a tool to measure exposure. The next section will be the main results and vulnerability profiles, which focuses on the drought vulnerability indices and the qualitative findings for each water use sector individually, with sector-specific drought vulnerability index classifications and a detailed discussion of the sector-specific drought solutions, experiences, challenges, and needs identified from interviews and the survey. The vulnerability profiles section will conclude with a discussion of cross-cutting themes and findings that consistently emerged across water use sectors.

Methodology

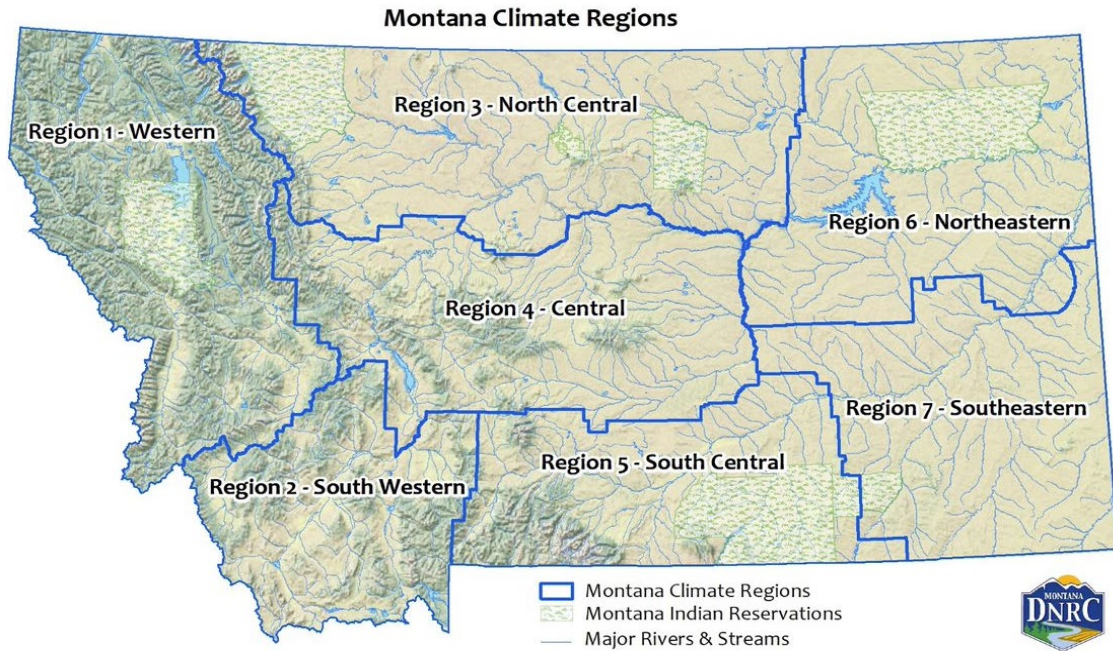
This vulnerability assessment was conducted using a mixed-methods approach to collecting and analyzing both qualitative and quantitative data. The qualitative data were gathered through interviews with stakeholders in sectors impacted by drought across the state. The qualitative data was then coded into themes and key issues identified from stakeholders, which will help guide a narrative and identification of drought adaptation strategies across sectors and regions. Primary quantitative data were gathered through the online survey of water users and stakeholders across the state, and publicly available secondary data was collected and integrated from a wide range of sources. Survey data were analyzed to identify patterns in experiences by region and sector. Secondary data were used to construct the drought vulnerability indices.

Primary Data

Interview design and responses

Semi-structured, in-depth interviews were conducted with key stakeholders throughout Montana in order to capture diverse perspectives and generate a rich understanding of experiences related to drought across climate regions and water use sectors in the state. Interview participants were initially sampled using DNRC's existing list of regional stakeholders engaged in the update process of the Montana Drought Management Plan. All individuals on the list of regional stakeholders were contacted via email and asked to participate in an interview. Additional interview participants were recruited using a snowball sampling method, where interview participants were asked to refer contacts who may be interested in participating in an interview for this study. Additionally, members of the assessment team contacted sector-specific organizations and asked them to share interview recruitment information with their membership and networks. Similarly, a survey (detailed below) was distributed to regional stakeholders and organizations which included a question about interest in participating in a follow-up interview. Throughout the data gathering period, the assessment team and DNRC staff sought ways to identify individuals in climate regions and water use sectors that were underrepresented in the sample. A map of the Montana climate regions can be found below (Figure 2).

Figure 2. Montana Climate Regions



Interviews were conducted between July and September 2022. In total, four interviewers on the vulnerability assessment team conducted interviews with 63 stakeholders. Representatives from all seven climate regions and the following water use sectors were interviewed: Agriculture, Conservation and Land Management, Recreation and Tourism, Energy and Industry, and Planning and Community Development. A detailed breakdown of interviews by water use sector and climate region is shown in Table 2.

Table 2. Interview participants by climate region and sector

Region and sector	Number of participants
Region 1: Western	
Agriculture	2
Conservation and land management	5
Energy and industrial use	1
Planning and community development*	8
Recreation and tourism	1
<i>Subtotal</i>	17
Region 2: Southwestern	
Agriculture	2
Conservation and land management	6
Energy and industrial use	2
Planning and community development*	5
Recreation and tourism	2
<i>Subtotal</i>	17
Region 3: North Central	
Agriculture	5
Planning and community development*	2

<i>Subtotal</i>	7
Region 4: Central	
Agriculture	3
Conservation and land management	1
Planning and community development*	1
<i>Subtotal</i>	5
Region 5: South Central	
Agriculture	4
Conservation and land management	3
Recreation and tourism	2
<i>Subtotal</i>	9
Region 6: Northeastern	
Agriculture	2
Planning and community development*	3
<i>Subtotal</i>	5
Region 7: Southeastern	
Agriculture	3
<i>Subtotal</i>	3
TOTAL	63

**Note: The planning and community development sector includes participants who identified with the municipal water supply sector. Because of similarities and substantial overlap in interviewees and types of issues addressed across these two sectors, they were combined for the qualitative analysis.*

Interviews were semi-structured, meaning they were conducted using a pre-determined interview guide, though some follow-up questions were generated organically based on the topics or ideas introduced by interview participants. The primary questions asked were focused on understanding how individuals experienced, responded to, planned for, and adapted to drought conditions. Participants were also asked to reflect on the availability and value of existing drought monitoring, response, and planning tools in Montana and how an updated statewide drought management plan can be most useful to individuals in their sectors and communities. The full interview guide can be found in Appendix D. Interviews lasted a duration ranging from 30 minutes to one hour and were conducted over the phone, via an online platform (e.g., Zoom), or in-person.

Survey design and responses

In addition to interviews, an online survey was developed to generate supplementary stakeholder feedback. The survey was launched through the online survey platform, Alchemer, and distributed to contacts on DNRC’s list of regional stakeholders and sector-specific organizations throughout the state via emails that included a link to the survey. The survey included 11 close-ended questions and four open-ended questions. Participants were asked to identify the county they live in and the primary and secondary water use sectors with which they most identify. Other survey questions focused on the impacts, experiences, and observations of drought that participants have experienced. The survey questions were informed by previous drought assessments (Colorado Water Conservation Board et al, 2018; Pritchett et al., 2013) and were developed with the intent of complementing data gathered through interviews.

In total, 245 valid survey responses were gathered, with participants representing all seven climate regions and all water use sectors. The breakdown of survey participants by climate region and sector is shown in Table 3 below. The full survey guide can be found in Appendix D.

Table 3. Survey participants by climate region and sector

Region and sector	Number of participants
--------------------------	-------------------------------

Region 1: Western	
Agriculture	8
Conservation and land management	22
Energy and industrial use	1
Planning and community development	19
Recreation and tourism	1
Other	1
<i>Subtotal</i>	59
Region 2: Southwestern	
Agriculture	9
Conservation and land management	6
Energy and industrial use	1
Planning and community development	19
Recreation and tourism	5
Other	8
<i>Subtotal</i>	41
Region 3: North Central	
Agriculture	39
Planning and community development	3
Other	2
<i>Subtotal</i>	44
Region 4: Central	
Agriculture	16
Conservation and land management	4
Planning and community development	13
Recreation and tourism	1
Other	9
<i>Subtotal</i>	43
Region 5: South Central	
Agriculture	9
Conservation and land management	2
Planning and community development	4
Recreation and tourism	2
Other	3
<i>Subtotal</i>	20
Region 6: Northeastern	
Agriculture	8
Conservation and land management	1
Planning and community development	3
Other	4
<i>Subtotal</i>	16
Region 7: Southwestern	
Agriculture	5
Conservation and land management	2
Planning and community development	1
Other	1
<i>Subtotal</i>	9
TOTAL	232

Note: The options for sector categories provided in the survey vary slightly from the sector categories presented throughout the rest of this report. Changes were made to the sector categories based on the

secondary quantitative data available to generate drought impact scores. Some survey respondents did not identify their climate region and/or primary water use sector, therefore the total number in this table is lower than the grand total number of survey responses that were received.

Qualitative data analysis

With the consent of participants, interviews were audio recorded and transcribed verbatim using the online transcription service, Rev. Interview transcripts were then analyzed with thematic coding methods using NVivo Qualitative Software (QSR International Pty Ltd., 2022). A coding guide was generated by two members of the research team in two phases: 1) initial coding based on the topics and themes addressed in the interview guide and resulting interviews, and 2) focused coding where more detailed categories and emergent themes were developed based on the initial analysis (Glaser, 1978; Saldaña, 2009). The resulting coding scheme included ten primary codes and a total of 114 subcodes. A list of the coding scheme can be found in Appendix E. The coding analysis was completed by two members of the research team, with intent of ensuring a high degree of intercoder reliability (Creswell and Poth, 2017; Saldaña, 2009). After each coder analyzed an initial subset of transcripts, coding discrepancies were addressed through a deliberative process among the coders until agreement was reached among them.

Survey data analysis

Survey responses were analyzed in two ways: Responses to close-ended questions were cleaned and descriptively analyzed in R/Posit (R Core Team, 2021), and responses to open-ended questions were analyzed using the same qualitative coding guide used to analyze interview data. Summary tables of the close-ended survey responses can be found below.

Limitations

While the assessment team sought to recruit interview and survey participants from each primary water use sector in each climate region across the state, not all sectors are represented in each climate region in the samples. In general, the number and sectoral diversity of interview and survey samples based in western climate regions was significantly higher than for the central and eastern regions, however, this is in part reflective of the population density and geographic distribution of professionals in key water use sectors across the state. Ultimately, it is unclear precisely how many individuals in Montana are associated with each water use sector within each climate region, but it was the aim of the assessment to capture as many perspectives as possible within the given time and geographic constraints of the project.

Participant recruitment was conducted through existing networks and stakeholder contacts available to the assessment team and DNRC, which likely limited the number of individuals reached by the recruitment efforts across water use sectors and regions.

The study was also limited by time and geography. Based on the timeline of the assessment and weather conditions, qualitative data collection was primarily conducted in the summer months, which is a busy time of year for individuals in many water use sectors. The assessment team worked to minimize limitations due to time and location by offering multiple ways to participate in the interview (e.g., phone, Zoom, or in-person) and a variety of times, including outside of normal business hours.

Secondary data

Exposure data from U.S. Drought Monitor

Exposure was measured as drought frequency and change over time over time using data from the U.S. Drought Monitor (2000-2022). Frequency was the number of weeks a county experienced D2 or greater drought conditions. Change over time was calculated by graphically depicting drought severity for each county (using the U.S. Drought Monitor classifications; integers from 0 to 4) and modeling the slope of each using linear regression. The slope value represented the general direction of change (positive or negative indicating increasing or decreasing severity, respectively), as well as the magnitude of the direction (higher absolute values indicate greater rates of change in either direction). Drought frequency and change over time were analyzed annually and seasonally (Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov).

Data from the U.S. Drought Monitor were used because they represent a convergence of evidence: multiple different drought indicators and indices are considered, as well as the expert judgement of drought science professionals and impact reports from water users on the ground. The change over time modelled variable uses historical trends to project future conditions. This historical trend approach accounts for changes at a finer resolution (county-scale) than most global climate models, and, thus, it provides more opportunities for adaptive management. Long-term drought predictions are difficult to make because of the multiple climatic and human factors involved; however, there is broad scientific agreement that persistent drought events are a natural feature of Montana's climate, and increasing temperatures in the future due to climate change will exacerbate drought conditions (Whitlock et al. 2017).

Data processing

The U.S. Drought Monitor has been classifying drought intensity and impacts since 2000. The categories of drought used in these estimates include None, D0, D1, D2, D3, and D4. The larger the number, the more intense the drought. More information about the weekly process and classifications can be found on the U.S. Drought Monitor website¹. Data were downloaded from the U.S. Drought Monitor for all weeks between January 2000 and December 2022. These data are in vector format, thus in order to aggregate by county, the data were converted to gridded raster format at 4 km spatial resolution.

Drought Frequency

The D2 (i.e., "Severe Drought") designation was used to create a Boolean mask of all weeks between 2000 and 2022 that were scored greater than or equal to D2. Data were then divided by seasons: full year, Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov. For each season, the total amount of D2 or greater weeks were summed and then averaged for each county in Montana. The values are standardized to be between 0 and 1, where 0 represents the minimum frequency of D2 or greater drought in Montana and 1 represents the maximum frequency.

Drought Change

Raw values of drought severity from the U.S. Drought Monitor were used. For example, D2 drought is represented by the integer 2 and D4 drought is represented by the integer 4. The data were then split into seasons: full year, Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov. For each season and grid cell, the change of drought severity over time was modeled using a linear regression. The change for each county was then calculated by averaging the slope of the linear regressions within each county. The units of the slope

¹ <https://droughtmonitor.unl.edu>

values were converted to the change in drought severity per year from 2000 to 2022. A negative slope represents a decreasing drought severity, while a positive slope represents an increasing drought severity.

Drought vulnerability index description and data

As discussed in the overview, many vulnerability assessments include an index or scoring system to rank vulnerability by geography, or demographics like industries or sectors (Fontaine and Steinemann, 2009; Colorado Water Conservation Board et al., 2018; Chen et al., 2015). Some methodologies utilize qualitative data or a mixed approach of both quantitative and qualitative data to generate scores. While this mixed approach may be useful for generating an index or score in some circumstances, the use of qualitative data can introduce bias when generating a standardized score, because qualitative data are based on human perceptions, which are likely to differ from individual to individual. The research team for the Montana drought vulnerability index chose to minimize bias by utilizing publicly available, county-level secondary quantitative data sources for the vulnerability scoring index. Qualitative findings, like real world drought experiences, adaptations, and statewide needs, add depth to the narrative without influencing the vulnerability indices directly.

The Montana drought vulnerability index methodology closely follows the methods used to generate the ND-GAIN Country Index (Chen et al., 2015), an open-source index that shows the vulnerability to climate disruptions for 192 countries. The ND-GAIN methodology was used to calculate the Montana drought vulnerability index for several reasons. First, it engages a comprehensive definition of vulnerability that includes three dimensions that span biophysical and social factors: exposure, sensitivity, and adaptive capacity. A second advantage of the ND-GAIN index is its adherence to transparency, reliability, and consistency in data-sharing systems. Its features are widely available in UN countries, accessible to the public, and collected from reliable organizations. Finally, the index calculation provides a clear and systematic methodology for normalizing data for comparison and analysis across water use sectors.

Drought vulnerability indices were calculated to assess and compare drought vulnerability across regions and water use sectors within Montana. The Montana drought vulnerability index methodology uses historical U.S. Drought Monitor classifications and trends, and various publicly available, sector-specific demographic variables to calculate county-level drought vulnerability scores for each water use sector in the state. The intent is to provide stakeholders and policy makers with a tool to easily compare the impacts of and vulnerability to drought, for different water use sectors across Montana. By combining the Montana vulnerability index with interview and survey data, policy makers can make informed decisions so resources, funding, and drought policy can be most efficiently and effectively implemented.

County-level data from publicly available sources were compiled for each water use sector in Montana. All indicator variables are included in Table 4, with the name of the indicator, the water use sector it is associated with, the data source, and brief description. These indicators are representative of either sensitivity or adaptive capacity indicators, which together, make up indicators that can be representative of how humans are impacted by drought. Descriptions for each indicator variable can be found in Appendix C.

Table 4. Drought impact (sensitivity and adaptive capacity) indicator variables

Indicator	Sector	Source	Description
Cattle Population	Agriculture	USDA Census of Ag	Total cattle population

Crop Sales	Agriculture	USDA Census of Ag	Total crop sales (\$)
Crop Land	Agriculture	USDA Census of Ag	Total area of crop land (acres)
Irrigation Withdrawals – Livestock	Agriculture	USGS	Irrigation withdrawals for livestock (Mgal/day)
RMA Liability	Agriculture	USDA Risk Management Agency	Risk Management Agency liability payments for crop insurance related to drought (\$)
% Ag Employment	Agriculture	Headwaters Economics	Percentage of total employment in the agriculture sector
Irrigated Acres	Agriculture	MT DNRC	Total irrigated agricultural land (acres)
Native Trout Presence	Conservation & Land	FWP	native trout presence in streams
Wetland Area	Conservation & Land	Montana State Library	Total wetland area (acres)
FWP Land Area	Conservation & Land	Montana State Library	Total Montana Fish, Wildlife and Parks land area (acres)
Impaired Streams	Conservation & Land	MT DEQ	Length of impaired streams (mi.)
Impaired Lakes Area	Conservation & Land	MT DEQ	Total area of impaired lakes (acres)
Area Water	Conservation & Land	Census Bureau	Total surface water area (sq. mi.)
Conservation Easement Area	Conservation & Land	MT Legislative Fiscal Division	Total conservation easement area (acres)
Dewatered Streams	Conservation & Land	MT FWP	Total length of dewatered streams as defined by FWP (miles)
Hydropower Generator Capacity	Energy & Industry	MT DEQ	Total generator capacity for each hydropower generator (MWH)
Industrial Water Withdrawals	Energy & Industry	USGS	Total water withdrawals for industrial use (Mgal/day)
Mining Water Withdrawals	Energy & Industry	USGS	Total water withdrawals for mining use (Mgal/day)
% of Population on Public Water Supply	Municipal Water Supply	USGS	Percentage of the population receiving water from a public or municipal water supply
Per Capita Domestic Water Use – Public Supply	Municipal Water Supply	USGS	Per capita domestic water use in for the population who receive water from public supply, such as municipal water (Gal/day)
% of Population Served by Surface Water	Municipal Water Supply	USGS	Percent of the population served by surface water sources for public water supply
Total County Population	Municipal Water Supply	Census Bureau	Total county population
% Change in Population (2010-2020)	Planning & Community Development	Census Bureau	Percentage change in county population from 2010 to 2020 census
Population Density	Planning, Policy, and Community	Census Bureau	Population Density in total number of people per square acre
Domestic Water Supply Withdrawals	Planning & Community Development	USGS	Total domestic water supply withdrawals by public from all sources (Mgal/day)
Lodging Tax Collections	Recreation & Tourism	MT Dept. of Commerce	Total lodging tax collections (\$)

Fishing Access Sites	Recreation & Tourism	MT FWP	Number of fishing access sites
MT State Parks	Recreation & Tourism	MT Natural Heritage Maps	Number of state parks

Notes: *In the qualitative analysis, municipal water supply is included under the planning and community development sector due to similarities in interview applicants and substantial overlap in the type of work within these sectors. However, in the quantitative analysis and vulnerability indexing, municipal water supply is separate from planning and community development as there are well defined differences in the quantitative data for these sectors. Municipal water supply data focuses specifically on public water supply from municipalities, while planning and community development is focused on county wide growth and water supply from both personal wells and public supply.*

Drought vulnerability index calculation

Step 1. After compiling county-level secondary data for drought impact indicators, two county-level drought exposure metrics were calculated using data from the U.S. Drought Monitor classifications spanning the years 2001 to 2021: drought frequency and the change in drought severity. Drought frequency is a measure of the amount of time a county is in D2 drought or greater relative to all counties in the state. The drought frequency values are standardized between 0 and 1, where the county with the lowest frequency of drought will have a value of zero and the county with the highest frequency will have a value of 1, relative to all other counties. The change in drought severity is calculated using a linear regression, where the change for each county is found by averaging the slope of the regression within each county. A negative slope represents a decreasing drought severity, while a positive slope represents an increasing drought severity. A full description and methodology for calculating the exposure indicators can be found in the exposure section of this report. Both exposure metrics were calculated for the full year, and seasonally for: Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov.

Step 2. County-level secondary data for drought impacts and drought exposure were used to assign state-level minimum and maximum values (baseline minimum; baseline maximum) and reference data points for each indicator variable. Baseline minimum and baseline maximum values (i.e., the highest and lowest values across all counties) were used in the calculation of the drought indicator scores (Equation 1) and are necessary to scale the data. A reference point is also set to scale the data, and is representative of the value for each indicator that would be considered least vulnerable to drought. The reference data point for each indicator variable was the lowest value (baseline minimum) because this value was considered to be the least impacted by drought relative to all the other counties. This approach ensures comparability across the state for each water use sector.

Step 3. Normalized scores for each impact and exposure indicator in a county were generated using the following formula, where direction equals 0 so that a higher score means higher impacts or exposure (worse):

Equation 1:

$$indicator\ scores = \left| direction - \frac{(raw\ data - reference\ point)}{(baseline\ max - baseline\ min)} \right|$$

The individual scores for each impact indicator were averaged by water use sector for each county. The individual scores for each exposure indicator were averaged for each county. After averaging, the impact averages and exposure averages were weighted, with the impact average being weighted by 0.67 and the exposure average being weighted by 0.33, so the total of the weights are 1. A two-thirds weight is given to the impact average because the adaptive capacity and sensitivity variables make up two-thirds of the

vulnerability definition and are thus assumed to have a greater impact on vulnerability relative to exposure. The weighted averages were then added together for each water use sector by county, which results in the county-level and sector specific drought vulnerability scores.

Step 4. After combining the weighted averages, drought vulnerability scores were re-normalized using equation 1 again so relative comparisons of drought vulnerability can be made among counties within each water use sector. For example, the county with the highest average score in a given water use sector will have a score of 1, representing that it has the highest vulnerability to drought relative to all other counties when considering that sector. Alternatively, the county with the lowest average score in a given water use sector will have a score of 0, meaning that it has the lowest vulnerability to drought relative to all other counties when considering that sector. The normalized vulnerability scores are the final county-level and sector-specific drought vulnerability indices.

Step 5. After normalizing the vulnerability scores for each water use sector, counties were classified into categories of low, medium-low, medium-high, and high vulnerability based on their scores. Counties with low vulnerability have scores ranging from 0-0.25, counties with medium-low vulnerability have scores ranging from 0.26-0.5, counties with medium-high vulnerability have scores ranging from 0.51-0.75, and counties with high vulnerability have scores ranging from 0.76-1. Results will be presented on maps within the results section for each water use sector. Additionally, season-specific scores will be presented for each water use sector in Appendix A.

Key assumptions and potential limitations

Setting reference points

One of the key assumptions made in creating the drought impact index is related to how indicators are determined based on their representation of sensitivity and/or adaptive capacity, since this impacts how reference points are created for the drought impact score equation. For example, an indicator of sensitivity would have a reference point value that would represent “little or no sensitivity,” which would be the lowest value. Alternatively, an indicator of adaptive capacity would have a reference point that is the highest value, as a high value would represent “high adaptive capacity.” In theory, it should be simple to differentiate between sensitivity and adaptive capacity and representative indicators of them. In practice, however, this is not always the case and therefore presents a great challenge since many indicators could reasonably represent both terms. To demonstrate this challenge, a hypothetical example of an indicator that could characterize both terms is presented.

If we are looking at data from the agricultural sector, for example, and have data on irrigated agricultural land, one could argue that dryland agriculture is more sensitive than irrigated agriculture to drought. Alternatively, it could also be argued that more irrigated agricultural land would lead to higher adaptive capacity relative to dryland agriculture. Both arguments land on the same conclusion but are framed in different ways depending on which vulnerability component is being considered. The same argument could be made for many other drought indicator data across water use sectors.

To avoid the potential for the two-sided argument and to simplify the interpretation of the index, the research team assumes that all indicators characterize both sensitivity and adaptive capacity, and when combined can be thought of as indicators of human susceptibility to being impacted by drought. The indicator variables are intended to represent the presence of a water use sector in a county, where a greater presence of the water use sector will lead to that county being more impacted by drought conditions relative to other counties within that water use sector with a smaller presence. Therefore, for

example, a county with more agricultural land, or a higher percentage of people on municipal water supply will be more likely to be impacted by drought than a county with less agricultural land, or fewer people on a municipal water supply system. Ultimately, this assumption leads to the use of a reference point in step 4 of the index methodology always being the baseline minimum for each indicator, as the minimum value will represent the least susceptible county to drought by indicator.

Using the U.S. Drought Monitor

While the U.S. Drought Monitor is the de facto measure of drought in the United States, it has certain limitations that should be noted in evaluating drought exposure in Montana. Although the Drought Monitor is based on many quantitative metrics, it is ultimately a subjective measure of drought because it relies on trained, professional people to identify convergence of evidence and qualitatively designate location and severity of drought. This creates challenges when trying to decipher whether the results are related to changes in biophysical or human factors. For example, drought monitoring professionals could be inclined to offer conservative recommendations for decreasing drought severity in a particular region because it is difficult to judge when drought is receding in the moment. In addition, the available data may be insufficient to accurately capture fine-scale differences across a large area. Nonetheless, the U.S. Drought Monitor is the standard designation of drought and is considered the best, comprehensive, metric of drought over the past 20 years. In the end, drought is a subjective concept, therefore measuring it subjectively may be the best means of evaluating its exposure.

Interpreting the vulnerability index

The drought vulnerability index was created to classify and compare the impacts of drought in Montana at the county level for each water use sector. The index utilizes publicly available data sources that represent exposure, sensitivity, and adaptive capacity metrics for each water use sector. Across the five water use sectors, metrics from the U.S. Drought Monitor and drought indicator variables are used to create a standardized drought vulnerability score for each county within each water use sector, where the scores are interpreted as the vulnerability of a given county relative to all other counties within that water use sector. The vulnerability scores were used to classify drought vulnerability by county and water use sector into four categories: low, medium-low, medium-high, and high.

It is extremely important to only compare scores *within* a water use sector, and not to compare scores from one water use sector to another. The data sources used are sector specific and intended to be standardized only within a water use sector. Table 5 demonstrates an example of how the index classifications should and should not be interpreted.

Table 5. Interpretation of sector-specific index classifications

Example: Comparing Agriculture and Recreation and Tourism	
Do:	Don't:
Compare classifications of Agriculture in county A to classifications of Agriculture in county B	Compare classifications of Agriculture in county A to classifications of Recreation and Tourism in county A

Compare classifications of Recreation and Tourism in county A to classifications of Recreation and Tourism in county B

Compare classifications of Agriculture in county A to classifications of Recreation and Tourism in county B

It is also important not to interpret the drought impact index as ranking some counties as more important than another county. For example, if we are looking at the agriculture water use sector, the drought index is not implying that drought vulnerability for a single farmer in a low vulnerability scored county are less than a single farmer in a higher vulnerability county. If we assume that drought exposure, for example, is equal between two counties, but the two counties have different classifications for sensitivity or adaptive capacity metrics, we can also assume that each individual farmer or rancher may be equally affected by drought no matter the county they reside in because their exposure to drought is equal. However, in the county that has higher sensitivity and/or lower adaptive capacity, there will be a greater number of individual farmers or area of farmland that is impacted by drought than in the county with less sensitivity or more adaptive capacity to drought. Each farmer, no matter of their county classification, will potentially need resources to help manage the impacts of drought. There simply may need to be more resources overall allocated to high vulnerability counties because a greater number of individuals and communities in those counties are impacted. The drought index is meant to be interpreted as a baseline to easily identify where the greatest impacts may occur, which can provide information to support efficient allocation of state resources across all counties to maximize and target benefits.

Results: Drought Exposure

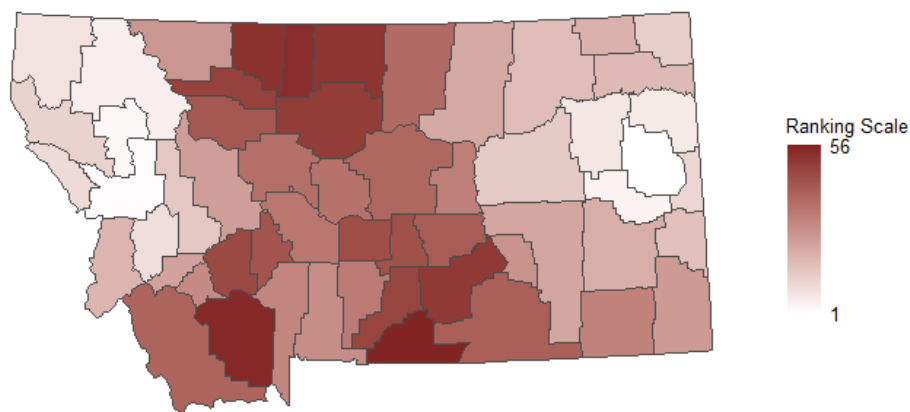
Drought exposure is defined as the presence of meteorological, agricultural, and/or hydrological drought. To capture these effects from drought, two indicators were developed based on historical data from the U.S. Drought Monitor². The first indicator represents the frequency of drought over the past 22 years. The second indicator represents the change in the magnitude of drought over the past 22 years. By combining these two indicators, the key aspects of drought exposure historically and trends in how exposure might be changing in the future can be captured. These results are broken down into seasons, aggregated by county boundaries, and—when appropriate—normalized to be relative to one another.

While the U.S. Drought Monitor provides a valid and consistent quantitative metric for capturing drought exposure, many people experience or monitor drought conditions and exposure in different ways or with metrics and observations that are not captured by the drought monitor. Many participants shared their perspectives on drought exposure, which are outlined and discussed by water use sector below. These observations are intended to complement and compare the qualitative information and on the ground experiences to the standardized quantitative metric of the U.S. Drought Monitor to ensure that all aspects of drought exposure are captured.

Figure 3. Drought exposure frequency in Montana counties 2000-2022

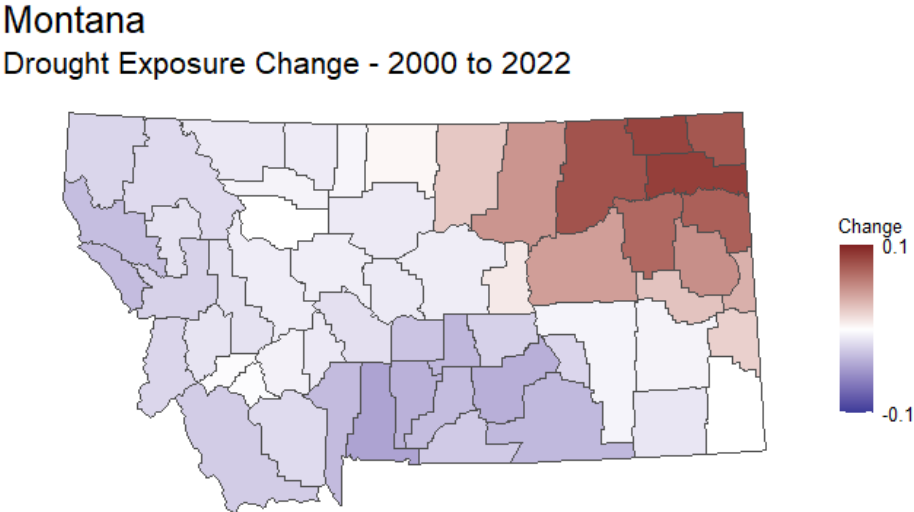
Montana

Drought Exposure Frequency - 2000 to 2022



² <https://droughtmonitor.unl.edu>

Figure 4. Changes in drought exposure in Montana counties 2000-2022



Results: Vulnerability Profiles by Sector

Agriculture

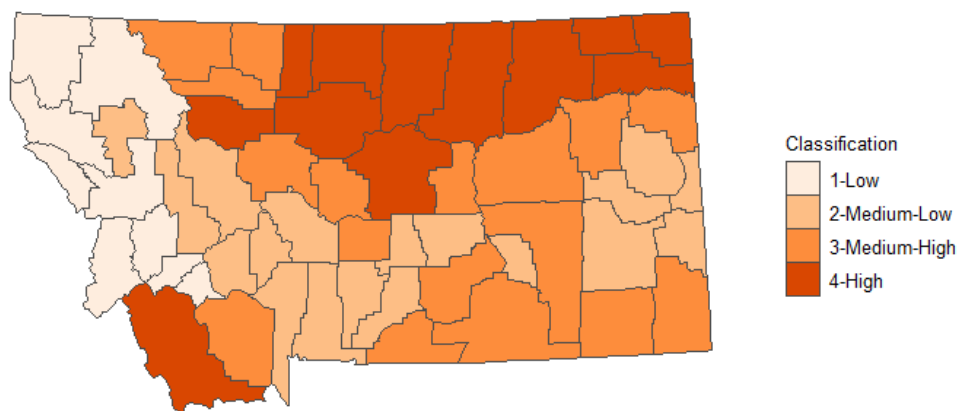
Agriculture was the largest sector by number of interviews and number of surveys. The assessment team interviewed 21 farmers and ranchers across the state, with an even spread of two to four interviews per region, as well as 96 survey respondents spread throughout the seven climate regions; agriculture made up 39.2% of all survey responses.

Agricultural vulnerability index

Figure 5. Drought vulnerability index by county for the agricultural sector

Agriculture

Drought Vulnerability Classification



The Northeastern and North-Central regions of the state generally had the highest vulnerability to drought within the agriculture sector compared to most other areas of the state, with the exception of Beaverhead county in the Southwestern region. These high scores are largely related to these regions having large agricultural economies compared to many other parts of the state, combined with high exposure in the past five years. Although Northeastern Montana has had the least amount of drought exposure of any region in the state over the past 22 years according to the U.S. Drought Monitor data, in more recent years it has seen the greatest increase in drought severity of any region of the state, thus contributing to the region's high vulnerability in conjunction with the large presence of agricultural operations there.

All other areas of the state to the east of the Continental divide have medium-high to medium-low vulnerability. This can be attributed to primarily high drought exposure, as well as large agricultural presence in many of the counties. The Northwestern region of the state, to the west of the continental divide, has low vulnerability scores for agriculture in comparison with the rest of the state. This area of the state has a smaller agricultural presence compared to most counties east of the divide, as well as generally lower drought exposure in comparison to the rest of the state.

Coping with and responding to drought impacts in the agriculture sector

Sensitivity can be conceptualized as experiencing and responding to the impacts of drought, and in this section, we present thematic description of sensitivity in the agricultural sector.

Impacts of drought

The impacts of drought on ranching and farming are undeniable: drought is detrimental to pasture and crop quality, water supply, and soil health, and it primes conditions for other ecological and natural disaster impacts. According to one rancher, drought is always present:

Drought is, it's one of those things, anyone who's in agriculture and particularly if you raise livestock in the Western part of the country, drought is always there. It's always kind of hovering in the background and no matter how good the years are you know that it's coming back and it's just a matter of, is it going to be a long-term, many-year drought or are we going to get by with just maybe a one year and then it's gone like in 2012. But you're always worrying about it. – Rancher, South Central Region

Impacts to livelihoods

Exposure to drought conditions can exhaust the literal and symbolic savings of farming or ranching operations. The severity of drought exposure varies greatly depending on the operation type, the practices in use, the location, and what is available for local resources. From survey responses, we heard that the impact that drought has on one's livelihood is one of the most difficult challenges a rancher has to deal with. As one rancher felt, drought tends to hit agriculture the hardest:

But the first people, anytime that there is a drought and a shortage of water, the first group that seems to get hit are farmers and ranchers. What nationwide, where 2% of the population, that's not a big voting block to sway government opinion on people that you're worried about. But on the other hand, it's not just, yeah, they're using water, but they're growing everybody's food for them. I kind of wish folks would remember that part of the equation. – Rancher, South Central Region

One of the most consistently mentioned impacts of drought on the livelihood of farmers and ranchers is the added cost of time and energy that hauling feed or water brings. As drought conditions impact water availability and pasture quality, these necessities become an added burden for producers. In a year with sufficient water supply, many producers rely on their own fields and water resources to maintain their operations. During a drought, and especially during the past few years, participants explained that there has been a significant spike in the cost of hay due to less water available for everyone to grow their own.

Yeah, so with the drought comes higher hay prices, which is a given. And if it's hard on our winter and our late fall, early winter grazing, then we're feeding hay earlier to keep those cows in the condition that we want them in... So that's another big, that was in the thousands of dollars as an unexpected expense that we usually don't have to do, all of a sudden just to get those cows bred. As far as hauling water, it's just, yeah, it costs us. Time is the biggest one. Twice a day, hauling water, it's tough to get a whole lot of other things done, especially if, say, you break down on the water trailer or the pickup, that becomes your priority because you got to get water that day. So yeah, those are our, definitely a good increase. I'm not sure that the percent, I wouldn't say 50%, but I would say there's a good increase in the percent of feed-related expenses and bills that we have because of drought. – Rancher, Central Region

According to one rancher, a good measure of a drought year is how much hay is needed to supplement the pastures:

So also, because hay had to come from so far away, there was a lot more spent on freight and gas prices went up. So, we normally don't spend anything on hay, and for the 2021-'22 winter, we spent \$126,000. Yes. So, like our, we're not a huge place. Our normal operating budget for the year is like \$250,000. – Rancher, Central Region

Often, the only options for financial stability during drought years are to reduce input costs for the upcoming crop, or sell livestock, which means cutting income as well. According to participants, there is no great way to stay ahead of drought impacts. When asked about the extent to which drought impacts their farm, an organic farmer who lives on the Montana-Canada border replied:

Oh, terribly. Yeah. The three years have been terrible. We had 37% of our average production last year. It's not looking so great this year either. So, we're not yet through harvest. So I can't tell you what that number is this year, but yeah, the lentils were a total loss... – Farmer, North Central Region

Out of our 21 interviews and 96 survey respondents, one participant responded that drought affects them positively: It makes them a better planner and operator. Based on our data, this positive experience was a rarity.

Access to water

Livestock and crop producers alike count on water supply during their growing season. Due to drought conditions and a changing climate, participants in agriculture noticed less and less water available: “*We have stock water in ponds that haven't been dry since we moved here that are bone dry.*” With decreasing water available due to drought conditions, producers noted experiencing a shortening in growing season and decreases in crop profitability due to the inability to regularly irrigate.

People who didn't have irrigated ground didn't get a crop at all in 2021. And then people who did have irrigation got a crop, but it still was 50% or less. And then going into 2022, the reservoirs were at historic low levels, and snowpack, there really was no runoff. They normally will run maybe even six weeks of water, and they had 10 days of irrigation water. – Rancher, Central Region

A few participants expressed frustration with Montana’s system of prior appropriation and having water rights called by senior water rights holders, essentially leading to water shut offs for junior water rights holders. The effective shutdown of a water resource can be frustrating for junior water rights holders, especially if needed to maintain a business. Collectively, participants suggested that more communication around water shutoffs would be beneficial to reduce tension among water users and help producers prepare more effectively.

We had our main water rights shut off early in the season. Didn't know if they'd come back. They did, but we were shut down during critical month in May, early May, late June, or late May, early June, we were shut down for critical period for our irrigation. You just have to suck it up and know everyone else is suffering alongside you. – Rancher, Central Region

In the case of limited water availability from surface waters, some producers have sought out new water sources during intense drought conditions, such as drilling groundwater wells or installing pumps in drainage ditches. From the survey, several participants associated with the agricultural sector shared that they are interested in learning more about or expanding funding for infrastructure related to irrigation such as pipelines, troughs for cattle, and floating pumps.

Ecological impacts and soil health

For participants in this sector, soil health and water infiltration are inextricably tied to any conversation about drought. Participants shared that when there is not much precipitation in the forecast, it is important to capture and retain as much as possible moisture in the soil.

Several participants spoke to the principles of soil health and underscored the importance of implementing healthy pasture and soil management practices, particularly during times of drought. One participant compared their neighbor's management practices to theirs, describing how overstocking and continuous grazing results in a visibly different quality of soil:

For example, there's this property we drive by every day when we go to check on our cows, and it's a small little section. It's dry land. You can't irrigate it because it's like all rocky and stuff. And they have too many heavy animals on it, and they continuously graze it. And I tell my kids... My oldest is eight. I'm like, "Look at the difference between the road and the fence." So this is un-fiddled with, aside from the spring done by the county or whatever. And then on the other side of the fence line is where these people have been managing their land. And it looks like a desert. Looks like dust and dirt. It looks like it's going to blow away. It looks like the sage brush is going to give up soon and start blowing away. – Rancher, South Central Region

Many producers see soil management as a way to mitigate the effects of drought that they are experiencing. Some participants explained that they are willing to take a cut in profit and lose a crop in order to protect their soil health to ensure the long-term viability of their operation:

I probably won't be able to irrigate these two fields here this year. And I've been working on soil health for five years here. I got to decide if I'm even going to do a cutting. I'll probably lose my alfalfa for this year and then have to figure out how to reseed. But how can I keep that soil as healthy as possible in the year that I can't irrigate and more likely than not still going to be a hot August. – Farmer, South Central Region

Another ecological consequence of drought that a few participants described as impacting their operation is that wildlife, particularly ungulates, will feed on irrigated lands, adding additional pressure on the already limited forage. One participant shared that the only effective way to keep wildlife away is to be physically present in the fields, which means adding additional labor at an additional cost. One rancher in the Western region noted that, in their experience, wildlife feeding on pastures is not really an issue when drought conditions are not present because the wildlife have other, natural places to forage.

Pasture and crop quality

Pasture and crop quality are highly dependent on rainfall and, often, suffer drastically during a drought. Participants in agriculture depend on the quality of their pastures and crops for the success of their business each year. When asked, "what is the biggest way you use water?", a rancher from the South Central region replied, "*The big way that I use water is to pray for rain or snowfall, but it's mostly rain, the spring and early summer to make grass. And that's pretty much it.*"

In addition to poor pasture and crop quality as a result of drought conditions, participants also described facing increased weed growth and, for many, the arrival of grasshoppers. Producers noted that during a drought, crops and pasture will suffer while weeds will flourish:

Well, the amount of water definitely has an impact on the quality of pasture because I think that dry, hot years makes it more difficult to control weeds and so you'll have more weeds that year and you could very well have more weeds the next year. All the work you put into controlling weeds can sometimes go to hell. The weeds do great, and the grass is slow to catch up with growing, so that's a big deal because you put a lot of money into controlling weeds. And when you have a drought and the grass isn't growing and the weeds are, then that's disconcerting and you feel like you've been set back.- Farmer/rancher, South Central Region

One of the more heated topics raised by both interviews and survey participants was the frustrating duality of grasshoppers and drought. Producers who are already suffering from less water availability and

increased weed growth described having to grapple with the effect of grasshoppers feeding on pastures and crops. As one rancher from the Western region noted, *“it sucks when you’re working really hard and you’re moving backwards,”* reflecting on drought-induced grasshopper outbreaks. Left unaddressed, grasshoppers can decimate entire fields, leaving no forage for cattle and barren soil: *“But last year was just, it was so hot and so dry, and then the grasshoppers that we had, just annihilated everything.”*

Some participants shared that grasshoppers are the biggest drought-related concern for them and their operations: *“And on top of that, if you have drought, it also seems that you’re going to have grasshoppers, seem to go hand in hand and I don’t know why. So you get no rain, no grass, nothing’s growing and what is growing the grasshoppers.”*

The toll that grasshoppers can exact on pasture and crops that are already in decline due to drought conditions results in catastrophic conditions for some producers: any pasture or crop that *is* surviving the dry spell is then annihilated by hoppers.

Just a perfect example too, in Eastern Montana last year they had a horrendous drought, D4 or whatever, it was awful. Crops burned up, they had nothing, it was terrible. And then they had grasshoppers, they came in and ate whatever was left. And my daughter sent me a picture of a stem of some grass and it was solid grasshoppers. Solid. – Rancher, South Central Region

Secondary drought impacts

Participants in the agricultural sector also mentioned flooding and wildfires as drought-related impacts that affect their operations. As one rancher from the South Central region commented, *“I think there definitely is a connection between drought, and fire, and mismanagement of forests.”*

Wildfires are natural, but the severity and spread of fires can also be impacted by forest and land management practices. Participants in the agriculture sector have a unique perspective and are able to see the land affected through different types of management. According to a rancher from the Southeastern region who lends six generations of historical perspective to the experience of wildfires, *“it’s part of a natural process, but they burn more intense now, with all the fuel and the heat.”* It is the inability to contain and manage these fires that has become a growing concern among participants.

I mean, I can see places that were burnt back in the early sixties. And it burnt the hillside off and there was beautiful grass after that. But now the cedar trees and the ponderosa pine are taking it back. We had a bad fire in 2000, it burned up I don’t know how many acres, but it was on the forest and some of my private land that I have on the forest. And hell, after that fire there was rock formations I didn’t even know were there. They say this country used to burn every 15 years. It’s part of the natural process, but there’s a lot at stake. – Rancher, Southeastern Region

Wildfires pose a considerable threat to farms and ranches. Participants described remaining diligent to storm monitoring and having a plan in place for disasters as necessary protocols in managing their operations.

I guess the other thing about drought that we never touched on at all, that is a major factor, it can happen any year, but it’s worse in the drought years is wildfires and where we happen to live in an area that burns. So, trying to remain vigilant during... Most of our fires are caused by lightning. So, any of the afternoon, evening thunderstorms are kind of cause for concern... It’s like drought, it’s part of the natural cycle and you just have to deal with it. – Rancher, South Central Region

As participants noted, flooding can also be exacerbated by poor soil health and poor water infiltration in relation to drought. From a producer's point of view, regardless of the cause of a flood it can cause serious damage to an operation. From one interview with a rancher located on the Yellowstone River, they described the impact of a recent 500-year flooding event on their operation:

We lost all of our fencing, all of our water tanks, all of our feeders. We have a [large] rocks in a good portion of the field down there. And what used to be our [river]bank is in the middle of the river. We have to have that [river]bottom or we can't calve. That's our place to send our pairs. And it always has had lots and lots of grass, so even if it's dry it's good cover for calves. And it was big enough that it would handle lots of pairs. Now it's smaller, and now it's sand, and now it's rock. – Rancher, North Central Region

Mental and physical health impacts

One of the less commonly discussed but important topics in the agricultural sector is mental and physical health. In recent years, the expansion of and messaging around the resources available to farmers and ranchers has helped to normalize these topics. Participants were specifically asked if and how drought impacts their physical and mental health. Several participants shared that drought can have a considerable impact on their health due to the financial stress and increased labor demands it generates.

Yeah, I think that's the unspoken thing that goes on with drought, is the uncertainty and the stress. It's a real deal, and I fear for people that are unable to talk about it or don't have people to talk about it because there's going to be a lot of, we're just going to start seeing the fallout of last year's economic impacts in the coming year. I think as people try to, we've gotten some moisture and people are going to expand again, they sold their cows at, you could buy a bred cow for 700 bucks last fall in the peak of the drought, to buy her back is going to be 1400 to 3000 depending on what the national market does. There are going to be a lot of people that lose their livelihoods. The stress of carrying that every day is huge. – Rancher, Central Region

As participants described, the toll that drought can take on the livelihoods of farmers and ranchers can be significant and, ultimately, , disheartening and depressing. One rancher describes drought as “insidious”:

But to those of us that do work on the land, it can be a terrible, heartbreaking thing. One of the worst things about drought is the insidious nature of drought that it creeps on you incrementally and things just kind of get a little worse and then a little more worse. And it's always there, even in the good years. – Rancher, Southeastern Region

Another participant described how drought conditions can result in a number of cascading mental and physical impacts

I won't lie, last year was tough. When you go outside and every step you take, a hundred grasshoppers fly up and that's no exaggeration...and it hasn't rained all year and it's over a hundred degrees, I think we had like a month of a hundred degree weather last year, and nothing's working, you don't know if you're going to be able to pay your operating note back, if you're going to be able to make your land payment or your equipment payment, and everything just burning up, nothing's growing, it wanes on you. I struggled last year just to get the motivation to go out and do anything. I mean, you watch everything just not working and you feel like maybe you didn't work hard enough or maybe you should have pushed a little harder, or there's got to be some reason, something you didn't do, it's not working out, and it's tough. I gained a few pounds, I shed them off this spring, but it's rough because you look at your kids and you're doing all this, trying to provide something for them, hopefully you can leave them something and you don't know if anything's going to work out, if you're going to lose it all. It's rough. – Farmer, North Central Region

Alongside the mental impacts of a drought, the physical effects of drought can be cumbersome to one's body, with the extra hours of work and increased tension. According to a farmer and rancher in the Northeastern region, preparing for another year of drought conditions is physically demanding: *"I'm old enough that irrigating that much I hurt both my shoulders, I was exhausted. I spent all winter getting in shape ready for another drought year of irrigating."*

Contributing factors

Water distribution

Often, one of the most significant factors that contributes to an agricultural producer's experience of drought is the system of water distribution that they operate within. Surface water distribution occurs at different scales and structures ranging from individual water users, to formal, structured distribution through irrigation districts and/or the use of water commissioners and ditch riders. The local management of water resources in combination with the type of water right a producer holds can impact the timing and amount of water that they receive throughout the growing season, and, as a result, can exacerbate or alleviate the impacts of drought. Several participants commented on how the presence of irrigation districts or local water distribution managers, such as ditch riders and/or water commissioners, can be helpful during times of low streamflow.

One participant briefly described the role that water management plays in their region, explaining that the irrigation district helps to conserve water throughout the growing season:

'[The irrigation district]They're managing the flows and the canals and the deliveries and the shutoffs. So with them managing all of that, it's just part of the whole system, keeping us as much water as we can for as long as we can for the irrigation season. – Farmer, Central Region

Similarly, a rancher from the Central region shared how the presence of a water commissioner has helped increase the efficiency of water distribution while also "keeping water flowing to people" throughout their particular watershed:

And so you can't just take whatever you want, there's a water commissioner that's checking to be sure that you are only taking your right... And so that helps keep the river flowing, which then helps get the water rights actually distributed. And especially the natural flow of water can carry the stored water. If the river stops flowing, it takes a lot longer to fill all those pools that have started to dry up than if the river's already flowing already. So there's a much more efficient delivery of water to keep the natural flow running. So that's something they started in about 2002 and have refined over the years and have a pretty good way of keeping the river going and keeping water flowing to people. And so that has made a big difference. – Rancher, Central Region

Participants discussed how conflict can arise among producers and other landowners when there is a lack of communication and an enforceable management structure for water distribution:

How other operators are using their irrigation rights and their farming practices, raising practices, definitely impact us in terms of what kind of runoff is coming off, quality of runoff is coming off of their fields. How much water we get, there's the Musselshell, the tributaries aren't adjudicated, they have water rights that say how many CFS they're supposed to be taking, but they're not enforced. They don't enforce the side channels. So for example, if one of our upstream neighbors decides to take all of east fork of Spring Creek coming out of the little belts, it definitely impacts flows up and down the river and impacts what we're able to take out of our diversions. Last summer, although we had the third oldest water right and it was open clear until September, we couldn't get enough water out of the river

to use it. It had been diverted upstream, arguably against the rules, illegally. But like I said, it's not enforced. – Rancher, Central Region

Surface water management and distribution was one of the most frequently identified challenges in the agricultural sector. Participants spoke to how successful ditch riders and water commissioners can be at managing and distributing water, highlighting how a well-managed system of water distribution can impact the agriculture industry.

The water use or the ditch riders, the water commissioners are doing an amazing job keep water in the river this year. They're really doing well. I know that if I said, Craig, he's the chief water commissioner on the river right now, I said, "Craig, I'm not getting my water. Can you help me out here?" I think he'd definitely go and enforce the rules and that's how the decision would be decided. So it's nice knowing that that's got some teeth to it. - Rancher, Central Region

As participants shared, communication and clear expectations are key when it comes to water distribution and potential irrigation restrictions during periods of drought. In some instances, participants described developing a more informal system of accountability among their neighbors, as one participant described:

Especially this time of year because the river's dropped and there's just, I mean we're still pumping out of the river. Not a problem. It's not as low as we were afraid it was going to be after last year, but we still have to of work with our neighbors and take turns because there's not, I mean, everybody can't have everything on at the same time. So we have a ditch rider who manages that for us. But a lot of the times it's easier to just call the guy across the road and be like, hey, when are you going to be done? I'm going to turn on my side when you're finished. – Farmer/Rancher, Northeastern Region

Several participants also described how the presence and management of reservoirs within their watershed can help them during drought periods. Reservoirs are important drought management tools because they allow water to be stored during wet periods and released when needed, usually during late summer when conditions tend to be drier and hotter.

Other users: Cooperation

Participants consistently shared that working with other water users can be tense, but they noted that outweighing that tension, is the acknowledgement that cooperation is important to avoiding conflict and making sure everyone's water needs are met, particularly during times of drought. One rancher from the Southeastern region explained that cooperation is the first choice, unless it's not an option: *We work with the fish and game as best we can. You know, if we've got an abundance of water, we've got a plan to release that excess water we have to aid the spawning of the sauger and the other fish in the river, coming up out of Yellowstone. But lately, we haven't had any excess water.*

Participants who are willing to be “neighborly” described feeling less tension with nearby users. Some of the helpful strategies identified included acknowledgement of the needs of all water users to support their livelihoods and ensuring communication is clear.

I mean, we share water rights on a ditch with, well, three of our main ditches all have other users on them. So we're communicating with them, some on a daily basis, some you don't have to that much. For example, [a large landowner], we're neighbors with them and we share water rights on a ditch. And so they've got I think five pivots that they're operating off that water right. We've got one, and so it's constant back and forth on where the water's going on any given day or any given week. – Rancher, Central Region

Some producers talked about water distribution for irrigation being at odds with recreation interests, sometimes leading to contentious interactions. However, as irrigators have practiced cooperation with recreators, agreements can be reached:

The one good thing about this project here is [this dam] was built for a single purpose use only, and that was irrigation, but it was also built for flood control. It does not have a recreational designation to it. It does not have the fish or anything like that. But I know quite a few years back, we had a few of them [recreation] groups coming at us and we made an agreement with them to keep a certain amount of streamflow in the [river] for the fish and for recreation. We got an agreement with them to keep a minimum flow in there. They kind of helped designate what that streamflow needed to be and we have no problem as long as the inflows coming in to the dam, into the reservoir, we'll match that... We've always had them discussions with different groups and we've always had pretty good agreements with them. – Farmer, Central Region

Other users: Conflict

While cooperation and strong communication among water users is the best-case scenario, conflict within and across sectors is likely to occur as water availability is limited. As mentioned above, the most frequently discussed conflict among participants in this sector was water use for irrigation and water use for recreation. Participants described feeling like recreators have a considerably different experience of drought which impacts their understanding of water resource management, : *“I know that folks in town, it's a drought, but they're wow, we don't really get much rain. Unless the level of the lake goes down and they can't go water skiing it doesn't seem to bother them.”* For participants in agriculture, this is frustrating because many of the dams and reservoirs in rural ranching communities were created for irrigation water storage, to be released when drought conditions are present: *“You know, one thing about it, we are... Tongue River is all very rural. I do get complaints in late summer from the boaters on Tongue River Reservoir, ‘Well, why can't we have more water in the reservoir?’ ‘Well, it's an irrigation dam.’”*

As participants noted, without effective communication, a lack of water for one sector can easily turn the potential for collaboration into conflict.

Monitoring data and resources

When it comes to monitoring drought conditions and weather patterns, participants mentioned a variety of resources. The most commonly referenced sources of monitoring information were lived experience, on-the-ground monitoring tools, producer networks, and weather service.

Lived experience/historical perspective

According to many participants, a person's lived experience or historical perspective is often the best available monitoring tool. The rich knowledge that comes from working with the same land and within the same climate for generations is helpful in determining what is happening in a given year. Many participants in agriculture rely on this lived experience: *“Always talked with my dad about it. Because of course he'd seen a whole lot more than I had and he could give a lot of perspective and historical perspective.”*

Several participants suggested that the lived experience of drought is often the most beneficial tool at their disposal, particularly because it is specific to the land on which they operate. Some participants felt that, due to the aggregate scale that drought monitoring data are typically captured, one producer's on-the-ground experience can differ considerably from that of others' within their climate region, or even county. A common theme that emerged in interviews with farmers and ranchers is that the broader, statewide narrative on drought conditions relies most heavily on monitoring stations and gages than on the personal experience or anecdotes of individuals working across the state. According to one rancher, the heavy focus on data can cause one to lose sight of the human elements of drought.

So I wish I had a good game plan, but I honestly think that the agencies involved in this have lost the human touch angle. And you can gather all the data you want on an inanimate object, the computer, but it does not give you what's really going on. People north of

Chinook have hauled their cows over to Browning where they've had more rain. We have neighbors that were going to haul theirs to North Dakota and got lucky and found pasture closer. I mean, everybody's just kind of trying to make it through. In hopes that this next winter will give us the moisture we need. – Rancher, North Central Region

The richness and depth of knowledge available from intergenerational farms and ranches in Montana is reflected in the understanding of the climatic patterns that come from being in one place for so long. One rancher from the Northeastern region shared an example of how this historical perspective can help determine the severity of drought year to year: “*Because the river was so low, I mean, my dad's been here for 40 years and he said there's rocks that stuck out he's never seen before.*”

In terms of understanding the experience and impact of drought conditions on the agricultural sector, some of the most informative interviews were with producers who had a place-based family history spanning several generations. One participant reflected on how the expectations around water availability have shifted over the many generations their family has operated on the same property, linking these changes to climate change:

And so, I'm the fourth generation. The fifth, the sixth generation are working on the place now...So, I'm quite aware of drought, climate change and how... I think it really boils down to climate and how that is affecting us with drought. I mean, when I took over [the operation] we always figured the snow would be gone by the 4th of July. Now it's pretty much gone by Memorial Day. – Rancher, Southeastern Region

Participants felt that having benchmarks for what used to happen at specific times throughout the year is helpful when thinking about the course of what might happen next. Using historical perspective as monitoring data, participants identified patterns of drought cycles and reflected on these patterns in comparison with current trends. In some cases, being able to reflect on previous experiences of drought helped to ease the stress of the unknown in coping with current drought conditions. One participant reflected on their family’s collective understanding of drought:

The benchmark mark for me is 1988, is probably the worst dry year that I've ever been through. But before that was the 1950s. And before that, of course the 1930s, the dust bowl time. The late teens started to get bad, but some of the worst fires in America's history were during the teens. Then you get back into the 19th century and though records are a lot more spotty all the way back to the 1850s, terrible droughts that they had through there.

And the historical record would show that I would say a thousand years ago throughout the Americas were droughts that were decades long. Of course, things like that, you look at that and doesn't make you feel very good that if we were sustaining generation-long drought in North America a thousand years ago, well that can certainly happen again. I don't want it to, because I mean then everything changes. As I said, we can withstand a year drought, maybe two-year drought, but you start getting into three and four-year droughts that puts a lot of operations out of business. And that would probably do for us as well because you have a drought lasting that long, I don't know anyone that can keep your cows that long with no grass. – Rancher, Southeastern Region

On-the-ground monitoring

Similar to using lived experiences and historical perspective as a way to monitoring drought, several participants shared that they rely on their own on-the-ground monitoring tools to capture useful data. For example, participants described using their own daily visual cues, soil tests, soil moisture probes and more to inform their drought responses. For some, on the ground monitoring is as simple as the Central region: “*It's mostly just looking at the ground.*” For others, on-the-ground monitoring involved a few tools in addition to visual cues, like this producer based in the Northeastern region : “*We go out and dig a*

hole with a shovel and squeeze the soil and see how much water's in it. And just kind of keeping track of rainfall."

Some producers suggested that what they can test and monitor on their own property is more effective drought management information than any statewide or regional tool can provide. According to one rancher in the Yellowstone Valley, one's own monitoring is most helpful:

There's an awful lot of what I would just call citizen science because people have lived here forever and they've gone through all the changes that occur here. And you can tell, you know when it's going to be dry, you know when it's going to be wet, and then whether or not you even knew that, does it really matter in the scheme of things because every day you have to get up and adapt to whatever conditions are present. And so do I care what that Mesonet station says up there? I don't know. – Rancher, North Central Region

On-the-ground monitoring is similar to using lived experience or historical perspective as monitoring tools because it comes down to one's familiarity with the land. Participants consistently shared that the data available online through monitoring tools is never as effective as going out onto one's own land:

Not really, because in terms of the way I manage my land, I'm out there every day looking at the pastures, and I know that the residual that I leave and the stocking density that I have, those are the things that are going to make the biggest impact in terms of the water I keep when it lands on the property. And so I don't know where I would go to find information other than the land that's going to tell me what I can see in terms of I can dig a hole or I can put a soil probe in to see how much water's penetrating, but going online to some resource hub, I mean, I don't know how that's going to help me. And it's not to say that it couldn't. I just don't know what I would go look for that I can't find by going to the property. – Rancher, South Central Region

Monitoring sites, networks, and services

One of the more consistent messages that interview and survey participants in this sector shared was that drought monitoring data was not accurate or precise enough to reflect their personal experience of drought. As one participant shared:

So I don't really pay attention to too much of some of the weather monitoring locations. And it's kind of actually messed us up in some of the drier years, because these little spots that don't represent a large enough area is where they've put some of these monitoring sites for rainwater, and I don't feel like it's been an accurate representation of what's going on. – Rancher, North Central Region

To some participants in this sector, the perceived depersonalization of drought research leads to the mis-categorization of someone's drought conditions on their individual farm or ranch. The U.S. Drought Monitor classifies the level of drought someone is experiencing for policy and programming purposes, but participants often did not feel that the U.S. Drought Monitor was useful to their operations. A survey response regarding drought monitoring summed this message up: *"Drought monitoring is advancing but still doesn't adequately capture what's happening on the ground. Our area is shown as emerging from drought on the U.S. Drought Monitor and that is totally not the reality here on the ground."*

Alongside the inconsistency with drought classifications, many participants spoke about avoiding the drought monitor for mental health reasons: *"Right now, we look at the drought maps once in a while and they're just frankly really depressing so I've just stopped looking."*

For some producers, stream gages are helpful when drought monitoring: *"I monitor the river flows every day. USGS gages."* SNOTEL sites were also mentioned by a few participants as being helpful in predicting how much moisture they could expect during the upcoming growing season.

National Weather Service

A few participants described using short-term weather forecasting services to make operational decisions, but, at the same time, they described these resources as unreliable.

We use the Weather Service and just the 10 day look ahead. But even that it's not guaranteed, you can't tell, I mean, it may say 20% rain and then we get nothing. And one of our units below gets something. So yeah, I don't know. I don't if there's any way that we can possibly do some better jobs of predicting so that we can actually know when to seed and when not to seed. – Farmer, North Central Region

Although better than it used to be, participants consistently acknowledged that the National Weather Service simply provides a best guess:

And the National Weather Service, well any of the weather channels that you get particularly on the internet these days, we're a whole lot better now than we were 10, 20 years ago at being able to predict the weather, but they're still not that good. They still don't know. It's still just a best guess. – Rancher, Southeastern Region

Those who did use the National Weather Service had NOAA's weather and drought monitoring and resource at top of their list: "NOAA's three month, that's a good one. NOAA, I think their drought monitoring. They're pretty good. They're not accurate, but who can be, you're trying to look into the future and anytime, no one so far as I know, has a crystal ball and can tell you what the future's going to bring."

More often than not, participants took to individual weather reporting for increased accuracy, such as personal weather stations, electronic rain gage setups, and old-fashioned rain gages:

Well, you can look at the weather every day and see it's going to be hot and dry with no possible rain coming. We use an electronic rain gage setup and our weather station tells you what the wind is, how much rain you're getting. And we back up electronic with the old-fashioned catch rain on the post.

I do have a Davis Weather Station in the yard as well and I record all environmental conditions at that time, wind, rain, sun, sunlight, grow degree days and stuff like that is recorded there. And so, I kind of use cumulative sets of data there to know what my conditions are out here, but it's a lot. – Rancher, North Central Region

Accessing information

While a handful of participants described using monitoring data available through state and federal agencies to inform their businesses, many were unaware of drought monitoring resources or did not find them to be relevant to their day-to-day operations. In interviews, participants' disinterest in available data was often linked to questions around the accessibility, transparency, and accuracy of available data. In general, there appeared to be a gap in producers being able to access information and readily apply it to their operations. As one participant suggested, "it does seem like there is a lot of information, it's just maybe more of finding it all, where is all of it, and how is this different than that, or is it the same? And then really, what does it mean and how do we use it?"

One rancher and farmer from the Southcentral region, described accessing drought information on state websites, but was frustrated with not being able to find the same resources as they had in the past

Though I find, in the past couple of years, it's been harder to find the information I want. Well, maybe the page that it used to have been no longer there and I have not had an easy time finding it. Used to be, you could go to a page that would list year to date, water, rainfall precipitation for your county and you could use the water year or the year and that doesn't come up as quickly as it used to. I see that there's a map and its color coded and I find that really more difficult to deal with. – Rancher, South Central Region

Drought response

Public policy, relief, and payment programs

The drought-related relief program most commonly utilized by participants in this sector was the subsidized hay trucking program to help offset cost of purchasing and transporting hay. This program is designed to pay producers back in gas prices for hauling hay and is based on U.S. Drought Monitor classification.

So that's over a thousand less than normal. That forces you to buy feed at an inflated price because once it becomes known that it's necessary, price goes up. I can't fault the federal government, USDA, they do have some programs to help us, but a lot of those are based on the current drought designation of D-2, D-3, D-4... Well, they're in federal government programs, hauling water, the program says they will pay you 7 cents a gallon. It is on the honor system, but of that 7 cents a gallon, they pay you 75% of that. And then they take sequester off of that. So, it's not really 7 cents a gallon. Last year, they helped pay for transportation of the feed you bought. So they paid 75% of \$6.60 a mile, but you did not get paid for the first 25 miles. So each load would be based on the miles. – Rancher, North Central Region

Participants also mentioned the LFP program and the Hay Hotline, but no clear pattern emerged to categorize how participants felt about the utility of these programs. The Hay Hotline is an online portal where producers can donate, buy, or sell hay, pasture available or pasture wanted. The Livestock Forage Disaster Program (LFP) offers payments to eligible livestock producers with eligible livestock in the event of a designated disaster. Payments help producers with grazing losses suffered on native or improved pastureland due to a qualifying drought.

The main limitation of any aforementioned policy or program is the drought classification system for determining whether a producer is able to qualify, and what kind of help they qualify for. The limitations for assistance described by participants were tied to the previously described challenges around drought monitoring:

Well, when you start to deal with drought classifications for the federal programs that are helping us, we lack enough stations in varied locations in Blaine County to give an accurate representation of where it is raining and where it's not. For instance, to the east or to the west of us, in the Bear Paws, at one point they got five inches. We got less than an inch. – Rancher, North Central Region

Participants also described recurring themes of frustrations with neighboring ranches who do not necessarily manage their land well or adapt their practices for drought conditions but receive more benefits. The idea that “poor management gets rewarded” was raised by several participants, suggesting that existing relief programs disincentivize any shift in practices or a desire to do be better stewards of your land. One producer talked about the frustration of building better soil health systems and not being rewarded by any government programs:

I guess what I would say is if we want more operations like ours that are more diverse and attempting to be resilient, given what we know about science and resilient systems, then we have to change some of the policies to actually support systems like ours better. What would be most helpful for operations like ours is that you can't build soil on quarterly profit reporting cycles. So when we have a loss, right now that loss the amount of money that we put out to seed to crop, we have to carry that personally. We have to take that debt on personally. And if we don't have crop production, because it's a challenging year, we still did cover cropping. We still did diverse crop mix. We still did cows. We still trained people. Nobody is paying us for those things. So, we need to find ways to decouple farm stability and success from annual crop production revenue. – Farmer, North Central Region

Another limitation of government subsidies or programs related to drought relief mentioned by participants is that they are a temporary fix: the money can help dig people out of a financial hole but does not encourage change or adaptation.

And it's just like shooting yourself in the foot, because it's like this black hole that's going to only need more and more and more and more resources, and it's never going to make a dent in the real problem. So unless we can incentivize people properly to change their agricultural practices that will interrupt that degradation cycle, then nothing's really going to change. And I think that's not a responsible use of taxpayer dollars. I mean, I don't like to see my friends in the community go under or not be able to pay their mortgages or loans because in the course of a year, things changed rapidly, and now they can't pay their bills. And that might be worthy of a one-time help. I'm not cold-hearted. I'm not going to be like, "Oh, well, sucks for you." But at the same time, that's not long-term sustainable at all. So I would not be in support of some sort of policy that required funding that was like let's just keep putting a band-aid on this problem so people don't have to change and they can just keep struggling and shuffling down the road. – Rancher, South Central Region

The participants who described changing their practice to adapt to drought conditions felt they were not able to receive any funding or relief for their efforts:

And I reached out to them because it's supposed to fund helping apply or implement more sustainable practices. And I was like, well, I have a very expensive seed bill coming my way because I'm putting a bunch of perennial seed stuff out, and that stuff's not cheap. Does that qualify? Because the reason I'm doing that is completely for sustainable and good reasons. It doesn't qualify. You'd think it would, and it should, but it doesn't. – Rancher, South Central Region

Insurance

Crop insurance is designed to protect agricultural producers from many types of hazards, including natural hazards like drought and economic risks like unstable commodity markets. However, crop insurance products are not well-tailored to integrated and otherwise adaptive systems that are working to decrease vulnerability over the long term. As one producer who works with a crop-livestock integrated system described their experience with crop insurance:

We use crop insurance. We've attempted to use whole farm revenue for operations like ours that are super diverse and that has not worked well because the paperwork amount for that... We were supposed to ensure your revenue, didn't depend on what you're growing, but then the companies are asking for all this other detail and then there's these double jeopardy where if you have another crop insurance policy, say for wheat, and you get paid out on that, it's deducted off your whole farm revenue. Yeah, there are disincentives. – Farmer, North Central Region

Now that drought is becoming a more frequently occurring phenomena, participants felt that insurance policies or qualifying metrics might need to change in order to meet the level of need among producers: “*I know there are some people who get private drought insurance, and last year they barely got a payment. They were pretty disappointed with how that went.*”

Networking

Several participants felt that establishing a network of farmers and ranchers is helpful to get people talking about drought response and adaptive capacity. For some, it's as easy as this: “*I just call people and talk to them.*”

As participants described, talking to neighbors and peers is a great way for producers to learn about other strategies for coping with drought or finding out about a grant or payment program that they might not

have known about that fits with their operation.

Yeah, just because you run into some neighbor, a buddy, and they're going through same as you, and[you] hear what they've been doing, and then you can kind of see, "Well, boy, that would work great on my operation," or, "You know, it's not really feasible for the way we're set up, that won't work. But that's a good idea, maybe I could modify something I'm doing to make it more efficient," or speaking with a neighbor, I learned about some FSA programs that I could apply for to help out that I wasn't aware of. So that was a relief in some spots. – Rancher, Northeastern Region

Gathering participants together in rural areas can be challenging, but was described as valuable to producers for when responding to the myriad challenges related to drought:

But we did, in May, in early May, so we were still pretty well in, yeah, hadn't really rained much yet, and we had just a gathering of ranchers just to come talk about the drought, the questions you have and kind of lessons learned and what we all might learn from each other. And there were, I think there were 15 people who showed up. And it was really good, just really informal, like we're all suffering from the same sorts of things, and what are you doing to try to figure out? And so the conversation was anywhere from really specific, "Here's the feed mix I'm using," to more general, "Here's how I'm deciding what to sell from my herd," and that sort of thing. I really do think having, just having social events that are just fun. – Rancher, Central Region

Selling cattle

Selling cattle was one of the most frequently discussed strategies for ranchers to effectively adjust to drought conditions, though it represents a considerable trade-off. On the one hand, having less livestock mitigates the risk of drought because fewer animals require less water (irrigation for feed and drinking water). On the other hand, reducing cattle numbers greatly reduces an operation's source of long-term income. Of the ranchers interviewed, there was a varying degree of responsiveness to how this process goes. For some, it is an adaptive strategy, one that requires regular evaluation and flexibility:

Drought comes and goes and you have to have a long-term plan for drought. You see it coming and be flexible. We're in a yearly operation running about a 1,000, about 1,100 cows, and about 4,500 yearlings. If you're in a yearling situation, you can sell the yearlings and make room for the cows, if that's necessary. You have to be flexible in what you do. – Rancher, Southwestern Region

For others, reducing cattle numbers is a short-term risk aversion tactic that can pose considerable challenges for the following year(s) of operation:

And I guess that's the like, we were just talking about today, because we've sold so many animals, we're going to have a pretty good profit this year, but next year we don't know that we'll be able to pay our bills. So we were talking about, should we spend that money on buying cattle back? Which makes the most sense financial-wise, but not if we stay in a drought. So that's the whole game of, how long is this going to last and how hard is it going to be? – Rancher, Central Region

Others described using benchmarks to see what the level of moisture is, and then enact their plan to sell or keep cattle accordingly: "If we don't get moisture through the winter, we won't have cows next spring." Another participant stated:

You have to adapt to it, in certain ways. It takes more planning, more management. How to deal with it. You have to really be disciplined. I mean, this spring, we, my two sons and I on the ranch, we said May 1st, if we didn't get much moisture before May 1st, we had a list of cattle that were going. My brother and I, you kind of go along and you set

benchmarks, okay, if we go this far without, and it looks like things are going to still remain dry, well, we're going to sell off replacement heifers. Things still are not going then we'll start sorting out pairs and sell the bottom end of it. Trying to keep as much as you can. But understanding that if it's a drought, keeping cattle through a drought's terrible hard thing. It was just good that this year we didn't have to do it. – Rancher, Northeastern Region

Developing a drought response plan in agriculture often helps producers to separate business decisions from emotional attachment when difficult decisions are necessary. As participants described, sacrifices must be made in order to keep an operation alive during drought, and hindsight helps inform producers about how to do it better during future droughts:

I think the plan we should've had would've been sell the animals sooner than we did. And we're just a small family operation, and I'm like the head. I make the decisions. And so, I was too emotionally attached to my animals. I can see it in hindsight just clearly, but in the moment held onto them too long. And it impacted the amount of money I was able to sell them for because I held onto them too long, and it impacted the amount of forage they took from the property because I held onto them too long. So those would've been important things to have in a drought plan that didn't exist. So, yeah, but I mean, since then, we've kind of made different plans of we're going to let the land dictate our carrying capacity. – Rancher, South Central Region

In addition to the majority of interview participants, 25 of the 29 survey participants for the agricultural sector identified selling cattle as in response to the question “how to do you adapt to drought conditions?” Specific responses included: reducing/liquidating cattle numbers, balancing livestock with available pasture when possible, weaning calves way earlier than normal due to decreased pasture, and selling cattle to pay for other expenses.

Drought planning

According to participants, getting ahead of and prepared for the driest times of the year, or planning for drought, is an often emotional but very crucial part of coping with drought. The type of drought plans described by participants ranged in their level of formality and included things like keeping debt low or at a minimal, grazing management plans to save rest pastures for dry spells, keeping federal crop insurance available, keeping hay over winter, as well as timing crops, conserving water, going into a more seasonal operation, selling cows for the winter or for good, integrating crop and livestock, building soil health, cutting costs, fighting weeds, stockpiling feeds, and storing water. In general, participants ascribed to the strategy of “*plan for the bad and hope for the best.*”

In addition to planning for drought specifically, hay prices were also described as a driving factor in drought planning. As participants described, in previous years, a lack of grass could easily be supplemented with hay to maintain livestock numbers since it was relatively affordable. Recently, the cost of hay has more than doubled in some cases, leading participants to feel that it is less feasible to supplement a poor grass crop with purchased hay. Such a significant rise in the cost of hay can result in a considerable economic burden for producers that would likely need to be accounted for in the year’s budget well in advance, or else the consequences can be dire.

I mean, when the spring started, we were already talking about probably having to sell some cows. Then we got a little shot of rain and everybody's expectations rose, and then the rain quit. And that was it. So right now, we've put a lot of money because we only put up 200 bales last year. So we bought a lot of straw, a lot of cake, a lot of creep feed. So we have a lot in invested in this year's calf crop. And we are trying to get to October to sell our calves. Then again, we'll take a look at what's in front of us. So it's not something where you can say, May 1st, you're going to do this on July 1st. So it's a day to day, look at what you have and what you can do. – Rancher, North Central Region

Farmers and ranchers who are planning for drought, such as using estimates from the previous year and planting different species that will do better, can still be wrong and run into difficulties. The participants who seemed somewhat at peace with their plan for drought and general feelings surrounding drought usually had the following mentality: “*You have a plan and then you have to readjust for what's actually going on.*” As participants described, being able to roll with nature’s punches and variability is crucial to being successful (or at least not failing) as a producer.

Local mitigation plans

A few participants were involved in broader and more formalized drought planning initiatives, such as through their participation in local watershed groups. According to these participants, building a drought plan for a region or a watershed can be beneficial to collaboration and collective water conservation. One participant provided this example:

Then we have a drought plan that's developed that has triggers that manages the fishing pressure, and also asks for participation from the water users to voluntarily put water back in the river on the upper sections, we are a part of it, but we support the [Candidate conservation agreement with assurances] program for the grayling. I believe there's 160,000 acres that are in that program. I think there's about 30 ranches doing that in, I don't know if you understand that program or not, but if they enter into that program and sign on, it's voluntary, if the grayling's listed and they lose grayling in their ... they have to work with the agency, people, the Fish and Game, the Fish and Wildlife are the two folks, along with DNRC, actually NRCS, in making all that program work. – Rancher, Southwestern Region

In this case, the Big Hole Watershed Committee was initially established to protect Arctic grayling populations as the grayling was at risk of becoming listed as endangered species, which was perceived as a negative management outcome by many local stakeholders. As a result, stakeholders throughout the watershed engaged in efforts to develop voluntary measures that would protect grayling populations. Several decades later, the Big Hole Watershed Committee continues to support the management of grayling populations while also serving as a forum for building cooperative relationships and effective local plans to respond to and build resilience to drought conditions.

Coalitions and watershed groups

As participants described, local entities are an effective way to engage diverse stakeholders in planning for and building resilience to drought. The benefit of these groups is to bring people together and promote dialogue about what is working, what needs to change, and how to best support needed changes:

Our goal is to develop community interest, all interests that are impacted by the Big Hole Watershed. We're not just talking about the river. Getting them together and working on a consensus basis to solve problems on the watershed. To keep the resource, enhancing the resource, enhance the experience of using the resource. – Coalition director, Southwestern Region

The facilitation of conversation among many stakeholders who share a similar interest in and knowledge of an area can be a powerful drought mitigation tool. Another thread that became apparent in participants’ feedback as to why these groups tend to work well is that there is no authority or hierarchy of stakeholders.

So the watershed coalition, we don't really have any power over anybody. It's just a grassroots group and it's there to facilitate conversations from the upper end to lower end that include all the water users along the way. We're communicating a lot about risk mitigation, trying to prepare for the next flood, next flood, next drought. Communicating

needs up and down the river in terms of what it takes to get flows all the way down to the lowest end of the river. – Rancher, Central Region

Adapting to drought in the agriculture sector

Adaptation includes many types of proactive planning for drought, and in this section, we present thematic description of adaptive capacity in the agricultural sector.

Education and outreach

In regard to adapting to and building resilience to drought, a few participants highlighted the value of education and outreach in making sure producers are receiving the most up-to-date and relevant information. One rancher from the Central region explained the benefits of communal education:

I think giving people the opportunity to come together and talk about it and the workshop format was what that was, it doesn't necessarily have to be that sort of a format, but that's one that seemed to work. And it was pretty well attended for our little community, and I think people got a lot out of just, they brought in an extension guy from Ringling and I can't remember his name, and I think people just want to be able to talk to their neighbors about it and that's a good format to do it in the safe environment. – Rancher, Central Region

Workshops were the most commonly suggested tool for education and outreach because they bring people together and can create the sense of a shared experience to help alleviate the isolation of coping with drought.

Restoration and conservation efforts

Most producers who are keyed into drought mitigation are also engaged in restoration efforts. When interviewing ranchers and farmers who diverted water from rivers for irrigation, participants often shared their hopes to increase restoration efforts in order to increase streamflow and therefore allow for irrigation. One rancher located along the Yellowstone River talked about the value of restoring tributaries:

We need to look at each tributary in this watershed and figure out what's wrong with them. And what's wrong with Six Mile is the aftereffects of the Six Mile Fire, so what are we going to do to fix it? Because it's starting to just move downstream and keep affecting other landowners. But maybe they don't ranch, so maybe they don't care. But if you don't care, then you can't get it fixed, and you can't save the creek. So, we need people. And I think lots of people care, but I think we need a strategic plan put into place that says this year, or these two years, we are going to work on [stretch] and these are the things we're going to do. So we've done the assessment, we've gotten the permits, and now we're going to start work and do this. And then just move on down... And just start looking, it's not just the Yellowstone. We have got to start looking at the tributaries and how to assist in making sure that they are as effective in their flows as we want the Yellowstone to be. – Rancher, South Central Region

From the survey, several participants expressed interest in expanding research into cloud seeding, ground water storage projects, off-stream storage projects, vegetative manipulation of watershed to increase yield by using herbicides, prescribed fire and logging where appropriate: *“Lack of fire and management has led to massive encroachment in our watersheds in the last 100 years.”*

Changing production practices

Adapting farming and ranching practices to a drier climate will likely be imperative in maintaining a livelihood as a producer in Montana as drought conditions become for frequent and severe. According to several participants, being open and willing to pay attention to what is not working is a skill that is crucial

to being able to survive in agriculture, particularly within the context of changing climate. According to one rancher in the Southeastern region, “*You got to play the hands you're called.*”

In interviews and surveys, participants described a variety of practices that individuals in agriculture can implement to better adapt to drought conditions. These practices included no-till drilling, reducing fertilizer usage, rest rotation grazing and pasture management, starting to plant/plow earlier to utilize rainfall more efficiently, crop rotations, cover cropping, monitoring soil fertility, moving towards seasonal operations, and fallowing cropland. One rancher from the South Central region talked about the dichotomy between conventionality and being open to questioning the status quo:

Yeah, I mean, I think this is a no-brainer, and I try to put myself in a super conventional mindset and be like, okay, well, I apply synthetic fertilizer every year and herbicides and pesticides, and I buy my seed, and I put it down, and it needs to grow. And I'm totally dependent on the commodity markets in terms of my beef or my crops. What do I need to know so that I can make these changes? And everything I've been doing, it makes sense. And I think that there has to be greater risk in continuing to do it the same way than in changing. And I think the government can help with that. I mean, things are already so fragile that even neighbors who are... I mean, and there's a lot of things that concern people about why they don't change. It's not just money. A lot of it is fear of failure. I don't know how to do it that way. And a lot of it is cultural because people are judgmental. And I'm kind of not a part of all that, because I'm first-generation, first-generation, woman rancher. And so, I don't care what anyone thinks about me. – Rancher, South Central Region

Some participants felt that drought forces them to use regenerative practices to mitigate the outcomes, which usually turns out to be a positive for their overall operation. When there is drought, people are more interested in implementing projects and practices that help keep water on their landscape.

And I feel like the risk tolerance for being open-minded to trying other things, it's got to be changing, because before it didn't make sense to try a different way, because what we're doing is good enough. It's working good enough. And that can't be true anymore. With input costs and yields and profitability, the game is changing. In my mind, people have got to be more open-minded to doing things differently than what's always been done, because what's always been done is not working. I don't know if that's true. It just makes so much sense. – Rancher, South Central Region

Soil health was also described as a key part of adaptive capacity and shifting practices to be more in tune with what is happening with the climate.

So for me, it's like regardless of how much rain we're going to get, I know that if I manage my land a certain way, I'm going to be able to make the most use of every drop that falls. And so since I can't control how much rain is going to fall, within reason...I actually do believe that the amount of healthy, green grass, living plants on the ground does actually influence the water cycle and the amount of rain that a property, not even a property, but a region, gets. And that concept is not widely agreed upon, but I think it's real. I think there's science to back that up. But that aside, since I can't control how much rain I'm going to get, I can control how much rain I keep. And that's all based on management decisions. And so I don't need to go other places to look for how much rain I'm going to get. Or even the temperatures, I mean, I put a seed mixture out based on cool season grasses and warm season grasses. And I hope that the conditions that they need to grow well happen, but I can't control that. So why would I spend my... And maybe I'm wrong, but why would I spend my energy looking at forecasting data that's going to show me how it's supposed to happen, but I don't know what it would change. – Rancher, South Central Region

As participants described, switching practices, going back to the basics, and being open to change are some of the most effective ways to stay resilient during drought.

Changing species

A few participants also described shifting their crop or forage seeds to more drought-resilient or native plant species. A sustainability manager for a farm talked about planting species with the future in mind:

I'm thinking about just plants and what do we do around that physical environment, barrier plants, water retaining plants, is there direction around... If we're going 25 years from now, we know that as you move into drought, you start to see plants die off which then increases the drought because the water's not being retained and it's just this vicious cycle... Somebody who's done a lot of work to say, "Here's the best plants to be planting when you're moving to drought," and maybe that's not crops, but maybe it's border. A lot of farmers put borders around their crops to help with dust. Can we, can they be planting specific things that are going to help us 25 years from now? So we're not trying to backpedal into it. – Farmer, Region 1

Exploring alternative crops and integrating new species into an operation is usually a matter of trial and error. In the survey, participants suggested that different crop varieties, drought tolerant western plants, site-specific livestock and plants, low water demand crops, and other drought resilient species should become a larger focus and more utilized in Montana.

Voluntary restrictions

According to participants, the ideal purpose for voluntary water restrictions is a symbiosis of sectors working together and understanding that water is an important resource for many:

The ranchers voluntarily cut their water to keep the river in a condition where you don't stress the fish in the other little river basin, by getting too much dry river bottoms. The fishermen thank us for that, but we're doing it for the river. – Rancher, Southwestern Region

Conserving runoff by maximizing irrigation systems, adjusting irrigation schedule, or reducing plot sizes were described as helpful when thinking about making the most of water, especially in a drought. One farmer in the Central region spoke to the amount of water he conserved switching from flood irrigation to pivots:

I guess that's probably one of the biggest things is the conservation of the water usage that we use out here. We try not to let anything when we're irrigating run down the drain, try to keep the water moving on dry ground all the time. And just mostly conservation type practices, being timely with our water, especially with the pivots. We've really started conserving, which since I've put more and more pivots up, we've conserved more and more water. We get allotted two acre-feet of water a year we pay for and get allotted two acre-feet of water every year to irrigate with. When we were flood irrigating in the old days, we'd probably use up all of it. Sometimes we'd go over that two-acre feet and since I put in the pivots, I probably only use about 65 to 75% of that allotment. - Farmer, Central Region

Water use for irrigation can be contentious when producers who rely on irrigation for their livelihood face water use restrictions during drought periods. The following quotes from a rancher in Paradise Valley show how voluntary restrictions feel when you are in survival mode:

One of the big ones that they always want ag to do is shut off your end gun on your pivots because that's conserving some water, but that's a loss of feed. And so in a bad year how do you justify that? How can you just say, "Hey, I'm a really good guy. I'm going to shut off my end gun because I don't really care." But you do care, and you need the feed. We already buy hay. So I just don't know, and I think the powers that be think that peer pressure

is going to make a difference. If this rancher shuts off his end gun and you didn't, you're going to be a little shamed and feel bad because you're not really doing anything to help drought, but maybe he doesn't need all that hay.

And so, it's never apples and apples. And I think if I told [my husband], "Hey honey, it's drought, we're at D-4, and so we're going to implement these voluntary actions. So you should shut off your end gun." He'd laugh at me, and I don't blame him. And we still do some flood irrigating. And frankly, I think that should get us bonus points and get us all out of flood restrictions because we still send flood irrigating into the groundwater, into the river. There's not many people that flood irrigate anymore. - Rancher, South Central Region

Among participants, there was a mix of opinions about which irrigation systems are most beneficial to water conservation, suggesting that there is a need for more localized irrigation and water conservation education so that producers can better understand apply appropriate water conservation techniques for their particular operation and hydrologic conditions.

Water storage

Participants described wanting access to water during the dry season and the frustrations that come with not being able to capture water during high spring runoff flows for use later in the growing season. As one rancher from Southwestern region shared, water storage is especially important to think about as more participants transition their flood irrigation systems to sprinklers and the rivers may not be getting the same return flow:

I think there would be an opportunity for a lot more off-stream storage of high spring runoff if we can. On the red rock here, we have a gravel pit that one of the users, it's a cooperative ditch that goes past that gravel pit. When we have high flows that we can't store, we'll run water into that gravel pit just to start building up the gravel water. One thing we've noticed, especially on the upper reach of Red Rock from say Dell to Lima, we've converted a lot of those flood-irrigated fields to pivots. We're not yet near the return flow that we used to have further down the river. That's one thing I'd like to see is exploration of projects where we could store high runoff in the spring just running off in the groundwater if nothing else. – Rancher, Southwestern Region

What's needed to build and support drought resilience in the agriculture sector

Resources that can decrease vulnerability should mitigate sensitivities and build adaptive capacity, and in this section, we provide thematic description of some resources that could build resilience in the agricultural sector.

Climate change

Participants often brought up flooding, drought, and other shifts in climate-related events when discussing the impacts of drought. One participant shared their observation that, while their region experienced severe flooding events, the soil remained dry: “Billings is flooding and we're drier than a popcorn fart.” Producers noticed differences in weather patterns especially when living in the same place for decades:

Yeah, it is. It is. And I don't know. Our annual precipitation never has been that great here, but the more... I grew up in the '70s. Back then, if you got over 100 degrees, that was a blistering hot day. Now, even this year, I think we had 100. Last year, we had 117. Like I said, I don't know if things, how much, what's causing the changing, but it is getting hotter. And I don't think there's anybody who could really argue with that. If it's hotter, same amount of moisture isn't going to be as good. – Rancher, Southeastern Region

Based on participant feedback, climate change has morphed from being a politically charged argument to becoming a bipartisan issue that highlights the importance of adaptation, regardless of the underlying cause. Producers from all over the state agreed that the climate is changing, and weather is more extreme:

I mean, we know everybody won't agree on how it's happening, but everyone will agree that it's hotter and we're having more extreme weather events. I mean, I've only been back for, full time since 2019. And since then I've seen a historic flood year and a historic drought year, two years apart. – Farmer, Southeastern Region

A consistent theme in interviews was the understanding some participants have regarding farming or ranching in a warmer, drier climate.

So the challenge is there's drought, but, and we knew choosing to farm here. We're in a place that's variable climate. It's more variable than it's ever been. And it's hard for us to say, because we haven't been here for as long as others. But my sense is given the climate records that the variability and the spottiness of where moisture happens and doesn't, is much greater than it has been in the past. – Farmer, North Central Region

Improvements to public policy, relief, and payment program

The most consistent thread we heard from participants on how to improve policy and relief payment programs specific to drought was to have a better and more representative system for the drought designations. Not only improving and increasing the metrics and monitoring that inform the designations, but breaking down each designation to better figure out who needs what assistance:

That's probably one of the biggest things when it comes to the advocacy of it, of them drought designations is that's when certain disaster programs start kicking in. Time periods. How many weeks are we in D2? How many weeks are we in D3, D4?...different levels of drought kicks in different programs within the government agencies ... for just different kind of helping programs or disaster programs that are available to folks to help mitigate the hurt of what drought brings with it. Whether it's through low interest loans or extension of loans or even just drought designation money. If it's a total loss and whatnot, we need disaster assistance of some kind. It opens up a whole other room full of disaster assistance programs with each declaration of end level of drought. – Farmer, Central Region

Monetary compensation for hauling water can be a useful tool to help mitigate the impacts of drought conditions for ranchers needing to get water to their livestock.

They do have trying to get because water's a main concern. So I think at the time, what I was trying to find out was about, was there a program for offsetting if you had to haul water to cattle because one of the summer pastures where we were at, they were starting these reservoirs and the reservoirs, they were drying up. So, we're running out of water for cattle. – Rancher, Northeastern Region

Another aspect of expanding public policy and thinking about payment programs mentioned by participants was re-examining the ways in which farmers and ranchers are compensated for their work. According to one producer from the North Central region, there is a way farmers and ranchers could get paid that better reflects the energy they put into caring for and developing practices that mitigate drought effects and conserve water.

I mean, everybody else in the supply chain takes their cut for their cost of production, no matter what. And we're the last ones to get the money so we get what's left over. That's not a system that's going to help provide really good land care. If there was a way for everyone in agriculture to have a base salary no matter what happens. It gets back to the stabilizing. – Rancher, North Central Region

Creative thinking is crucial to figuring out how to deal with and mitigate the effects of the drought conditions that farmers and ranchers are experiencing.

Additional resources and programs

Expanding drought resources and programs could be helpful in developing effective water and drought management in the agricultural sector.

I guess, I'm not aware of any state programs, and so that would be one of the things too, we've been working with the Farmers Conservation Alliances based in Oregon on, working on irrigation infrastructure upgrades. We were talking about, different states do have much larger infrastructure funding programs to help specifically with irrigation infrastructure that would definitely make more efficient systems that are going to help spread the water a lot further. – Rancher, Central Region

Some of the survey responses indicated that more irrigation infrastructure support would be helpful, such as: more support for off stream storage and flood irrigation, funding or resources for water development, cost share for water projects, water for livestock programs, cost share on dams, timely assistance for water infrastructure, water lines, water storage (dams), and cost share stock water projects.

Loans

According to participants, being able to keep their operation viable through drought conditions often comes down to the financial assistance they are able to secure through relief programs. Whether that money goes towards buying hay when you thought your pastures would be sufficient or hiring more help to haul water because your well is dry, more accessible loans or other flexible financial assistance programs for people who are struggling due to intense drought conditions seems vital.

If there was a program for people that either couldn't meet their operating note obligations or maybe they have a land payment and they couldn't make that payment, and maybe if there was a way you could go in and get a loan to make that payment and then have a payment plan set up over the next 10 years, where you can pay that note back, just the one year payment and pay that back. Or if you have some financial carryover on your operating note and then say, we'll just use round numbers, say you have a \$100,000 operating note, you only make \$60,000, you have \$40,000 carryover. Well, the bank's not going to loan you any more money and they may foreclose on you or find you insolvent and stop loaning you money, you're toast, you're dead in the water. – Rancher, North Central Region

It also seems beneficial to have a conversation on zero-interest loans, or disaster relief loans that can help people who are unsure about when they will be able to pay such a loan back.

So I mean, that's one thing, is to provide either emergency funding or emergency loans, zero interest loans, long term zero interest loans, like a 30 year loan that's easily affordable to pay back on crop ground, where you can drill wells, put a pipeline in and some tanks, or even grant money, because ECPs helping with range land, but if you have to cross BLM or state, they won't fund that portion of it. So if maybe there's a way to fill in some of the holes of some of the other programs that are being offered, would be great. – Farmer/Rancher, North Central Region

New policies

Some of the survey respondents offered ideas for policy and programming in support of drought resiliency in the areas of land use, water use, and leasing. Ideas included: to allow a credit on property taxes for flood irrigation, which would increase groundwater infiltration and return flows; allow for temporary grazing on federal and state land that is not being fully utilized; and allowing a postponement on some percentage of property tax until the drought conditions ease. Land leasing and custom grazing

was described as an effective way to best utilize the available feed while saving ranchers (and the government) the cost of hauling hay during intense drought conditions.

Mental health resources

Most participants knew about the mental health resources available to them as producers, but there was a notable split between participants who accepted and used them, and participants who did not feel that those types of resources could be useful to them. According to several participants, there is a taboo and misunderstanding of mental health care among older generations of producers. One rancher located in the North Central region shared their views on mental health resources:

And what would they do for me? It's not going to change what's going on. I mean, I don't feel like I'm in need of counseling. I just feel frustrated every day when I get up... So, I don't know what you're saying. I mean, yes, we're dejected in some ways, because every day you get up, you hope that the weather has made a turn for the better, but I don't feel I need counseling. Maybe if I have to sell all my cows next spring, I will. But counseling's not going to change the lack of water. If counseling would get the weather station reporting things straightened out, that would work too. I mean, the frustration is that you can't get a straight answer from anybody and it takes five agencies to determine a drought classification. – Rancher, North Central Region

Based on the mixed responses from participants on this topic, it seems that improving mental health among agricultural producers is much more about education and outreach than about the existence of available resources. Even though free services exist and awareness is growing, there is often a stigma associated with receiving mental health help in the agricultural sector:

There's a stigma of going and doing something like that, and you wouldn't want your neighbors to hear that you're doing that. Your reputation in these small communities is everything you have, and that's your future and how you're going to maybe grow, maybe find a lease that gives you the economy of scale to bring one of your kids home. And if people are hearing that you can't hack it and you've got to go get help for mental reasons, they're going to question whether you can hack it and make their lease payment or take care of their property. Or if they sell it to you, maybe you're working on a contract for deed, which means they hold the note until you pay it off for 20 years, maybe they wonder if you've got the mental toughness to make it that 20 years and pay them all their money. – Rancher, North Central Region

Increasing the availability of mental health services for participants in rural areas and communities affected by other natural disasters, such as fire and flood, were recommendations that some participants shared.

Social connection seemed to be something that producers missed and would like to strengthen. Participants noted that having a social network to share common experiences with was helpful in talking about ways to adapt to the drought conditions: *I think just staying in communication with all your neighbors and everything else, and we're all in the same boat.* One rancher in the South Central region spoke about the mental health stresses they faced, and how these stresses were relieved in past generations:

And then you lose the ranch, or you feel like you've failed your family, or any of those things. And you understand why they just give up and they're so sad. And there is no connectivity between families anymore. You spend all your time trying to survive. There's no Saturday night dances, there's no card parties. And that's what it was in Rich's parents' generation. Every weekend they had a card party at somebody's house. And there were

dances all the time. Who has time? And so, you lose the connections with your bigger family and you don't get them back. And then land use changes have really damaged that too, because all the old-time ranches in the valley are gone. – Rancher, South Central Region

Additional monitoring

Due to the spread of Montana's population, education regarding available monitoring sources is crucial to maintaining any degree of statewide data coverage. Participants in the agricultural sector often shared this perspective, and it seemed clear that due to the vast rural landscape, the monitoring available to most participants is not sufficient.

The big thing is education, just to pique the interest of people because there's a lot of holes in Montana where there is no data coming from different parts of Montana. Of course, it's always a big thing when you get into the higher populated area...So naturally, there's not as many holes in populated areas as there is out in the vast planes of Montana where it might be 15 miles between neighbors. And if neither one of them neighbors is interested in trying to record that data or even report that data, then that even makes it a bigger hole of lack of data within those areas. So educating them into the reporting and the value of that reporting of environmental conditions is probably one of the biggest things. – Farmer, Central Region

There was also some animosity among participants surrounding the lack of on-the-ground monitoring conducted by local offices. A few participants had the perception that agencies that gather and share drought information sit at their desks and get information from computers instead of going out into the field to observe the impacts of drought. The discrepancies between the data that are used to designate droughts and what is *actually* on the ground has caused some hard feelings:

In their pickup in Lewistown, DNRC can and drive north into South Blaine County and going north it's as evident as the nose on your face, the situation here. You should go to Hader, or Schnook, and look at the line at the water stations where people are hauling water, that don't have a source on their own place. I mean, it's not just us. There's a lot going on, but you can't gather that information sitting behind a desk. I guess that's also my frustration. – Rancher, North Central Region

Based on the drought monitoring data collected, many producers are more inclined to take matters into their own hands and monitor their own field's conditions. If participants are already out doing their own monitoring, the best way to support or guide these efforts may be to create a baseline worksheet and facilitate a place to upload this data so it can become part of a public database:

And then I've been trying to make it known to a lot of producers, if there's other reporting type websites and stuff like that, where we can record what our rainfall is out here, so I keep track. I report to CoCoRaHS, which is a precipitation accumulation website. It comes out of Colorado [State] University and they compile all of that and is trying to get individual farmers to start reporting to that. And you have to get an official rain gage put up in different stations. I actually have three of them on three different farms of mine that are about 15 miles apart. I report to that daily to keep a daily record of it. – Farmer, Central Region

Expanding gages and monitoring stations

Possibly the most consistent takeaway from the interviews with producers was the need for more moisture stations. The following quote depicts one producer's strife with monitoring stations:

So it's such a broad area that we live in up here and there's so few data collection sites and it can vary, there's so many micro-climates here, it can vary so much. And one thing we've complained about Phillips County, is they actually have some of their rain monitoring sites

in some of our wetter areas, so they can actually show that we've gotten more moisture than what we've actually gotten. – Rancher, North Central Region

More stations are needed to give a more accurate depiction of who is getting what moisture, which translates to who is in which drought category, which then decides how much federal support a producer might receive.

Well, when you start to deal with drought classifications for the federal programs that are helping us, we lack enough stations in varied locations in Blaine County to give an accurate representation of where it is raining and where it's not. For instance, to the east or to the west of us, in the Bear Paws, at one point they got five inches. We got less than an inch, in the area of seven tenths. – Rancher, North Central Region

Having more weather monitoring stations could also help agencies make better and quicker decisions regarding drought. Participants felt that it is important to recognize the varied climates that make up the vast state of Montana; one county should not have to rely on one rain gage for a county drought level assessment when the county could be larger than an entire U.S. state:

So, I mean, to really get an accurate base, you'd have to do polling like you're doing or have a lot more monitoring sites. I mean, it'd be interesting to know how many monitoring sites that Rhode Island has, just the state, because I bet they have more than we do in this county. And there's so many micro-climates in this county, it's crazy because we got the Little Rockies sitting over to the west and a lot of our storms come out of the west, and then you've got the Milk River and the Missouri River. Well, those three things really affect the weather patterns because those fronts hit the Rockies and they bounce off the Rockies in different ways. – Rancher, North Central Region

Although stream gages did not appear to be a top monitoring tool for producers, when asked about expanding resources, several expressed interest in reestablishing some of the sites and a better system for collecting the stream gage data: “*What I think is really needed and what we are lacking to manage the drought, is we need to maintain our river gages... I'd like to see a little more funding put towards them, not only reestablishing, but monitoring and then the collection of the data from those gages.*”

Although snow monitoring was helpful to some participants, the snowpack data can sometimes be misleading information for drought planning for producers. Two ranchers in the Central region shared that SNOTEL is not actually an accurate representation of the snow that will be available at a lower elevation. According to one rancher, “*more accurate representation of the whole winter snow accumulation would be helpful and soil moisture at different elevations would be important too.*” Another participant shared:

The thing that the SNOTEL misses, they're all at high elevation, all the monitoring sites. They give a false sense of security sometimes, when you can look out your window and see the foothills haven't gotten any snow all winter, and how many times you have to plow your driveway out is a pretty good metric of what's happening in the foothills. And so SNOTEL can give a falsely high measure of the snowpack I think, or what the runoff is going to be I guess, I guess they're measuring the snowpack just fine. Just how the impact, what the runoff is going to end up being like. – Rancher, Central Region

Soil Monitoring

Many producers described relying more on soil health and soil moisture to determine how to plan for drought. Increasing the availability or education around soil monitoring would be “*a great planning instrument.*” As one participant described:

So, what we really need now is soil monitoring, moisture monitoring. Not only in the Big Horns, but out here on the prairies, too. So we have a good idea of what we have to start

with, and how long it's going to last, and how deep the moisture goes and what... It'd be a great planning instrument to have that, a network to soil monitoring. – Rancher, Southeastern Region

Furthermore, encouraging a soil monitoring network for participants to talk about how their soil health correlates with drought conditions would be a useful addition statewide strategy for agricultural producers.

Communication and outreach

According to participants, getting everyone on the same page is one of the biggest challenges in implementing a successful state plan. Successful communication between the state and regional entities, between data monitoring agencies and water users, and between different types of water users would help to reduce conflict and create a more streamlined understanding of drought conditions and adaptive strategies.

Well, I think just improving the communication would help a lot. If we could monitor the data and just disseminate it out to the public on where we're at so that the ranchers, the recreationists and the fishermen, we're all on the same page, we all know what we're facing. We can get through a problem if everybody's on the same page, but if you get a lot of finger-pointing and saying one faction is taken advantage of the others, well, that doesn't solve the problem. – Rancher, Southwestern Region

Making communication and outreach easy and accessible was important to participants in this sector who are often busy and cannot devote a lot of time to trialing new things. Beginning education and outreach before things get “really bad” is crucial to helping participants avoid difficult situations and set up a plan to prepare for the worst:

I think we are really good at communicating when things are really bad, right? The drought has reached a severe state. Wildfires are starting, that's all over the news. Everybody knows that's happening, but when we move into those early metrics, how do we start to communicate outwards on that. That's what I would like to see come out of. This is not only a plan for how the state responds as this is happening but how the state communicates how this is happening. – Agricultural nonprofit, Western Region

Diverse communication strategies

In considering which communication strategies are most effective for agricultural producers, we received mixed responses, which is reflective of a need for diverse communication strategies in sharing drought information and management strategies. Many rural producers suggested that mail works best. According to one participant, everyone gets mail, whereas email can be filled with spam and often deleted.

I don't know how you would get it out, whether it would be by mail. I know everybody wants to do everything electronic, but I mean, there's a lot of emails I get, I never open and I just delete... And that I really still think the mail is the best way. And everybody has to have an address to get their mail. So, I do think the old-fashioned mail is still the best way to put that information in the hands of the people that should be using it. – Rancher, North Central Region

Some participants also expressed interest in text messages on their cellphones because it is an easy, an effective way to share information without calling and disrupting someone's day. According to one rancher: “*We read it, respond to it when we can. Really, there's no other communication quite like that.*”

Another unique but interesting point of view was that the state missed a major drought PR opportunity during the flooding. According to one participant, using an event that gets people's attention on the news

is a great way to spread information and be apolitical about it. With extreme flooding and drought events, there may also be an opportunity for education on soil health and best practices.

I don't know if the people who have the information don't have a lot enough voice, they don't have a platform, or people don't want to listen to them because sometimes this gets a little political with different parties, but it's like if a flood comes along and takes out a bridge or takes out your house or takes out your business or your town, that kind of isn't a left-right issue. That's a very localized issue, that like this flood doesn't care how you vote. I think that that would've been an opportunity to get on the same page. And I just don't feel like it was. I don't know. I was like we need to put money in like a radio ad campaign and go across all the radio stations in the state and be like, "This is how science works, and this is why stuff is flooding." I don't know. I don't know. – Rancher, South Central Region

Education for residents

Participants also underscored that drought education must be kept succinct and targeted. One of the best strategies for education within the agricultural sector is peer-to-peer sharing of stories and practices. This is most likely to occur in workshop or facilitated meeting times.

Communication is big. Just get the word out of what people are finding and how other people are doing. We get stuck in a rut and we just keep doing the same thing. Well, maybe there's better ways to do stuff. – Rancher, Southeastern Region

Transparency between reporting stations and residents is key to upholding an effective avenue for sharing information. Participants talked about wanting to know more about the weather reporting stations and the metrics that are used to determine a drought: “So let's be a little more open. Tell us where you're gathering that.”

Many participants felt that, as more first-generation producers and out-of-state landowners alike are buying land in Montana, it is a good time to share succinct education of their water rights, how to conserve and manage water, and best practices for land and water stewardship. Increasing education for all types of landowners was discussed by several participant as important in making sure that the land is taken care of and is resilient to dry conditions:

Things I see that are not happening in our drainage, but I presume are going to be relevant and like the Jefferson, Madison, Gallatin, those watersheds are dealing with a huge influx of out-of-state landowners purchasing land, and they're not going to have the historical background or knowledge to be able to manage their water rights the way they have historically done. I don't know much about irrigating in those watersheds, but I think reaching out to that sort of individual, and we've got some on our, few on our watershed that are having some impacts, some positive and negative impacts, I think that's going to be more and more relevant because local landowners, farmers, ranchers are displaced by drought. Gentrification of the state, and that's something that I don't think gets talked about enough, is that we've got to have an educational component coming from the state level on best practices. – Rancher, Central Region

Localized outreach

In a state so widespread as Montana, localized outreach and convening is imperative. Producers in the same region can experience considerably different conditions, and as a result, different challenges related to drought conditions. One rancher shared their experience of being lumped together with producers in very different regions as part of a state group:

I haven't attended all the meetings. I've attended like half, I think. And sometimes I'm just discouraged because, like I remember one example sticks out in my head a lot. And it's this guy from Billings. And I was like, first of all, why am I in a small group setting with a guy from Billings? We're not in the same environment. – Rancher, Southwestern Region

Storytelling

According to many of the producers in this sector, monitoring data and numbers mean very little without an element of storytelling to provide context: *“Well, I mean doing the data, like the numbers, and then having the stories to back it up, that's where I think you can really make meaningful change and increase understanding.”* In order to engage farmers and rancher in utilizing monitoring data more effectively, the messaging around drought can play a significant role. Several participants mentioned that highlighting on-the-ground experiences of drought and the types of adaptation strategies that producers are actually implementing could go a long way in helping producers across the state transition their operations to being more drought adaptive.

Drought data and forecasts

Participants expressed wanting more predictive tools and forecasting to help them make difficult decisions: *“I would love to have more tools that would help us actually predict what's coming. We're trying to decide right now. Should we pay for seed that we could seed fall seeded rye and winter wheat, should we even bother?”*

Some producers acknowledge that this would be helpful, but is a big ask:

Yeah, I would be interested in being able to find some new source of even to be able to look more at any patterns or any clues that might help us kind of prepare for it. But like I said, I don't know, I think it's pretty tough to determine for sure, like, "Oh yeah, next summer for sure is a drought year," I think that's kind of hard to do, in my opinion. – Rancher, Northeastern Region

Figuring out what is already in place for expanding drought data and forecasting is important to knowing whether something needs to be elevated and education increased, or if something needs to be created to serve a need. One participant provided this example of a seemingly successful ground-based data expansion program:

The Montana Green Grower's Association, we put a call out to all of our members for voluntarily providing plots of ground where we could put these ground-based stations. I have not heard one person say, "No, I don't want that on my place." Everybody wants one on their place. So the ground is available, the plots are available. It's getting the funding in place to get these systems up and running. And then the biggest thing on that is to make sure that there's enough funds allocated for it to be maintained into the future. – Farmer, Central Region

It is evident from this quote that participants want to have their own data from the land they operate on. This speaks to the other evidence for a need to expand and increase soil moisture and stream gage sites.

In the same genre of predictive tools, one rancher and farmer in the South Central region shared: *“I think this is probably available somewhere too, historical. I think a historical outlook is helpful and to the extent that there is such a thing called a predictive outlook, that, of course, would have some benefit.”*

Support for adaptive practices

Adapting to drought conditions requires financial support and education. One idea shared by a participant related to support for adaptive practices was to create incentive payments for producers to practice better land stewardship and increase soil infiltration:

In Montana if we could change something and pay people to actually do cover crop, if we could achieve farm financial stability over the long run, that is going to be the biggest incentive to change. It's not about like, "Oh we'll grow, cover crops. Here's \$5 an acre." It's like, what is a base living wage salary for everyone in agriculture. If you want to do something else, figure out how we're going to have health insurance for those of us. USDA statistics are like 86.9% of us are working an off-farm job to have health insurance or some

stable income. So I don't know what the statistic is in Montana. That's the one I got from USDA for... So agriculture's pretty important to Montana. And I think just continuing to figure out, "Oh, well how do we tweak crop insurance or pay for conservation?" What we need to be really backing up is saying, "What's the fundamental way to assure base income for people that are in agriculture?" – Rancher, North Central Region

Another way to support participants who want to try out new ways of farming or ranching may be to provide equipment that is available for rent or lease. This way, participants can try something without a considerable financial investment into that tool.

I think there should be like a county piece of equipment, a no till drill that the county owns that you can rent from them or lease or whatever, instead of... I think if I wanted help spraying toxic stuff on my land, I think I would get help for that. But if I want help with a no seed drill or something, there's no help for that. That's backwards. – Rancher, South Central Region

It seems clear from participants that grasshopper control is crucial, especially during an already intense drought period. From the survey we heard, “Help us with other added production problems such as grasshopper controls. This pest is another added factor that comes often with drought. Weather is not ours to control but hoppers are not an individual farms problem or mismanagement result. They are a community and statewide problem and we need the states assistance.”

Support for peer-peer learning

A few participants shared that ranch and farm tours are a great way to educate other producers and encourage the adoption of new drought-resilient practices. Switching practices can improve soil moisture retention, but the trial and error one goes through to find what works can be burdensome, so learning from others who have undergone the process for similar operations could be an effective means of expanding the adoption of adaptive practice.

Opportunities for water storage

Finding new ways to store water for irrigation and for livestock was discussed by participants as a helpful way to adapt to drought conditions while maintaining their livelihoods. Producers expressed wanting to see more water development programs for livestock to help supplement ponds or streams that are not filling in as they used to.

Well, I think there would be an opportunity for a lot more off-stream storage of high spring runoff if we can. On the red rock here, we have a gravel pit that one of the users, it's a cooperative ditch that goes past that gravel pit. When we have high flows that we can't store, we'll run water into that gravel pit just to start building up the gravel water. One thing we've noticed, especially on the upper reach of Red Rock from say Dell to Lima, we've converted a lot of those flood-irrigated fields to pivots. We're not yet near the return flow that we used to have further down the river. That's one thing I'd like to see is exploration of projects where we could store high runoff in the spring just running off in the groundwater if nothing else. – Farmer, Southwestern Region

Furthermore, some of the programs that were helping with water development have shut off funding:

And so water development, funds for water development would be very helpful. And NRCS has totally cut off their EQIP programs. They used to do a fair amount of water development programs. They just shut it off. And I think it's a misguided policies from state level, higher ups, barking up the wrong tree. They used to be pretty helpful and they're not anymore. As a result, we're turning to other organizations like world wildlife fund for assistant and developing water and fencing infrastructure. – Rancher, Central Region

Finding the right people to do the job is important for adaptation in agriculture. According to some producers, there is a balance of labor availability and expertise that is hard to find:

*If I wanted to have a new irrigation system, for example, you would need the information to figure out how to do it and then you would need funds to actually do it. And that, I could see, would be a long-term project so I don't know if there was some easy to obtain loans specifically for that a project that might be good or sources for materials and then sources for contractors. To me, that is one of the big issues is finding the people to do the right job.
- Rancher, South Central Region*

In addition to water storage opportunities, we had a few participants who are excited about cloud seeding as a water generation tactic and would like the state plan to consider this technology for adaptation.

Support for watershed groups

The need to talk to fellow producers and have the reassurance that they are not experiencing drought alone seemed to ring true for many participants in agriculture. Watershed groups were identified as a great way to create a sense of community and getting diverse stakeholders on the same page.

I think that the best way to reach the landowners is really through the local, like the conservation district boards, who are landowners themselves, who are talking to their neighbors. And the same with the water user associations, water managers, and the board members of those groups in sharing whether it's information about FSA, or it's information about an upcoming workshop where they can come and talk to each other, of like really reaching people at the ground level. – Rancher, Central Region

Conservation and land

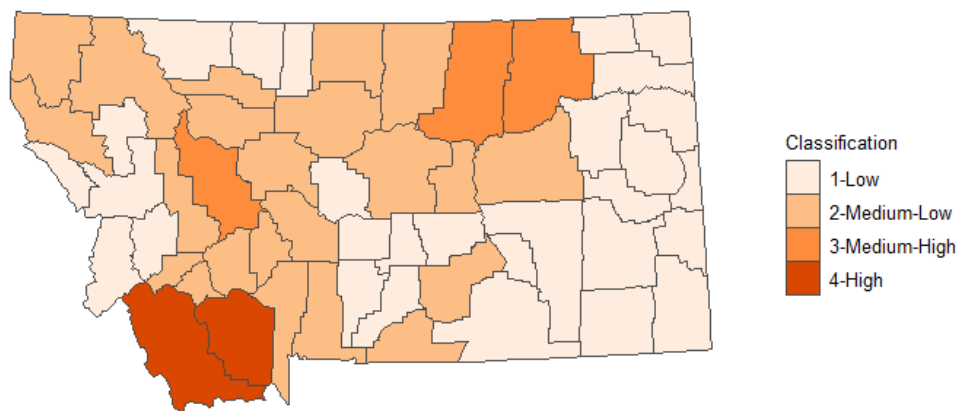
In total, 15 interview participants identified conservation and land management as their primary sector. Positions among these participants included professionals in conservation-focused nonprofits, state agencies, university researchers focused on climate and water resources, environmental consultants, and water quality specialists. These participants were primarily focused on the Western (one), Southwestern (two), Central (four), and South Central (five) climate regions, though a few have a statewide focus. Additionally, 37 participants responding to the online survey selected conservation and land management as their primary sector. Of the survey respondents, most were located in the Western and Southwestern regions, though a few were located in the Central and South Central regions, and one in the Southeastern region.

Conservation and land vulnerability index

Figure 6. Drought vulnerability index by county for the conservation and land sector

Conservation

Drought Vulnerability Classification



The counties with the highest vulnerability in the conservation and land water use sector were in the Southwestern region of the state. Southwestern Montana’s high vulnerability can likely be attributed to a combination of drought exposure and a high degree of ecological value and native fish species, as well as impaired or chronically dewatered lakes and streams. The medium-high vulnerability in Phillips and Valley counties in the northeast is likely due to recent increases in drought severity as well as a high degree of impaired river and stream mileage in the Milk and Lower Missouri rivers, as well as Fort Peck Lake.

Coping with and responding to drought in the conservation and land sector

Sensitivity can be conceptualized as experiencing and responding to the impacts of drought, and in this section, we present thematic descriptions of sensitivity in the conservation and land sector.

Impacts of drought

Impacts to profession

While professionals in the conservation and land management sector did not describe direct impacts to their livelihoods, economically speaking, drought has clear impacts to their professions and significant implications for the future of their work. In particular, participants commonly expressed current frustrations and future concerns for the health of forest and riparian ecosystems. Several participants also specifically noted concerns for the viability and success of on-the-ground ecological restoration projects in the context of the broader ecological concerns related to drought. One survey participant described the impact of drought on their work: *“My organization has had to start thinking about drought, water policy and new ways to engage all water users year-round to deal with and because of drought. We have also had to let go of other priorities because of the increasing severity and impacts of drought.”*

Impacts to ecosystems

Most participants in this sector were primarily focused on rivers and the health of riparian ecosystems within the state. As one participant explained, drought detrimentally impacts rivers in a variety of ways:

Rivers impacted by drought, they are too warm. There's not enough flow. That makes all our nutrient attenuation and everything, dilution, are more challenging. And from a river-process perspective, if you have a series of drought years, I mean, 10 years with no real high peak flows, your rivers just kind of stale, right? It takes dynamic processes to keep regenerating your pools, to keep pulling in wood to make new structure for fish. So, drought impacts rivers by essentially making them more homogenous. It doesn't clean out the sediment, your pools start to fill in, there's no process to generate new riparian vegetation. So, drought affects all things rivers – Environmental Consultant, Southwestern Region

Threats to the health of fish populations as a result of drought were of particular concern to participants in this sector. In general, fish populations were discussed as a kind of bellwether for conservation work in response to drought. For example, one participant described their organization's mission, *“We focus on...[native fish] health and populations, but that's really just the symbol, if you will, for clean and healthy streams and rivers in general.”* Impacts to streamflow and subsequently, water temperatures and nutrient levels, present dangerous conditions for fish health:

We're certainly seeing some disturbing trends in our wild and native trout, and I think across the board, the biologists and we as an organization, recognize that a lot of that has been drought-driven. And not just the low warm water quantities that we hit each year, but how long those are being sustained. For, now, longer periods of time we are at low water in our rivers and streams, stretching into the fall when some of these species spawn, when critical habitat is dry rather than historically having been wet. – Nonprofit Director, Western Region

As another participant explained, dewatered streams, as a result of both drought and overuse, are not historically uncommon occurrences in Montana, but economic shifts away from extractive industries toward recreation and tourism, along with the impacts of prolonged, more severe periods of drought, have made protecting the health of fish populations and riparian ecosystems all the more urgent. Several participants spoke to the increased length and severity of droughts in recent years, and the compounding effects that long-term drought conditions have on riparian ecosystem health, including impacts to water quality.

Multiple participants shared water quality concerns as a result of drought. One participant explained with reduced stream flows *“you of course have increased water quality issues, like more sediment or different pH and water temperature and concentration of pollutants or algae because there is less water.”*

Additionally, another participant clarified that “hot water temperatures [are] actually a pollutant. It's considered a pollutant and needs to be addressed.” Collectively, drought impacts to water quantity and quality present significant threats to the health of riparian ecosystems and the ecological, social, and economic interests that rely on healthy rivers in Montana. At the same time, as Montana's population grows and climate conditions continue to shift, “There's a reality that we have decreasing water supply and an increasing demand of more population and more people putting demands on that in new and bigger ways.”

Similar to the threats that drought poses to riparian ecosystems, one participant focused on statewide forest management described an increase in overall vulnerability of forest ecosystem health due to interrelated and compounding impacts caused by drought. Prolonged drought conditions, in particular, can result in increased susceptibility to pest and disease outbreaks and higher intensity wildfires. Managing forests under these conditions is not only crucial for maintaining ecosystem health, but also in protecting human communities and infrastructure, including watersheds that supply drinking water, but as the participant explained, it can be “very hard to be responsive to all of these different factors.” Furthermore, they explained that with increasing frequency and severity of wildfires across the state, management personnel and equipment are increasingly dedicated to responding to wildfires to the point that few resources remain to manage forests more broadly or even proactively manage for wildfire risk:

So, when you're talking about projects that are supposed to be designed to help reduce wildfire risk to a community, but you don't have a workforce to go do that because they're in the drought-stricken corner of the state fighting fire...it's also hard to get ahead when you lose three months out of operational time out of the year chasing fires around. –State Agency Employee, Western Region

Related to ecosystem management concerns, a few participants involved in ecological restoration projects expressed challenges with drought threatening the very projects that seek to mitigate drought impacts:

Well, drought has a pretty profound effect on how well some of our projects survive. A lot of our projects involve planting riparian vegetation or reestablishing wetlands. And if there's no water, that vegetation dies and if the water level varies considerably over time, that can also have a pretty profound effect on the vegetation survival. We've had a number of projects where lack of water, lack of precipitation has significantly damaged our efforts to revegetate the riparian areas. – Water Quality Specialist, Central Region

Collectively, participants in this sector described concerning trends in drought-induced impacts to vital ecosystems across the state, trends which they expect to worsen with the predicted impacts of climate change. One participant explained that increasing severity, length, and frequency of droughts is the new reality that stakeholders are already facing:

It's like, drought is real, it's ongoing, but then there's climate change component of that, too. And I don't really care how we frame the issue. I just think it's a reality that we're in it. And I think there's consensus there, almost. I don't want to say 100% consensus. But I think most Montanans who are stakeholders and participating in this issue know that climate change is real, drought impacts are getting more severe, they're happening quicker. – Nonprofit Employee, Western Region

Contributing factors

Other users: conflict

Participants in this sector frequently work with other stakeholders to address drought impacts and often reiterated the sentiment that effective drought management cannot happen in silos, but rather requires the participation of diverse users. Engaging with other water use sectors, however, is not without its

challenges, and at times, can be contentious. As one participant explained, “*There tends to be a lot of finger-pointing in the water world. Ag's the problem. Industry's the problem. Rather than also recognizing those users are sometimes part of the solution.*” A common tension identified by participants was between consumptive and non-consumptive users, such as agricultural producers and fishing outfitters, respectively, who may have different understandings of both their contribution to drought and their responsibility to mitigate drought impacts. One participant representing a watershed coalition explained:

The biggest sources of tension are between irrigated... Are between raft or... Fishing outfitters are the ones that are the fastest to complain about ranchers taking water. They're the first ones to point out full headgates when they're being asked to obey hoot owl restrictions or something like that. There is still tension between the regulated sort of mandatory fishing restriction versus voluntary irrigation conservation. So that tension exists. We have to do a lot of explaining to people that no one's breaking any laws and that these irrigators are entitled to those rights from when they bought their property. And we're not in any place to be making decisions about who wins and loses. – Nonprofit Director, Southwestern Region

In this context, a few participants discussed Montana’s system of prior appropriation for water rights as a potential exacerbator of tensions among water users. Based on their experience, however, one participant felt that even when senior water rights holders are legally allowed to draw as much water as they need at the expense of junior rights holders, in general,

People don't tend to do that when push comes to shove because people don't want to hurt their neighbors or people don't really want, I don't think, to see the streams go dry. And if you're willing to work collaboratively, people are a lot more willing to listen and work together on solutions and potentially give something up that they wouldn't otherwise have given up to make that happen. – Nonprofit Employee, Western Region

Impediments to landscape scale management

Another challenge that a couple participants noted as affecting their ability to mitigate and respond to drought is the scale and jurisdiction at which natural resources are often managed in the state. Working at a statewide scale, there are myriad of management concerns that agencies have to take into consideration, yet there are limited resources to respond to them, including funding, personnel, and equipment. One participant explained how this context can make it difficult to prioritize certain management actions over others:

The other problem that I think we're facing as agencies is with, it's very hard at a statewide level to say here's "our first, second, and third priority." Based on fuel conditions alone. And so, then if you wanted to add in more of the, like, well, what about community value, what about infrastructure value? And so it's like, that's another layer that makes prioritizing even more difficult. And...then what about this community that's been in a severe drought for seven years? Do we need ... how responsive can we be? – State Agency Employee, Western Region

Additionally, state, and federal natural resource management agencies operating in Montana have frequently faced litigation from interest groups concerned with particular management practices. A couple participants noted that this can be a significant impediment to on-the-ground management activities, including those that are intended to mitigate or build resilience to drought impacts. In the context of the U.S. Forest Service, one participant explained, “*Region one for the Forest Service, which Montana is a part of, is the most litigated region in the US. And so, that does have a significant impact on the Forest Service's ability to conduct large scale forest management that they see as necessary for executing the*

mission of their organization.” Another participant working for a small nonprofit organization echoed this frustration:

So, our federal agencies are just totally hamstrung in trying to do good projects. And they're the ones that manage the bulk of the landscape that could be managed in a way to better serve our needs for climate and drought mitigation. And those agencies are just crippled by litigation and the threat of litigation... And so, the timeframe that it takes to get these projects done is just not meeting the need at all. – Nonprofit Director, Southwestern Region

Conifer encroachment

A few participants also shared a particular drought-related concern at the intersection of riparian and forest ecosystem management: conifer encroachment. As these participants described it, conifer encroachment is both a result of drought and an exacerbator of drought impacts, as growing numbers of conifers encroach on areas that were historically wetlands and riparian zones, they take up significant amounts of water, further altering the landscape. One participant engaged in ecological restoration projects explained:

We believe that there's a lot of water being taken up by too many conifers on the landscape, and just generally speaking, that conifer encroachment issue is huge. So, if we look at where we can get more water, we think that vegetative manipulation is one of the best ways that we can get more water yield in the watershed. – Nonprofit Director, Southwestern Region

Given the potential impact of conifer encroachment on water availability, participants suggested that their organizations and others engaged in ecological restoration work would benefit from research studies that seek to quantify the amount of water conifers are capable of diverting and monitor the effects of vegetative manipulation practices on water availability.

Monitoring data and resources

When asked about the types of drought monitoring data and resources they access in their work, participants mentioned the state drought monitor, DNRC drought updates, NRCS SNOTEL sites, stream gage networks, and Montana Mesonet stations as key sources of monitoring information and data. In general, participants in this sector track drought conditions and monitoring data frequently in order to make informed decisions, understand the impacts of drought on ecosystems and wildlife, and educate other stakeholders and the general public. Several participants represented in this sector are also directly engaged in watershed groups that have drought management plans in place that include certain monitoring triggers that, if reached, put specific management responses into action.

By far the most commonly discussed source of monitoring information in this sector was stream gages. Participants emphasized the importance of having real-time data that is gathered throughout watersheds across the state and is distributed by a trusted third-party entity. Many participants are well-attuned to the streamflow and water temperature data gathered by stream gages and considered the gages to be “*critical sources of information*” for their work, now, “*more so than ever.*” Streamflow data is often used by participants to understand when drought conditions are present and when those conditions have reached levels that trigger restrictions, both voluntary and regulatory. Participants consistently shared the message, “*we all collectively lean on our stream gage infrastructure.*”

Yet, despite the clear importance that this sector places on stream gages and the data they collect, many participants spoke to the challenges and frustrations around maintaining a robust, well-funded network of stream gages. With stream gage infrastructure facing a lack of funding in recent years, and in some cases,

gages going offline, participants underscored the value of stream gages and their interest in not only maintaining existing infrastructure but also expanding it. Several of the organizations and agencies represented in this sector have been involved in funding, either directly or by organizing funding sources, to keep stream gages up and running. In regard to funding, one participant made the analogy, *“if you want to think of it as a chessboard, no one pawn can pay for the whole thing, but we all rely on the whole thing.”* While funding for stream gages remains somewhat piecemeal, several conservation organizations have made it a priority to find *“ways to better fund stream gages, to keep them online for all users not just anglers and boaters going out there and wanting to know flows, using those things, to determine when restrictions are warranted, when those triggers are hit.”*

Another key source of monitoring data that participants in the conservation and land management sector rely on is snowpack data through NRCS SNOTEL sites. In combination with stream gage data, participants described tracking *“snowpack and surface water levels and streams”* in order to *“forecast what conditions we might be able to expect at the worst time for drought.”* Participants explained that snowpack provides valuable insights into not only the extent of precipitation that different regions in the state are experiencing but also the timing of that precipitation, which can be a key factor in forecasting drought conditions, particularly in watersheds that are reliant on snowpack and subsequent spring runoff. A few participants also described shifts in snowpack trends in recent years that have been documented in SNOTEL and hydrograph data, such as *“peaks of early runoff happening in March and April that really didn't used to happen until June”* and *“rivers are staying lower, greener longer, and then when the peak comes, it just goes [up] like this, and then it comes back down [quickly], and you're out.”*

A few participants also mentioned the value of the Montana Mesonet stations and being able to monitor soil moisture, which is often helpful when engaging landowners and other types of stakeholders in drought mitigation and planning efforts. A representative from one conservation organization explained, *“Our folks on the ground who are helping implement drought management plans are using those [soil moisture data] on an hourly, sometimes, basis within their day.”*

Drought response

When preparing for and responding to drought, participants mentioned a few existing statewide policy tools and programs that have been helpful such as private water leasing for instream flow, hoot owl restrictions on rivers, and grant funding through DNRC for watershed management and irrigation infrastructure projects. As a water conservation policy tool, one participant explained that private water leasing has *“worked really well, but that has limitations because of the process. And so that's what the DNRC is looking at right now... And then FWP can do their own water leases, too. We would just like to see more of those done. I guess, make that an elevated priority.”* While it is possible to secure water leases for instream flow purposes in Montana, a few participants felt these options could be more streamlined and utilized more frequently to support riparian ecosystem health and drought resilience more broadly.

Several participants felt that grant funding through DNRC, FWP, and other state agencies has been instrumental to their ability to do conservation work related to drought. For example, one participant explained, *“We wouldn't be probably anywhere near a draft of a drought management plan if it wasn't for help from the DNRC.”* Similarly, another participant described the resources accessed through DNRC as *“invaluable and very much appreciated.”* Another participant discussed how project funding through their organization is often paired or matched with funding from a variety of state agencies. Overall, it was clear that participants in this sector utilize and rely on funding opportunities from DNRC and state agencies to be able to successfully plan for and implement drought mitigation projects.

While there are policies and programs that support the individuals and organizations in this sector in preparing for and responding to drought, a few participants also described limitations to these existing tools. The limitations discussed related to the competitiveness of available funding resources and the triggers for drought relief. One participant working at the watershed-level described challenges related to relying on competitive, cyclical funding streams:

I mean, I do rely on the DNRC's Watershed Management Grants program every year. But definitely it's a challenge now after [several] years of doing this. My first couple years it was really easy to get a funder's attention and explain to them what a good process we had going and what the benefits were. And now it's much harder just because funders tend to like something that's new and different. – Nonprofit Employee, Western Region

Another participant discussed the problems with federal drought relief assistance programs that have the potential to incentivize poor land management practices, particularly among agricultural producers. They suggested that existing relief programs provide more financial resources to individuals who are experiencing drought impacts more acutely, but this can mean those who are managing land to encourage more drought resilience receive less financial assistance.

Drought planning

When it comes to planning for drought, participants working in the conservation and land management sector felt that their role was distinct from sectors that directly rely on water for their livelihood, such as agriculture or recreation and tourism. Rather, they viewed themselves as conveners of diverse water use interests with the purpose of building collaborative solutions around the common goal of conserving water during times of drought. In order to ensure that water remains flowing in streams at levels critical for ecosystem functioning, many participants in this sector explained that collaboration was key and was often the basis for their drought planning efforts. As one participant described their organization's role, "I think our job is to make sure that people and wildlife and everyone who needs the water resource has it available when they need it."

Often, drought preparation within this sector entails forecasting conditions and asking questions like, "how much water reasonably can we expect? What's the worst-case scenario? And then, how do we adapt if we do end up in a worst-case scenario situation?" Participants in this sector described frequently tracking drought conditions and working to ensure that:

All the tools [are] in place to be able to make management decisions, to protect resources during those drought times. So, whether that's putting fishing restrictions in place or closures, things like that, or just educating the public that we're coming into a drought time and to be watching temperatures and flows. – Biologist, Western Region

While the primary focus of this sector is the protection and stewardship of ecosystems, participants recognize that the success of their drought mitigation and planning efforts is inextricably tied to other water use sectors. Therefore, drought planning in this sector is driven by science and monitoring data, but often operationalized through relationship- and coalition-building across diverse interests. Without the support and participation of diverse water use stakeholders, the opportunities to effectively manage for and build resilience to drought to support healthy ecosystems are considerably diminished. One participant reflecting on the benefits of multi-stakeholder collaboration explained, "most of the time, by and large, I think people are willing to sit down and make those concessions that everybody needs to make an agreement to work to benefit the greater good... I can say from experience, litigation doesn't really get you what you want sometimes when it comes to water." Similarly, in the context of forestry management, a participant underscored the importance of building partnerships with a focus on landscape-scale conservation in order to manage for drought impacts:

I'll just re-highlight, it's working with partners to prioritize what's happening and where. And then, also just going for the approach that we need to make a healthy, resilient forest. And, at a landscape scale, that's really the only thing forestry wise we can do to help try to mitigate or offset some of the pressures that the trees are under. – State Agency Employee, Western Region

Adapting to drought in the conservation and land sector

Adaptation includes many types of proactive planning for drought, and in this section, we present thematic description of adaptive capacity in the conservation and land sector.

Education and outreach

One of the primary ways in which participants in this sector described adapting to or building resilience to drought was through public education and outreach. Several participants focus their education and outreach efforts on river recreators, while others are more focused on promoting landowner stewardship. For example, one participant described efforts to encourage anglers to be mindful of drought conditions, *“largely paying attention to water levels and water temperatures when people fish so that they are practicing fish-friendly angling techniques.”* Another participant works with agricultural producers to promote *“really good stewardship practices. Really good practices on your farm, so that you're retaining your organic material, you're storing more soil moisture in your soil.”*

Participants often described their public education and outreach efforts around drought as increasingly important within the context of population growth and climate change. As drought impacts may happen more frequently and with greater severity, participants in this sector are engaged in efforts to *“try to convey that information to the community in a way that they can understand like okay, this could happen again really easily as climate change continues.”* A forestry professional described their engagement with landowners:

A key activity I'd say we do is landowner and public education about insects and disease, what they can and should be doing to prepare their property or their home for wildfire, just because of the eventuality of the constant potential that a home is impacted by wildfire, really in any month of the year in any fuel type, from grass to heavy timber. – State Agency Employee, Western Region

Restoration efforts

Nine interview and two survey participants spoke to ecological restoration work as a means for adapting to drought, and many of the organizations they work for are actively engaged in restoration projects. Whether indirectly or directly focused on mitigating drought impacts, these projects play a significant role in how the conservation and land management sector is managing for and seeking to build resilience to drought. One participant working for a conservation nonprofit explained, *“we're trying to be more proactive about things that we can actually do to mitigate for drought. So that's where our restoration programs come in and the particular focus we have on water storage.”* Another conservation organization similarly developed a restoration team, largely in response to drought:

One of the most tangible results...is showing people a project that was on the ground, moving dirt or putting water back in a stream that used to be dry. People can see that and be like, "Oh, okay, I'm going to support what you do." So, there's that restoration program I think was kind of the genesis of that need. – Nonprofit Employee, Western Region

Restoration projects tied back into the collaborative work that participants in this sector are engaged in, where successful projects are often contingent on multi-stakeholder involvement and support. When

identifying projects, one participant shared, *“We really try to invent these projects that improve the system, take it from a high level, ‘Where can the restoration be conducted?’ And then use that information to go out and introduce yourself to the landowners and try to make these projects happen.”*

Participants described restoration projects as both an opportunity to mitigate drought and build resilience to it. A few participants referred to their organization’s restoration projects as “process-based restoration,” essentially seeking to restart the natural ecosystem processes that retain water on the landscape. Water storage, in tandem with habitat restoration, was often shared as a key focus of restoration work in this sector. One participant described the logic of restoring floodplains for water retention:

There's more and more research being done on how much water a restored floodplain stores from spring runoff or high water times, and then gradually releases during base flow, or as rivers and streams hit low flows...I think in the early years, a lot of repair and restoration flood plain work was done because it provided better habitat, and now we've realized that it also has a huge impact on storing water, natural water storage. – Nonprofit Director, Western Region

Specific examples of floodplain and riparian restoration mentioned by participants included building out and reinforcing streambanks and beaver dam analogues (BDAs). Several participants have been engaged in BDA projects, which are designed to imitate beaver dam structures in order to *“trap sediment, and then fill up [the stream] to that level, and then revegetate with wetland vegetation. So instead of this small little stream three feet down in here, we have just a wet area that's higher up in elevation.”* Another key focus of the floodplain restoration described in this sector was connectivity and *“reconnecting streams to their flood plains.”* One participant focused on restoration in the context of flood mitigation described similar projects, suggesting that, *“What we would do for flood impacts is the same as what would happen for drought.”*

In general, participants highlighted ecological restoration, particularly river and riparian restoration, as a key drought mitigation and resilience strategy in their work, but also acknowledged that restoration work is a dynamic and complicated process with varying degrees of success. Furthermore, it can be difficult to define what success looks like. As described earlier, some participants have seen restoration projects fail as a result of drought conditions. Yet, as one participant put it, *“River restoration is an art. We're learning, right? There's trial and error involved. It's not perfect, but if we don't work at it, we're not going to figure out what works.”*

Water restrictions

Several participants have also been involved in developing and implementing strategies that conserve water and protect water quality. Some of these strategies are regulatory in nature, such as fishing restrictions, while others are voluntary. While the state implements hoot owl restrictions and, in some cases, river closures, to restrict fishing on rivers when certain flow and water temperature triggers are reached, a couple organizations represented in this sector have been involved in work to ensure that those triggers are reflective of the most current science and appropriately conservative to protect the wellbeing, and not simply the survival, of native fish populations. As the body of scientific evidence grows,

There's been more and more of that research showing that sort of the range of temperatures at which wild and native trout thrive versus are imperiled. And in fact, we've been advocating for the last year or so that we lower the temperature at which our state agencies begin restricting fishing in waters that have native trout, particularly our state fish, the cutthroat trout. – Nonprofit Director, Western Region

A participant engaged in fisheries management similarly explained, *“A lot of our work is centered around making sure we have the right regulations in place to be protective of fisheries, putting protections in*

place at the right time, and making sure that we don't have regulations out there that are actively harming populations during drought times.”

Several participants are involved in collaborative and voluntary approaches to water conservation, such as watershed-level drought mitigation plans that utilize a shared giving model. These plans stipulate that when certain drought conditions are present, the various stakeholders that are party to the plan voluntarily implement water conservation strategies. One participant explained:

It's this whole idea of shared sacrifice or some people call it shared giving, the idea that if the stream reaches a certain flow or temperature that certain things would happen. And usually it's at a certain flow, if it reaches a certain cfs, then people start ... to reduce their withdrawals and that's on a voluntary basis. Although it's, in some cases, a more formal plan. I mean, yeah, at this trigger, this will happen. Or at this stage of cfs, this will happen.
– University Researcher, Southwestern Region

A few watershed groups in Montana have found this model to be successful in maintaining stream flows during drought years, allowing them to avoid more extreme situations where the state must “call on” junior water right holders for instream flows.. This collaborative strategy, however, requires that the majority of water users agree to limit their water use, and because “*It's all voluntary. It's not set in stone, and it could change. And it has changed.*”

Water storage

In addition to restoration projects aimed at building natural water storage capacity, another commonly discussed strategy for building resilience to drought was the strategic use of existing water storage infrastructure, such as reservoirs. As one participant shared, “*we've gotten to the point in some drainages where we're looking for, in drought years, we are looking for ways to get more water in the river,*” and as a result, some biologists within their agency have made decisions to shift the timing and amount of water releases from reservoirs to support the survival of key fish populations that depend on downstream flows. Another participant described their organization’s interest in existing dam infrastructure:

We are interested in conversations about increasing traditional dam storage capacity, where it's appropriate, where dams already exist and there is available water. Why would we not consider raising dam and reservoir levels, if from our organization's viewpoint, some of that increased capacity is committed to instream flow during times of drought or just low water in even a normal summer? – Nonprofit Director, Western Region

Similarly, another participant justified their organization’s interest in reservoir storage as a means for drought mitigation, “*The reason why we talk so much about headwater storage is because we've seen it successfully work before both on smaller projects...and then at the state level like Painted Rocks Reservoir.*” In general, several participants in this sector underscored the significance of enhancing the water storage capacity throughout the state to meet the increasing pressures of drought. One participant put it starkly, “*The drought of last year, really highlighted to us the need for more substantial storage, if we have a shot at dealing with warming trends and changing preset patterns that we're starting to see pretty regularly now.*”

What’s needed to build and support drought resilience in the conservation and land sector

Resources that can decrease vulnerability should mitigate sensitivities and build adaptive capacity, and in this section, we provide thematic description of some resources that could build resilience in the conservation and land sector.

General reflections on state plan

Many participants reflected on what the motivating factors and key pieces of a state drought plan are, as these pieces provide the framework for specific needs. One of these motivating factors is the recognition that water resources are owned by everyone in the state, and therefore need to be protected for the benefit of everyone, as expressed by one participant who shared, *“It’s like how do we protect the resources that we all own? The water resources belong to all of us. The state holds them in trust, but it’s for the benefit of all people in Montana. So, it’s like looking at protecting all of those interests.”*

There is an underlying sense that long term shifts in climate are a huge aspect to consider in the plan, and that drought will likely be directly influenced by these shifts. One survey respondent noted that the plan should consider climate change as an *“extreme threat and climate resiliency as a priority.”* (survey) Another participant stated the shifting reality and changing climate should be a motivating factor for progressive and forward-looking plan that is based on current science:

I think just really pushing the envelope in a progressive manner that recognizes the current science as well as the current science that is forecasting and very forward looking, to just really put it in the face of folks around here. Like, “Look. These last two years have been pretty dry, but we’re expecting more of that and maybe more intensity of that. And so, the sooner we can get out in front of it the better.” - Conservation District Supervisor, Southwestern Region

Some of the challenges to implementation noted by interview and survey participants are keeping people engaged in planning and making sure that the plan and information stay relevant to localities. One of the issues with drought is *“keeping the iron hot”* throughout the year in regard to planning as stakeholders generally seem to engage in planning when drought is actually happening but disengage once winter rolls around or drought conditions appear to improve. Of seemingly greater importance to participants is the need to make the drought plan and informational resources or data relevant to localities, as drought response or conditions may be highly variable depending on geographic region. One participant noted that considering nested scales of implementation to local planning to be *“very, very important, but if you are not thinking of it as sort of a Russian doll of going down at scale to these local plans and nesting them under that state drought plan, I think you’re going to have limited benefit.”* Other participants noted the challenge of using statewide data and turning it into something manageable and usable to grassroots organizations and localities. One participant stated:

I really applaud their efforts to do as much grassroots from the ground up as possible. But I think the challenge, and it’s not unique to Montana and I don’t know that there’s an answer to this, but then how do you coalesce that data, turn it into something manageable, where there are various concerns across the state and they’re different across different regions, but you still have to say something. You lose the granular context as you kind of aggregate up to the state level. University Researcher, Southwestern Region

While another participant had a very similar statement related to the challenge of the dissemination of statewide data and information to localities and specific areas of the state:

One of the trickier parts is there’s no shortage of newsletters coming through my inbox showing some mega data, big data effort happening, and then they produce some statewide thing but then to bring it locally to our watershed, sometimes these data layers and this really incredible work is happening at either a national or a statewide scale, but then unless we had either capacity funding or a specific grant to hire someone, we’re missing that next step to make those data sets relevant to our specific situation. – Nonprofit Director, Southwestern Region

Overall, participants in this water use sector expressed that an effective state drought plan is actionable, adaptable and scalable, and driven by a collaborative multi-stakeholder driven approach. An actionable plan to stakeholders is one that is not in place just for planning's sake, but that includes real policy recommendations and mechanisms to take action, and as noted by one participant:

Concrete, next steps about how to get there, right? Because just planning for planning's sake is just like, what are we doing? Yeah. It's important I think to have all of the technical stuff in there too, obviously. I just think reading through the 1995 plan, there were some policy recommendations in there, but it wasn't explicit. – Nonprofit Employee, Western Region

Other participants noted frustration with continued meetings, but no real action. One expressed that their “biggest frustration on the drought planning effort overall is that we've had lots of meetings and lots of discussions and for me, it's time for the rubber to hit the road,” while a survey respondent put simply, “Stop talking and start doing.”

A plan that is scalable and adaptable to meet unique community needs is also of high importance. Stakeholders need tools and templates that can be adapted and used for their specific needs, with the idea from one participant noting:

Recognizing that there's not going to be a one-size-fits-all thing in a state plan that is transferable to every basin or every river, every watershed...there have to be tools in the statewide plan that can be used at the local level to assess, okay, who are the water users? What are the concerns when we're talking about drought? How can we mitigate? How can we make a difference?” – Nonprofit Director, Western Region

This was echoed by another participant who stated that “every community's going to be different. Looking at it from a state level is how do you develop tools or programs that are adaptable to different community needs?”

The idea of having an adaptable and scalable drought plan to meet local needs leads to the necessity for a multi-stakeholder driven plan, and input and collaboration from different stakeholders and groups from across the state. The challenge in this becomes making sure that everyone is on board with participation and that all groups and stakeholders are considered. As mentioned by one participant,

What works is making sure that you have a system that gets everybody on board participating and doesn't unfairly target one group or another. So, there's some equal participation and mitigation of impacts is equally spread across everybody who's got some interest. - Nonprofit Employee, Southwestern Region

Another participant noted that the participation aspect is important for “local community ownership and buy-in into the whole process. Then hopefully...the community's invested in that already and then they'll actually implement it.” Finally, collaboration across communities can be a highly effective way of learning what works and what doesn't in drought planning across different watersheds according to several participants. One participant summed up this idea of collaborative coordination across watersheds, stating that:

I think some broader coordination would be helpful in terms of drought planning. I think we could learn from each other across watersheds. There's not necessarily a one size fits all solution to drought management. So, what works in the Upper Clark Fork and what works in the Big Hole and what works in the Blackfoot might be different. But at least we can learn from each other, so I think that would be helpful. – Nonprofit Employee, Southwestern Region

Improvements to public policy, relief, and payment programs

Many stakeholders expressed ways in which public policy and drought relief from the state could be improved. In general, stakeholders want to make improvements and add efficiency to the overall water use system to keep the maximum amount of water in streams. As one user stated, there are a variety of areas where there have been thoughts about how improvements could be made, including “*stream flows, groundwater development, and then basically all of the regulatory tools that we need to use to put water back in streams, how do we improve those? How do we make those more efficient, and I guess, make them get a quicker response?*”

Other stakeholders in the conservation sector are considering how flexibility and efficiency can be improved in water laws and state funded projects. For example, one stakeholder stated that they are “*thinking about how, from a policy standpoint, accepting and believing very strongly that the prior appropriation doctrine is the right thing and the right way to do this, how within that structured system can you build some flexibility into that from a policy standpoint?*” Similarly, another stakeholder wants to “*look at water policy in Montana and making sure that it's up-to-date*”, as he noted that people across water use sectors are interested in working together to make sure resources are protected, but that current water laws can make that difficult:

There are folks interested in working together to make sure that the resource is also protected. Sometimes it can be hard to do with the current water laws and water policy in Montana. So, I think some sort of evaluation of where we're at there and if there's of common-sense things that could be done that work for all parties and make it easier to accommodate water users that want to work with resource managers and stuff like that.”
– Biologist, Western Region

Primarily, stakeholders discussed additional public policies and relief programs, additional monitoring, and communication and outreach so that the public and stakeholders can understand the tools and resources available to them as their main needs. The details within these main topics are detailed below.

Additional public policy, relief, and payment programs

It is clear that a substantial amount of the policy and relief within the conservation and ecological services sector comes through collaboration and working across other water use sectors to achieve goals. As one of the primary goals in this water use sector is maintain instream flows and ecological function, working with landowners, land managers, developers, and recreationists is a key aspect of achieving this goal as the actions of all water users can influence flows and water availability. As a first step for being able to achieve the desired goal, several stakeholders noted that landowner and stakeholder education and incentives are important so that they understand why action needs to be taken and have reason to actually act. One stakeholder stated:

I think the main issue is just getting more private landowners to be utilizing best management practices on wetlands and streams and general rangeland. But that can be a tough sell depending on who the property owner is and the property manager. And then of course, all of the additional development of people ... that sort of thing is really hard to connect with. So yeah, probably more education and more money tossed towards funding projects, so people don't have to pay, or pay very little to do the right thing.” – Conservation District Supervisor, Southwestern Region

Another aspect of the motivation for increasing education is that information is relatively scarce, and the fact that drought conditions are present is not always obvious to people, as expressed by another participant:

I think if there could be more information and more educating the public of this is what a drought looks like now in the 21st century and these are the conditions that we see through the Montana climate assessment and the greater Yellowstone climate assessment. We're moving in this direction; this is the new normal. These are things we need to start doing now to be more resilient as we go move forward with the future. I think a lot of people don't realize that we're in a drought as much as we are because we haven't seen big tornadoes of dust or something like a big visible element. – Nonprofit Employee, South Central Region

The result of working with other stakeholders from different sector that was also evident from interviews with members of the conservation and ecological services sector was their understanding of the need for resources, such as mental health resources, to help people cope with drought. When asked about mental health impacts, none of the participants noted that they themselves needed mental health resources for drought, but that it may be important for people more directly negatively impacted by drought, such as farmers or ranchers or recreation industry professionals. One participant noted that watershed groups that bring stakeholders together can be a great benefit to the mental health of people impacted by drought because it allows people to share their experiences and challenges, and that “*it's amazing how much easier it gets when you start talking to somebody else about those.*” Another participant also sees mental health resources as not only something that can help with short term drought impacts, but also something that can help people come to terms with long term drought:

I see a big component for mental health and mental health resources. Not only from a catastrophic event that is a shock that traumatizes an entire community, but also a long-term drought is going to create stresses on producers, communities in ways we don't really realize yet. If you are selling your cows because you can't graze and grow hay for them then or if you own a business that's tied to an outdoor activity, it's too dry, it's too smokey and people aren't just simply they're no longer patronizing your services. - Nonprofit Employee, South Central Region

Actionable policies or regulations

While education and resources to help understand and cope with drought are important, actionable policies or regulations to mitigate the impacts of drought or make sure that land and water use minimizes the possibility of negative ecological effects are equally important. One area where action can be taken according to participants is in development and land use regulation.

Land use and kind of responsible development question plays into this drought discussion as well, because I think we really are looking at kind of two diverging fronts that threaten our water resources in the state. And one of them is natural and one of them is man-made. – Nonprofit Employee, Western Region

Considering development is particularly important in the fast-growing communities of Montana. A survey participant stated their desire for the state to “*move forward with administrative rules that require communities to plan for drought--the development pressure and increasing use of expanding populations in our cities is drying up MT,*” while an interview participant suggested that “*working with city planners and developers and trying to get them on board with including water planning in their processes, and then incentivizing smart growth and development in terms of water, I think is going to be essential.*”

A common perspective across water use sectors is the importance of instream flow, which leads to the suggestion of implementing mandatory water protections or restrictions. Members of the conservation and ecological services sector took this idea a step further, noting the importance of not only water protection, but the importance of also protecting the whole riparian area to ensure that the ecosystem is maximizing

the benefits of water protections. As indicated by most participants in this sector, a functioning ecosystem can be a great drought mitigation tool because it increases natural water storage and hydrological function. This can be as simple as disincentivizing “*thirsty non-native riparian trees shrubbery*” (survey), as noted by one survey participant, or more complex riparian habitat or floodplain projects to improve ecosystem function and water storage, as suggested by several interview participants.

A problem that one participant noted with current policy related to water conservation and protection projects is that “*There's just kind of a one-size-fits-all tendency in agencies, that you lose the nuance of site-specific type treatments.*” They make a case for a change to policy based on the following argument, with suggestions of using conservation corps or providing incentives to landowners to add or improve riparian areas to supplement and add value to projects:

And on that policy side of the equation, the argument I think I'd like to put forward, is we have our stream access to rivers in Montana. We've determined that the rivers are a public resource, and that water is for the public. That's encoded in our constitution. It's been supported by the courts. Can we expand that to include the riparian area in some way? I think, on the extreme end of that, is there's an entity that makes sure you have your riparian buffers intact, like a Montana Conservation Core type entity, that just goes out and plants all your riparian areas. But there can be stages, right? Can you incentivize landowners to either not clear riparian areas, or to add riparian areas?” – Environmental Consultant, Southwestern Region

Another participant also emphasized the need for floodplain and riparian area protection and funding to support drought mitigation efforts:

One of the big, bigger picture, long-term strategies that I think is absolutely critical is getting money there for flood plain easements, channel migration easements, protecting these flood plain corridors in perpetuity or for some term. So, I think that we've been having lots of conversations along those lines recently and been reaching out to DNRC and figuring out how to get some type of funding in, because that's a really important drought mitigation strategy.” – Nonprofit Director, South Central Region

Changes to the water rights and leasing process were also a suggestion made by several interview participants. In particular, short-term leasing flexibility was noted as a way to quickly respond to drought and allow for more water to remain in streams. One participant had some ideas on how short-term leasing models could be improved or changed within current water law:

There is currently in law temporary leasing, but those sorts of things are relatively new in the scheme of the water use act and prior preparation doctrine. Some of those temporary leases, things like that are relatively new. So continuing to push the model on whether it's water banks, temporary short term split season leases, like you're going to give up water for in stream flow at this point of the season, but maybe not at this point in the season... I don't have all the answers, and I don't think any one participant does, but continuing to engage stakeholders to think creatively about how we can provide some of that short term flexibility. – University Researcher, Southwestern Region

Changes to water leasing were emphasized by several other participants, one of which noted “*we would love to see DNRC improve water leasing, their water leasing options, and point of discharge changes, POD, point of discharge changes for projects that would improve instream flow or aquatic ecosystems.*” Another is hoping for tools for “*some form of a viable, short term water leasing program to deal with extreme and especially flash drought. That would be amazing to see.*”

Creating flexibility within the current water right system would mitigate a lot of participants' concerns, but many participants also highlighted enforcement of water rights as an area for improvement because many are concerned with illegal consumptive use or lack of monitoring for many water rights holders. This was emphasized particularly in closed basins, where one participant found it to be important to be cracking down on *"illegal expansion of consumptive use, or just illegal consumptive use, again, especially in closed basins. And whether that's for filling ponds, or irrigation expansion, or irrigation use, there's a lack of enforcement."* A survey participant also stated that they *"would like to see DNRC get a handle on regulating exempt wells and monitoring (or requiring monitoring) of water usage by water rights holders. I would like to see DNRC more involved in enforcing water rights."* The desire for more enforcement naturally leads into many participants desire for additional monitoring.

Additional monitoring

In general, the majority of participants in this sector spoke to the value of having consistent, timely, and robust monitoring data in order to appropriately prepare for and build resilience to drought. Whether it was maintaining and funding existing sources of monitoring data in perpetuity or developing new monitoring tools, participants felt that monitoring data was at the core of both their work in conservation and land management and central to effective and efficient drought management strategies. As one participant stated, *"I just think the more data that you have, the better."* Another common theme:

Help with the science and monitoring of knowing, just better understanding where we could do more and where it's working. We just don't have a ton of capacity for monitoring ... But definitely there is a need for more monitoring support for all of this work and to help us choose wisely when we say we want to do a restoration project that has really drought resilience benefits, having the resources to know where to do that really depends on good monitoring data over time." – Nonprofit Employee, Western Region

The biggest monitoring need is for the maintenance and expansion of the stream gage network in the state, as this was noted as an issue and monitoring need by nearly two thirds of interview participants. Several participants expressed that one of the biggest challenges was funding for the stream gages, with one stating that *"there's always a struggle to keep a few of those USGS stations afloat. I would say most of the ones we have are fairly critical. So that would be the only issue is that sometimes funding them is piecemeal year to year type of situation."* Another participant also wants improvements to the stream gage network and infrastructure to be able to monitor flows and temperature and *"largely taking funding of those things off the backs of where it's been put increasingly, which is on watershed groups."* Put simply by another participant,

Having that robust stream gage network in Montana is so important, and anything the state can do, at the DNRC level and hopefully higher up, that will support for stream gauging I just think is so essential, and we should be adding stream gages and other data and monitoring efforts, not losing them at this point. – University Researcher, Southwestern Region

A couple participants in this sector suggested that there is also a lack of groundwater data and tools to monitor groundwater levels. These participants felt that having access to this type of data *"Would be super useful and also could lead to some positives around drought management."* Having monitoring data from multiple sources is clearly important to stakeholders.

Finally, soil moisture is also important as a monitoring tool, particularly for landowners to be able to understand more about their landscape and to be able to make informed decisions on water consumption and use based on that understanding. Expansion of data networks to understand how forest lands impact soil moisture retention was also noted as an interest that could be useful, as one participant stated that

they “wish we had more data on how forests affected or indirectly impacted water retention. Whether that's through preservation of a snow field later into the spring, or just how the tangible downstream benefit of a riparian area.” Overall, it is clear that monitoring can be improved in a variety of ways and there is a desire from a multitude of stakeholders to have better overall understanding of the hydrologic system to inform decision making. As stated by one participant:

I think that stuff, those tools being more widespread and available to people would be useful just to make people's water consumption more efficient. I think any tools that help people that give the public information on what drought conditions we're in and what things they can be doing could be helpful. – Biologist, Western Region

Communication and outreach

Communication and outreach is one area that many participants in this water use sector think is important for the state to support, particularly pertaining to the public. Part of the lack of concern for drought according to one participant, is driven by the fact that drought does not particularly impact a lot of the general public, and therefore, people do not take it seriously.

I think there could be better education of the general public on drought, and I think individual municipalities and cities are working on that, but it seems like that could also be something that the state takes on for its population to better understand drought as a regular feature of climate in Montana. I think we're in this unique position in Montana where we have enough water ... certainly in Southwest Montana, and I guess I speak less for Eastern Montana ... We have enough water around that I think a lot of people don't take drought seriously enough, or don't realize that we're sort of on the edge of drought a lot of the time. I think the state could do a better job of educating the general population on that. – University Researcher, Southwestern Region

This quote relates to a point made by another interview participant, who thinks that differences in which populations are impacted by drought and the representation of those populations by public officials at the state level impacts drought messaging and understanding. Specifically, there seems to be a lack of urgency in urban and suburban areas around drought because water is readily available to them. Coincidentally, these areas also have higher legislative representation, which is a large reason for the lack of drought awareness across the majority of the population and state policy level according to one participant:

More of the people of Montana are living in urban and suburban areas that are not as acutely impacted by drought, or at least don't experience it in the same way. So, you are seeing a dwindling political power of those rural legislators who have a lot of irrigators in their district or a lot of people trying to make money out on the landscape. And if you are a suburban water user or an urban water user, by and large, it's sort of like your electricity. You flip a switch and there's water, and you are not burdened or troubled by any of the ways of how that water got to your town. And so those legislators are not hearing the same urgency about drought and water that many of the more rural legislators are.” – University Researcher, Southwestern Region

To increase public awareness, many participants stated the importance of recognizing that all Montanans are water users and building messaging and education around that and not solely focus on water rights holders. One participant stated that:

Most of the time, I feel like the discussion is about how drought impacts water users. Not all the time, but I feel like most of the time that means people with water rights, irrigators,

municipalities, industry. But the flip side of that, obviously we're all water users in Montana. Everyone relies on clean water. – Nonprofit Employee, Western Region

To achieve messaging goals and improve communication about drought, localized outreach is also important to participant. Simply having more people providing education and outreach at the local level, and “*meeting someone in a place where the science means something to them*” is important. Another participant stated that bringing on more people and staffing to engage communities is highly important in regard to local outreach: “*I see that as being the best thing the state can do is perhaps you just bring on a lot more people in those roles who can reach more communities.*”

Tools and resources

Many participants shared ideas for drought response tools and resources that the state could provide. One of the resources that many participants referenced were best practices. Several participants in this sector felt that a primary goal of the state drought management plan should be to provide a toolbox of resources and tools that local and regional entities, such as watershed groups, can use to guide their drought planning and adaptation strategies. As one participant stated, “*I think the state can provide the toolbox of resources that can help inform those local watershed groups,*” while a survey respondent wrote that it would be helpful for the state to be “*providing more guidance and financial resources for countries to adopt policies to be more resilient to climate changes and drought.*”

Another area of support that participants referenced was through funding support and support for local planning. One participant had the idea of a “*drought resiliency fund.*” Other ideas included having a pool of funds to support short-term water leasing during drought periods and providing incentives for better land stewardship. In reference to local planning, one idea was to use existing local planning efforts as a guide and providing capacity and financial support to establish or maintain local watershed groups. One participant talked about the challenge of keeping local planning efforts going, and that support from the state would be really helpful:

So, we're all struggling to keep these local plans going, and it takes people and time and money. And our little local watershed groups are struggling to raise enough to do that. And in the end, the money we leverage is super helpful, I think, to the state. We're filling capacity needs that they probably can't fill right now. So, I think seeing that big picture of where watershed groups and local communities are doing good work, but where they could use support both from technical assistance and funding assistance is a real value of the statewide plan as well. – Nonprofit Employee, Western Region

Support for watershed groups was actually one of the most commonly discussed adaptive strategies that participants recommended the state take in updating the state drought management plan and leveraging federal and state resources is support for local watershed groups, including staff capacity, tools and resources, and funding. Participants consistently highlighted the significance of existing watershed groups and their effectiveness at building collaborative, voluntary drought plans and strategies. Watershed groups were often touted as the model for effective drought mitigation and resilience-building, and therefore the state should prioritize efforts to support these types of multi-stakeholder coalitions in a meaningful way. One participant, referencing funding and grants from the state, mentioned “*I can't understate how important that type of money is for groups like ours.*”

Part of the support, according to one participant, could come from providing a template and “*more real tools and funding for local watershed groups to get started, if they aren't in place. Or if they are in some nascent form, have this plan revision provide real usable tools to watershed groups to develop drought*

management plans.” Overall, the efforts of watershed groups and their ability to address watershed specific issues, particularly related to drought, are successful and something that the state should focus on supporting. As stated by one participant, watershed groups and planning works: *“I think, in terms of where to put resources and funding and capacity building, these expanding and strengthening watershed group efforts in different watersheds across the state seems like a really good place to focus, and I’ve definitely, yep, seen places where it’s working.”*

Finally, several participants referenced that exploring opportunities for more water storage could be a way to save and store water to help mitigate against drought. One of the participants stated that new dams do not necessarily need to be built, but that there are opportunities to improve existing infrastructure to increase storage. They stated *“I think there are water rights challenges to making that happen, but there’s a whole host of existing storage infrastructure. I’m not talking about building new dams. I’m talking about rehabilitating ones that already exist but are not storing as much water as they could.”* The main barrier to that, of course, is funding. Therefore, finding funds to complete projects and improve infrastructure is one of the areas people are looking for in a state plan.

Energy and industry

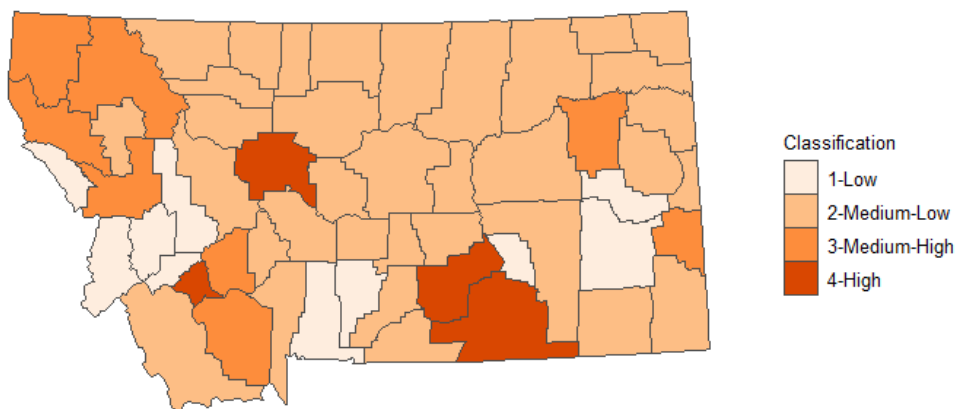
In the energy and industry water use sector, there were three participants and two survey respondents, all representing the hydropower industry. Other members of this sector could include professionals in mining or industry, however, no one from either of these industries responded to interview requests or survey outreach. Data used in the vulnerability index capture variables representative of hydropower, mining, and industry.

Energy and industry vulnerability index

Figure 7. Drought vulnerability index by county for the energy and industry sector

Energy and Industry

Drought Vulnerability Classification



Four counties in the state within the Energy and Industry sector have high vulnerability to drought relative to all other counties in this sector: Silver Bow, Big Horn, Cascade, and Yellowstone counties. Silver Bow county's high vulnerability is a result of the large presence of mining and the highest degree of mining water use in the state. Big Horn and Yellowstone county's scores can be attributed to the largest industrial water use in the state and also likely proximity to coal mining operations. Cascade county's score can be attributed to hydropower infrastructure on the Missouri river.

Areas of the state with Medium-High vulnerability are mostly due to the presence of hydropower operations, or highest increases in recent drought severity, which is likely the case in the Northeastern corner of the state.

Coping with and responding to drought in the energy and industry sector

Sensitivity can be conceptualized as experiencing and responding to the impacts of drought, and in this section, we present thematic description of sensitivity in the energy and industry sector.

Impacts of drought

In general, the participants in this sector did not describe drought as having major impacts to their professions and overall business viability, but drought remains a constant and ever-growing presence in their work and influences how they plan for future business operations under likely more extreme climate

and drought conditions. As industries reliant on natural resources, the ecological impacts of drought can have notable impacts on resource management and, in some instances, has shifted priorities in this sector.

Managing a private timber company, one participant explained how drought can have a particularly significant impact on their tree regeneration projects. While growing trees for timber is only one part of their business, the financial impact of tree mortality due to drought can be significant. At the same time, it is difficult to plan for or adapt planting schedules under drought conditions due to a number of challenging factors. The participant explained:

Things like our regeneration of plants, a lot of trees every year. Timing on that is highly variable. But the window is very narrow, and so we have to order our trees two years in advance. And so we don't get to say, okay, we're not going to be able to plant this year because it's going to be too dry because those trees are coming whether we want them to or not. So, that's a challenge. The strategies for planting in droughty years, you can try to plant earlier in the spring, but you have to have the contract labor available, the trees have to be available, the sites have to be accessible. So, a lot of that is, that's a lot of variables that go in there that doesn't give us a lot of flexibility and so we end up with a lot of financial risk to put the trees in the ground. Kind of like agriculture. You put the trees in the ground, then you start praying that you're going to have enough water to keep them alive through the year... We've seen years with 20% survival and so... You're looking at a \$150-\$200,000 loss. – Lumber Company Employee, Western Region

Beyond the challenges associated with planting trees, this participant also shared their concern for a variety of drought impacts on forest ecosystem health, including changes to species mix, infectious disease outbreaks, and reduced tree growth potential. They explained how, collectively, these factors impact their industry: “So, it affects long term investment strategies for timber landowners and growth rates, and what have you there.”

Participants working for utility companies did not describe concrete financial impacts from drought, but they did explain how drought affects hydropower operations. With reduced stream flows due to drought conditions, the ability to generate energy from hydropower is also reduced. Additionally, as entities responsible for reservoir management and downstream flow conditions, drought can affect their ability “to meet all of our recreation requirements per our [Federal Energy Regulatory Commission] license.” Again, while hydropower is not the company’s sole source of energy generation, drought necessitates changes in operation and is causing utilities to consider how they can mitigate drought impacts in the future.

Contributing factors

Changing conditions

Participants described the drought impacts they have experienced as being manageable in the big picture of their business operations, but they expressed concerns about climate change and how it may result in more frequent and more severe drought conditions. For example, one participant explained how warming temperatures can result in further reductions in available water for energy production and other uses due to evaporation from reservoirs:

We are seeing the summers, especially in the last 10 years, have become a lot hotter and a lot drier. And another thing that happens to us is in reservoirs... the warmer the water, the more evaporation you get... all the water that flows into a lake, you don't get all of it back out again because on a surface area that's that huge, there's a lot of evaporation. And like I said, the warmer the water, the hotter the weather, and the more it warms up, the more

water disappears into the air. And the less you get out. – Hydropower employee, Western Region

Another participant explained how the uncertainty around future conditions makes it difficult to plan for or prepare for drought: *“if we have changing climate conditions it's going to exacerbate those [drought cycles]. It's going to become more prevalent or longer lasting, it's kind of hard to predict. We don't really know if it's going to happen every three years instead of every five years. Or is it going to last for three years versus two years. That's kind of hard to predict.”*

Participants also tied wildfire risk to drought conditions and described some of the impacts that wildfire can have on their operations as well as the increased concern around wildfires in relation to climate change. For example, for those working in the timber industry,

The summertime is a great time to work in the woods, but if we start losing contractor capacity because they're off fighting fires or we have fire restrictions where our days get shorter... or we end up in a full woods closure where we can't work at all. Those are things we have to be able to plan for back in January. The kind of log inventory that carries through to get us through August and September then during the fire season. – Lumber Company Employee, Western Region

Wildfires can also impact utilities by threatening infrastructure and their ability to generate power. Additionally, there is the potential that power lines could ignite fires under high-risk fuel conditions, putting companies at risk of litigation. One participant described wildfire as having *“a big impact on operations.”* As a result, their company is specifically looking at wildfire resiliency strategies. As the participant described, *“We're, very aware of possible impacts with power companies and what's happening as far as fire goes. And none of us are denying that there seems to be more and more fires every year.”*

Access to water

One factor mentioned by the participants in this sector that reduces their business's vulnerability to drought is water storage. For utilities, the ability to store water is not only essential to hydropower generation but it also allows for flexibility in terms of mitigating both drought and flooding impacts. For example, *“Some rivers... there's a lot of storage where they have reservoirs, where they can hold the water, they can anticipate that they're going to have a lot of runoff in the springtime so they draw the reservoir down the and then fill it in the spring and then draw it down again in the winter.”* Similarly, the participant managing a timber company explained how their business has *“water storage capacity. We have ponds we can use and some... So, we'll have to plan ahead as far as how much water we try to hold back to have available through the drought periods.”*

Another participant explained that, while their company has water storage capacity, it is minimal, which puts more pressure on them to during drought,

Almost all of our plants are what we call run of the river plants, where we've got a tiny amount of storage where we can vary it on a daily basis or sometimes on a weekly basis. But generally speaking, the water that's flowing down the river is how much we have to generate with. And so, we just have to learn to do the best that we can with just a small amount of storage. So, obviously if we have less water, then we've got less generation. – Hydropower Engineer, Western Region

In general, having the ability to store water plays a significant role in mitigating drought conditions in this sector while also having the potential to mitigate impacts for other sectors, such as those who rely on surface waters downstream of reservoirs managed by utilities.

Other users

As with other water use sectors, when it comes to water and drought, participants in the energy and industry sector run into conflicts with other water users but also find opportunities for collaboration. Often, hydropower activities have direct implications for downstream users and are legally required to ensure that certain stream flow requirements are met. In drought years, it can be difficult to meet these requirements while also supporting their business. As one participant explained, “*We try to accommodate everyone's needs on that system and it's just challenging when you just have those little water years, but working with everyone and trying to come up with a plan when we see these events happen, I think our biggest thing that we can do is be prepared next time.*” In light of these challenges, this participant further reflected on their company’s strategy in times of drought:

I would say that's one area that [we] can improve on is trying to reach out to those irrigators and try and figure out really their schedule. When's the first cut, when's the second cut, because you have a certain amount of water going into [reservoir]. They do their first cut, they shut off the irrigation system and then you get a big gush of water. You're like, whoa, well, we could have been backing off at [dam] at this time for a week or so and then you don't know when they're going to kick it back on.

Trying to work with them along with a schedule that they have because each year is different on when they're cutting depending on weather and then also how long are they using that irrigation system? ...Working with them, I think that's personally my thing. – Hydropower employee, Southwestern Region

Particularly in the context of wildfires, the participant working for a private timber company explained that they have found success in forming a coalition of timber landowners to communicate with state and federal agencies. This organized structure has facilitated strong working relationships with agencies and collaborative responses to drought-related incidents. They explained the benefit of coalition-building:

So, having some kind of a common voice and a forum for the private landowners to discuss maybe amongst themselves what the strategy is before they sit down with their agency counterparts is beneficial. So, providing that opportunity for like-minded folks, people that have similar concerns to get together and work together collaboratively on solutions outside of just a government driven roles has worked well. – Lumber Company Employee, Western Region

Maintaining strong communication lines and working relationships with state and federal agencies was consistently discussed by participants in this sector as a positive strategy to navigate difficult circumstances around drought and managing water resources.

Water rights and population growth

Another aspect of water access and use that was discussed by one participant in this sector was Montana’s system of water rights, particularly in the context of population growth. The participant expressed concerns with increasing residential water use and the difficulties associated with restricting this type of use in the context of drought conditions:

The resources available for an old water rights holder like us to protect our water availability is becoming more difficult, especially when the new users are generally small volume but high number, it's hard to make the call on water rights when you're talking about residential use, right? Which often times [they] don't even have [individual] water rights or they're so disbursed that you really can't make anyone... I mean, it's easy to point to an irrigator that's over, exceeding their allocation, but to point to 2000 residential uses that are using more than their 15 gallons a minute, it's pretty hard to make that case. I think the whole water rights system is going to have some long-term challenges. – Lumber Company Employee, Western Region

While not specifically discussed by the participants working for utilities, population growth clearly has implications for the demand on their resources, potentially adding additional stress to the management of water resources for hydropower generation during times of drought.

Monitoring data and resources

When it comes to monitoring drought conditions, participants in this sector mentioned accessing several data resources, including NRCS SNOTEL, stream gage networks, the U.S. Drought Monitor, and NOAA National Weather Service. While participants utilize these resources in their work, the most useful data for utility companies was the data they gather directly from dams operated by the company or that is shared by other utilities who participate in a data sharing program. These data are monitored constantly in the context of hydropower and dam operation.

In the context of timber operations, direct observation and lived experience seemed to be the most useful monitoring tool. The participant who manages a timber company explained their strategy around tracking drought conditions:

We're generally trying to anticipate having less water available. And so, a lot of it just comes down to what does the Farmer's Almanac says, right? That might be... That's one of the resources that... One of the few resources out there. Its dependability is horrible, so it comes down to your gut. What do you think this year's going to be like? Roll the dice and do the best job of guessing you can. But as far as currently tracking, it's mostly on the ground experience and weather that's available. – Lumber Company Employee, Western Region

Participants working for utility companies also described snowpack data as being particularly helpful in predicting streamflow and reservoir conditions:

We use NRCS SNOTEL sites to give us a gage on how snowpack's looking throughout the winter. How precip is for a water year, water year is October through September. We look at that too, and just see how much precip we have actually gotten in those certain regions and where it's going to go with droughts, and we noticed it a lot last year, not only with us, but other companies around, not only the state, but the surrounding states that drought hit, but no one was really expecting it to be as drastic as it was. – Hydropower Employee, Southwestern Region

Similarly, a survey participant described their drought monitoring efforts: “Keep an eye on snowpack throughout the winter and keep running our natural flow forecast to try and help predict low water years.” Another participant expressed gratitude for the NRCS SNOTEL data and the other data that modern technology has allowed them to access:

Technology actually does help us because it used to be... back in the old days, they had to go trudge up into the mountains and measure the water manually. Now we have a lot of what are called snow telemetry sites where you can monitor how much snow water equivalent, how much actual moisture's in the water, at different locations up in the mountains. And then we can try to judge how much water we're going to have. We can compare to previous years if we have 150% of snowpack at a certain point in the year, what's that going to look like as far as how much water we're going to have in July and August. – Hydropower Engineer, Western Region

One participant also mentioned utilizing NOAA weather forecasts and stream gage networks to track precipitation and stream flow at different locations and further support efforts to predict conditions and water availability throughout the year. One participant also mentioned checking the U.S. Drought Monitor to understand the current state of drought across Montana and the broader region. Utility companies also utilize internal historic data records, as a participant explained, “to run through our models and pick

similar years, based off of what we've been seeing, inflow wise, we throw those into our model. It spits out a forecasted inflow based off of what our historic inflows were at that time.”

Adapting to drought in the energy and industry sector

Adaptation includes many types of proactive planning for drought, and in this section, we present thematic description of adaptive capacity in the energy and industry sector.

Whether they rely on monitoring and forecasting data or not, participants in this sector are often using historic weather and climate conditions to make informed decisions for their business. Participants described efforts to plan ahead and consider how the availability of water may affect their operations throughout the year. One participant explained that, while they are keenly aware of recent trends, they have yet to significantly adapt their business operations in response to drought, but realize that this may change in the future:

The biggest trend that we see is that in the summertime that there seems to be less water, but it's such... it's hard to get a trend off of just a few years of hot, hot weather. And so right now it affects our overall trend, but we're not making huge changes because year to year variabilities such that we have to still plan to have somewhat close to median flows most of the time. But we are considering what's going on and watching what's going on. So, we'll have to plan ahead as far as how much water we try to hold back to have available through the drought periods. – Lumber Company Employee, Western Region

This participant also explained that they are considering different tree species that may be better adapted to future conditions such as drought-tolerant species. Again, while they explained that their company has not implemented significant operational shifts yet, they are constantly weighing the costs and benefits of shifting their operations in response to changing climatic conditions.

Similarly, another participant expressed, *“I think we do need a plan for less water in the future than we have had in the past.”* One way that this participant and their company are adapting to changing conditions is through their participation in the Energy Imbalance Market (EIM), which connects utilities across the western U.S. As the participant explained, the purpose of the EIM is to support “the cheapest generation and the most flexible generation” in response to intermittent resources such as renewables. While this platform is generally focused on increasing the efficiency and reliability of energy generation across the west, it may also alleviate pressures on utilities to generate hydropower during periods of drought.

Overall, participants in this sector described relatively few actions that they are actively taking to respond to or prepare for drought, but consistently expressed that they are highly focused on tracking drought conditions and anticipate making more adjustments to their business in response to drought in the future.

What's needed to build and support drought resilience in the energy and industry sector

Resources that can decrease vulnerability should mitigate sensitivities and build adaptive capacity, and in this section, we provide thematic description of some resources that could build resilience in the energy and industry sector.

While there were relatively few participants representing the energy and industry sector, interview and survey participants did offer insights into what tools, resources, and information are needed to support the sector in its response to and preparation for drought.

In terms of monitoring resources, one participant expressed the importance of maintaining funding for the network of stream gages across the state, *“It's a continual fight for [stream gages] to keep all their flow stations and they're always trying to cut budgets and eliminate certain sites. And if there's a long history*

and then they go ahead and eliminate a site, then you're losing a lot of data. So just anything that they could do to keep what they've got.” Two participants also expressed interest in additional NRCS SNOTEL sites coming online or manually recorded snowpack sites being converted to SNOTEL sites, where real-time data would be accessible. These participants shared the sentiment, *“The more data you have the better off you are.”*

In addition to expanding existing sources of monitoring data, participants also suggested that having access to more forecasting tools could help them and their businesses more readily prepare for potential drought conditions. As one participant explained:

If we had some better long-term forecasts. I'm not talking about multi-year, but if we knew with some kind of certainty what the summer was going to look like back in January, right? It would allow us to... We thought we were going to have a hot dry summer. We knew we were going to have a hot dry summer with some certainty, then we could maybe do some different planning as far as log inventories, knowing that we're going to have reduced operating. – Lumber Company Employee, Western Region

Participants also expressed interest in building collaborative, multi-stakeholder plans and strategies around drought. One participant appreciated the opportunity to provide input as a stakeholder to the update of the drought management plan and felt that interacting with other stakeholders was key to building effective drought mitigation strategies. As they explained, opportunities to get *“everyone into one room and actually meeting each other and creating that relationship, I think is big.”* Similarly, another participant felt that it is important for individuals and organizations within specific water use sectors to understand how they impact other water users, suggesting that the state should focus on both education and building opportunities for stakeholders to interact and work collaboratively.

One participant also spoke to the intersection of drought and population growth, recommending that the state should develop strategies to support communities with their planning and zoning to ensure that water availability is a key consideration in residential development. Similarly, they would like to see more landowner education and outreach in order *“To get the word out about the why's behind water conservation and things about how we landscape our properties and why we shouldn't build any more golf courses, all that kind of good stuff, right?”*

Recreation and tourism

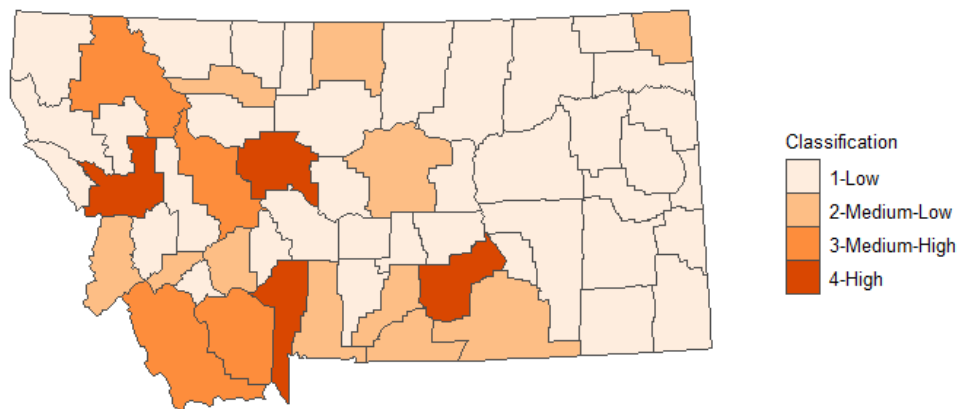
Representing recreation and tourism as a sector were five participants who work as fishing guides, fishing outfitters and lodge owners in Western, Southwestern, and South Central climate regions. There were nine survey responses, accounting for 3.67% of all survey responses.

Recreation and tourism vulnerability index

Figure 8. Drought vulnerability index by county for the recreation and tourism sector

Recreation

Drought Vulnerability Classification



Cascade, Missoula, Yellowstone, and Gallatin counties were the four counties in the state that had the highest vulnerability scores relative to the rest of the state in the recreation and tourism water use sector, which is unsurprising given their large populations and proximity to popular water based recreational resources in the state. Although it may be expected that some of the counties bordering the high vulnerability counties would also have high vulnerability scores, there are several reasons that this is not the case. For example, because Missoula County is the population center and base point for many recreational professionals such as fishing guides, it has the highest vulnerability despite the fact that guides frequently travel daily into other counties such as Ravalli, Granite, or Powell to fish the Bitterroot, Clark Fork, or Blackfoot rivers. Similarly, this is also likely the case with Gallatin and Yellowstone counties, where fishing outfitters or tourists use these population centers as a base to travel to area rivers for fishing or into Yellowstone National Park for recreation.

Counties with Medium-High recreation and tourism vulnerability scores include Flathead, Beaverhead, Madison, and Lewis and Clark counties. All of these counties contain popular rivers for fly fishing and floating or lie in close proximity to a National Park. The majority of the rest of the state have either Medium-Low or Low vulnerability to drought compared to the rest of the state for recreation due to the fact that there is either low recreational use or value on waterways in those counties, or that they lie close to counties with high populations that capture most of the tourism revenue. Although these counties may experience recreationally related impacts from drought, such as hoot owl restrictions, the human impacts from those droughts are experienced where the population base is, which can explain why recreational drought vulnerability is higher in those areas.

Coping with and responding to drought in the recreation and tourism sector

Sensitivity can be conceptualized as experiencing and responding to the impacts of drought, and in this section, we present thematic description of sensitivity in the recreation and tourism sector.

Impacts of drought

Impacts to profession

Overall, participants in the recreation and tourism sector overwhelmingly indicated that drought conditions have a major impact on their profession, as they are highly dependent on water availability to operate their businesses. As a fishing guide in the Western region conveyed, *“we are constantly working with water. That's how we run our business. So water flows, temperatures, radical changes to either of those affect us personally. And obviously, through our business.”* Similarly, another outfitter in the south-central region stated *“Our fishing business is obviously super dependent on water quality and water temp. Two things that really suffer when you have a lot of drought.”*

The inconsistent water availability, particularly in late summer, has had a huge direct impact on booking trips and scheduling, as the booking process usually happens far in advance. Part of this can be attributed to unknowns about future water conditions and being unable to reschedule if conditions are bad, as mentioned by one southwest Montana outfitter who stated *“The challenge for us is our bookings are so far in advance. We can't make some changes when we get closer.”* In the past, August could generally be counted on as a good month if water conditions were good and drought conditions are not present. However, more recently, participants have been noticing consistently dry conditions that often times lead to poor water quantity and quality, the presence of wildfire smoke, and hoot owl restrictions being implemented on many rivers. Additionally, clients have been noticing the changes too, and are starting to shift their behaviors based on weather and water conditions in later summer, as mentioned by one participant:

And I'm in a situation now where I can sell every trip I want in the month of July, but trying to get people to fish in August is really challenging. And that's just where we're at right now. The owners, the clients are a lot more educated, but the rivers and the environment that they're coming out to fish is also a lot less bountiful as far as what they want to do here. So I would say there's been a significant decline. – Fishing Outfitter, South Central Region

Another outfitter described a similar experience in August, where hoot owl restrictions are becoming the norm and therefore causing necessary shifts to their fishing schedule, which is a challenge:

So that's been a pretty significant change. And then just dealing with the hoot owl situation that happens almost every year now, usually starting in August. Although sometimes it happens a little bit earlier. And we've adjusted that schedule, running a lot of morning, half-day trips, and also just meeting clients at dark. And trying to be on the river as soon as it's light and being done fishing, no later than two at the very latest. So, and people are okay with that. Most of the people that we take understand the situation that we're dealing with, and are more than willing to accommodate it. So, but those are probably the biggest changes that we've seen just living here for the past 30 years. – Fishing Outfitter, Western Region

Two interview participants are also outfitters on the Smith River, which has restricted access and a limited number of permits to float the river each season, due to its huge recreation popularity. In recent years, drought has heavily impacted the river, causing it to become too warm and low to float relatively early in the season. In normal years, the river can be floatable through mid-July, so early closures have a huge effect on outfitters who book trips on this river. One of the outfitters stated, *“You know, we really*

don't even book trips in July anymore, because there's too much risk that we won't be able to run that river in July.” Another outfitter referenced the shortened season on the Smith last year, and the large impact it had on their business, stating *“Last year on the Smith River, our last trip was June 16th, which is normally the peak time of year to go down the river. We canceled 10 trips, which is in the neighborhood of \$300,000 worth of revenue, but also in Southwest Montana, we have closings that also impact our business.”*

Clearly, drought has a large direct impact on the recreation industry, particularly the fishing tourism aspect, as low flows and warm water temps cause a decline in the fishery and create undesirable conditions for the clients of fishing businesses. Outfitters are adaptable and do their best to adjust to the conditions, but there are clear challenges. As mentioned by one participant, *“We've been doing this for about 30 years. So we've seen some significant changes for sure. And we're just trying to adjust as best we can to adapt and make good choices, not only for the fishery, but also for our business and personal lives.”*

Impacts to water resources and increasing recreation

There is a general understanding across all sectors that things are changing, and water availability is much less than it used to be, which clearly impacts the resource. Within the recreation sector, it was consistently noted that increasing recreational use is compounding the issues of declining water availability and quality. As one of the participants stated, *“at the same time, the amount of water in our rivers is decreasing at a really rapid pace. You have a kind of corresponding increase in use. And whether that be rancher use, that is recreational use, municipal use.”*

Recent increases in tourism and recreation on rivers in Montana, especially those in western and southwestern Montana has led to concerns about crowding and health of the fisheries. Participants noted this surge in use and popularity, with one stating, *“recreational use has been increasing so dramatically. I know in the Madison the amount of fishing pressure has doubled in about the last eight years. And gosh, what would be the percentage? I don't know, about a 40% year-over-year increase in commercial trips from 2000 to 2021.”* When this increase in use occurs at the same time as drought, the outfitters and guides note not only a decreased outdoor experience due to crowding, but also a negative impact on the fishery as the effects of more fish being caught in drought conditions is appearing to harm the river and fish. This was noted by several participants, with one stating:

So that has dramatic impact on the fishing experience and the river recreation experience. It's harder to measure that impact on fisheries, although we see signs. We do have some quantitative measurements of hook scarring, which is fairly significant. But it is harder when more of us are wanting to love the rivers. The quality of the experience declines. – Fishing Outfitter, Southwestern Region

Ecological and secondary drought impacts

As the impacts of increased fishing pressure compounding the effects of drought are being noticed, the long-term effects of drought are also being noticed and considered from an ecological perspective by the outfitters, who are deeply connected to and reliant on the health of the river ecosystem. One participant talked about these long-term impacts to trout and how those effect their business:

And then long-term impacts are, we rely on wild trout, which are a cold-water species of fish. They need cold water. In the long term, when we have droughts, it can reduce fish counts in rivers. So even in a successive year, if we have a normal water year, we might have lower fish counts. So, we're pretty tied to the drought cycle, hits us pretty hard for sure. – Fishing Outfitter, Southwestern Region

Another fishing outfitter noted the impacts of drought on long-term fishery recruitment, and how drought

and lack of water availability can have negative implications for spawning and overall fish populations:

From a fishery standpoint, we're watching a decline in recruitment in a lot of streams in Montana. The primary cause is lack of water. Kind of mind boggling, isn't it? Fish need water. There's not enough water in the spawning season, if there's low water it's stressful. More water benefits fisheries. The other thing that happens is you have tributary degradation that gets exacerbated by drought. Tributaries dry up. Do you want to have a healthy mainstem? Have a healthy tributary. – Fishing Outfitter, Southwestern Region

The resiliency and long-term recruitment of trout populations declining because of drought can be exacerbated by other climatic and weather events, such as flooding. One outfitter in the Yellowstone region noted this potential issue after the historical flooding event at the beginning of the summer of 2022, which occurred after a drought year:

And so, these fish all get stranded out in these fields and that's an impact that's been happening for years, but the difference is after you've had a really bad drought year and ice in the river and the low, low water in the winter, you don't have the same resilient population you traditionally would have. – Fishing Outfitter, South Central Region

The relationship between other climatic events, such as flooding, for the recreation industry is complex, because in many cases, more water is a good thing for fisheries. However, many participants noted that “*too much of a good thing*” can exacerbate the negative impacts of drought for their businesses. One way in which that can happen is by essentially limiting the peak season, where most business occurs. For example, if there is a flood event in the early season followed by drought in late summer, outfitters peak season is shortened by both of those events. One lodge owner, when speaking about the historical Yellowstone flood, noted that “*in a flood, we lost all of our revenue for the next two weeks.*”

In addition to shortening the peak season, flooding can also cause damage that limits access to boat launches or certain areas of the river. When drought occurs, this could concentrate fishing pressure and negatively impact the fishery when it is most vulnerable with low and warm water. This issue was referenced by an interview participant, who stated:

Well, the floodings tough because a), a bunch of fishing access sites are closed. And b), a lot of the places we usually go, we can't get to, but the flooding in most years, if you have good high water, that's a real positive. But when you have, it's just like anything, too much of a good thing, it can be also too much. And there's been a lot of damage this year. I mean, if you go out to the Livingston golf course right now, and you walk down on the far end of those fairways, probably not right now, but after the flood, it just reeked of dead fish. – Fishing Outfitter, South Central Region

Flooding is a less prominent secondary climatic issue in how it relates to drought, and typically does not present substantial challenges to recreation sector members in normal years. Wildfire, on the other hand, is an extremely relevant secondary climatic issue related to drought that was referenced by many participants, particularly related to smoke. As wildfires often occur more frequently during drought, wildfire smoke becomes an issue that outfitters and their clients consider when planning trips. One interview participant noted that, “*secondly, typically when we have a drought, we also tend to have a lot of forest fires, which impacts air quality. And sometimes it really makes people nervous, and if there's a big fire in the area, they may want to cancel their trip, for obvious reasons. So there's some impacts there.*”

Another outfitter also stated that part of the recreational fishing experience is connected to Montana’s scenery, and that in Montana, “*You can see forever. There's clear skies. You see the mountains. I think that's what Montana's about. I don't think people fly here for 2000 miles and they can't see 30 feet in front*

of them because of smoke.” The wildfire smoke has directly impacted this outfitters business, as he added that “We certainly had cancellations the last couple of years because of wildfires.”

What used to be the popular tourism season seems to be slowly shifting as wildfires in Montana become more common throughout the late summer months. It was pointed out that clients have even become aware of the drought conditions and wildfire smoke coming into Montana from other states, and how that impacts business:

In a drought, it switches around. What we're seeing is people are learning that fire in California and Oregon, the smoke comes here. They're like, "Well, Montana's not that great of a destination in September." Now our season is shortening to June, July, August. And heavy in July and August. I always look at it like that. If things get worse in September and August, which is drought season, that's the peak season of tourism, and so as that goes down, you have a relative impact on your way of life. – Fishing Outfitter, South Central Region

In addition to impacting the client experience, drought also has a physical health impact on the guides who are out there every day. As one interview participant put it, *“It's oppressive, and it causes headaches. It's a physical ... I don't know, it feels harder on those tough years. I think that probably goes, again, with some of the mental fatigue. But there's a physical part of it as well, which is air quality when you're outside all summer.”*

Mental health impacts

Although mental health was not a topic that many participants noted as impacting them, it is no doubt a relevant issue within the recreation sector, as several participants noted that drought is a concern that impacts them. One survey participant noted that, *“watching our ponds dry up, the river levels drop, disease and other outbreaks, drought-stressed fish, the onslaught of invasive weeds, increase in fire regime, the demise of our forests, etc. keeps me up at night.”* An interview participant stated the impacts that drought has in simple and straightforward terms: *“no water, no work.”*

Contributing Factors

Changes to the recreational experience

One of the major ways that drought impacts the recreational water use sector is through its direct impact on the recreation experience and areas where people are able to recreate. Because drought negatively affects both water quality and quantity, the number of waterways that outfitters can bring clients to are limited, as they want to avoid these areas for both the quality of the fishing experience and to make sure they are not negatively impacting the health of the fishery. There is a ripple effect from this, however, as outfitters, in an attempt to avoid areas with poor water quality, tend to all go to an area where water quality is better which subsequently leads to crowding in those areas. This issue was noted by one interview participant:

And then we're significantly impacted by droughts in a variety of ways, one of which is during an excessive drought we have fewer options of where we can take people fishing. Some of the fisheries who might normally be good, when it coincides with warm weather, so when the flows get lower than average in July and August, it's not good for the ... You know, the trout, they're not going to feed all day long. We avoid those areas. We don't want to catch them when the water is too warm, because it puts stress on them. So it means we have less places to take fishermen. And other folks are going to those same places, so those areas that we do go to tend to get more crowded, so we have a poorer-quality experience. – Fishing Outfitter, Southwestern Region

One example of this problem is on the Madison River near Ennis. As noted by one outfitter, the benefit of having a dam-controlled river allows for adequate flows and cooler water in the heat of the summer: *“the Madison, with Hebgen Lake, that goes a long way to help increase flows. In a hot summer you can draw from the reservoir. We have that luxury in Madison that we benefit from.”* For this reason, southwestern Montana outfitters tend to focus on the Madison while many other rivers such as the Big Hole, Beaverhead, and Jefferson experience poorer water conditions. While the water quality is better on the Madison, the crowding often has a negative effect on the total recreation experience.

One outfitter noted the desire to address the issue and evaluate what exactly a sustainable use level is on some waterways:

It's going to be a really bitter pill for a lot of people to swallow, but if you have too many people on too little water and your priority is to provide quality recreational opportunities for residents and non-residents, then I think crowding is the quickest way I know of to ruin a person's quality recreational opportunities. So you have to adjust access to reflect, keep use at a level that's sustainable. And that means we all have to share just like water. – Fishing Outfitter, South Central Region

While occasional bad water years are not uncommon, the frequency and severity of the recent drought, and the expected change in climate continuing into the future is something that outfitters and guests alike are becoming aware of. One outfitter stated, *“if you have one year that's bad, that's okay. But when you get a succession of years, it makes it pretty challenging.”* He continued with this point, using his experiences with guests in the most recent year as an example, *“I think 2022 is the first time where I've seen guests, significant, really concerned about water quantity, and really worried about whether the water's going to be too warm to fish.”*

Ultimately, fishing outfitters think that it is important to be *“recognizing the very important economic value of river-based recreation in Montana, and particularly our trout fisheries.”*, as tourism is one of largest industries in Montana and the health of the rivers and fisheries are heavily tied to that industry. This means that many outfitters are starting to think about how drought will impact the state's rivers and fisheries in the long term, and what that means from a management standpoint. As one stated, *“It's not so much that it's all about fishing. It's just that it's about, we've got a lot of people wanting to use our rivers and the water available, and we have to figure out how to manage it in a way that supports as many boats as possible, so to speak.”*

Considering the value of recreation

As mentioned, the tourism industry in Montana is extremely large, and recreation is a substantial chunk of that industry. Despite the size of the industry, many interview participants in this water use sector feel that the value of recreation is not considered in water management and drought policy as highly as some other sectors. The primary reason for this is because recreation is not a consumptive water use sector, but one that relies on enough high-quality water remaining in the rivers and ecosystem. Despite the fact that water is not being consumed, fishing outfitters feel they deserve an equal spot at the table. As one stated:

We don't consume water, the fishing guide. We recreate in the water. So, it's not something we can participate in. But I think just going back to recognizing just how valuable our rivers are as recreational fisheries. It's a massive, massive economy for the State of Montana. Lots and lots and lots of good jobs that rely on it. And there's value. We just need to recognize that there's value in water being irrigated, growing crops, obviously, but there's also value in leaving enough water in the river for those trout in cold water fisheries to make it through that heat of summer.

That's also valuable... I'd rather them invest money into leaving water in the rivers. Then we'll all be happier. – Fishing Outfitter, Southwestern Region

Another member of the recreation sector, a lodge owner in the Yellowstone region, referenced the size of the Yellowstone tourism economy, and how water shortages or abundances directly influence the industry. He stated, “*the upper Yellowstone watershed is a \$500 million a year tourism economy. Half of that's out of state, half of it's in state. Obviously, drought and flood affect tourism, and therefore, that local economy.*”

Tension among water users

With water shortages related to drought, tension between water users can rise, as every last drop of water is important to the livelihood of those users, no matter their industry or affiliation. In the recreation sector, there is a general feeling among the interview participants that there needs to be better monitoring and management of water within the agricultural sector to ensure that producers and ranchers know how much water they are using, and to ensure that water rights are properly allocated. One participant who works in both the recreation and agricultural sectors stated that “*We don't have a clue what water users are using. If you've got bad actors in one place that are affecting another, nobody knows. There should be a high priority on how can technology help that and prioritize what are the most important water users that we need to tackle first?*”

While this participant makes a point about bad actors, it is important to note that the reference does not mean that all people in a certain industry are bad actors. What it does mean is that, without proper technology or monitoring, it is more difficult to catch the small number of bad actors who are overusing water. One solution this same participant suggested was to install meters on pumps, which would help users stay within their water rights. As he stated, “*I keep a meter on my pump. And so I look at it and I don't run above my water right. But I'd say 90% of the people don't do that. Everybody knows their water right. Nobody knows what they're using actually.*”

This same point was also made by another participant, who is a fishing outfitter in the Southwestern region. He mentioned that the water rights system is an arcane system that is slanted in the favor of irrigators. With that in mind, he mentioned that he would like more monitoring to ensure that water rights holders get exactly what they are allocated under that system, stating that “*What I am advocating is a way to monitor a stream or a tributary to make sure water flows legally to water users when they want it. They get no more. They get no less.*”

One of the main challenges and reasons for tension is that everybody wants more water for their respective needs, which is a point that is recognized by many participants. As one stated:

We're always wanting the most, up to a point, obviously, the most water that we can have in the river. Is better for the fish, better for everybody. And I don't know. That's why we talk about having a conversation with some irrigation folks. And then of course, they're like, "Well, that's my business. Right. That's going to impact my livelihood. And I'm not going to be able to put food on that table for my family." So that's a hot topic for those folks as well. – Fishing Outfitter, Western Region

Although there is occasionally tension between agriculture and recreation that can be exacerbated by bad actors on both sides, there is a recognition from most people within the recreation sector that their frustrations with water use and irrigation is not due to agricultural producers, but rather the system of prior appropriation that water law is based in. Therefore, they most strongly advocate for changes to the system that benefit all water users. One participant stated that:

And it's kind of the system we have. And as I've noticed on many occasions, especially in 2017 or whatever year it was that we closed down the Yellowstone to do the Whitefish kill. That was a year where we were cutting people off on water, like in 1888 and 1892. So when you've got water, that's that over appropriated that people with a water right from 1892, can't get water. Agriculture's not the problem. It's something else. And I mean, agriculture's, I don't want to say agriculture's any part of the problem. What I would say is we're all part of the problem and the problem is that we don't have enough water to go around and we just need to figure out how, and it seems as though we're entering into a climatic regime where our water future's a lot less dependable. – Fishing Outfitter, South Central Region

Although the tension between recreation and agriculture is the most common conflict, there is also tension within the recreation sector between different types of water users, particularly fishermen and casual recreational floaters. As one participant mentioned, the main issue is that recreational floaters crowd the rivers and access points, yet do not pay anything to use it, like license fees or permits.

And I know in other states, fishing licenses are paying for those access sites, boats. And the people that are tubing and recreational floating, they don't pay a thing. And it's not okay anymore. They need to, I don't care what it is, a tube tax or a parking fee. But I mean, they're using these resources to a detrimental level. And I know the outfitters get the heat and that's fine, but it's not us. We take care of that resource. Our clients are paying for that resource. We're paying for it. There's permit fees that we pay for. And I think that's something that definitely needs to be addressed sooner than later. And I don't know who would be doing that. FWP should definitely step up and charge some sort of a parking fee for those folks. – Fishing Outfitter, Western Region

In times of drought, when funding is needed for watersheds, fishing outfitters and guides would like an equal contribution from all water users, which includes casual floaters and other water recreationists who are not fishing but still use and impact the resource.

Adapting to drought in the recreation and tourism sector

Adaptation includes many types of proactive planning for drought, and in this section, we present thematic description of adaptive capacity in the recreation and tourism sector.

Monitoring data and resources

When asked about what types of data and resources are used to monitor drought conditions participants mentioned a variety of sources, including stream gages, snowpack, long term trends, and their lived experiences and on the ground observations. Additionally, many participants mentioned paying attention to monitors such as the U.S. Drought Monitor as well as long- and short-term weather forecasts. Generally, members of this sector tend to monitor resources that will help them make informed decisions on scheduling fishing seasons and clients and understanding current and future water flows and temperatures.

The most commonly mentioned monitoring resource for the recreation sector are stream gage networks, as these resources provide real time information to fishing guides and outfitters on flows and often times stream temperatures. Outfitters and guides are well in tune with what are considered good flows and proper temperatures to trout fish on the rivers they guide, so they rely on these gages to make decisions on which rivers to fish on any given day. As one participant mentioned, “*We also regularly look at stream gages, water levels, and they mean different things at different times of the year.*” For example, a participant mentioned that when “*there's a lot of snow on the mountains it's more a reflection of somewhat how much snow is up there, but also how warm it's been, or if it's been recent rain, so you have*

the rivers rising and falling, above average, below average,” so the flows often times reflect what has been happening with the weather recently and what can be expected in the near future.

The other thing that the gages are used for is for monitoring what the base flows for rivers look like in the offseason, as those *“give us an idea of what to expect.”* The base flows are important for getting an idea of what the coming season will look like and if there is concern for the long-term effects of a multi-year drought impacting future flows. As mentioned by one participant, *“if we're coming off of a previous drought year and our groundwater table is depleted, even if we get an average snowpack, we may still have lower than average flows later in the summer, because the groundwater table may not have fully returned.”*

Finally, the importance of stream flow gages in monitoring legal water use for all users was voiced by some participants. Without the gages, there is less information on where the water is going and how that impacts different water users. Members of the recreation industry would like to have more say and involvement in helping improve and pay for the stream gage network. As mentioned by one participant, *“for your water commissioner and ditch rider that are for “water users,” which are irrigators, I consider myself a water user. We would like to be at the table in paying for those things.”*

Another monitoring resource used by members of the recreation sector is snowpack maps and the network or SNOTEL sites in the state, as these can give people an idea of what flows may be expected later in the year, and time when spring runoff may be at its peak. These sites are watched *“throughout the winter and the spring to get an idea of how much total moisture is in the mountains, cumulative.”* For the recreation and tourism sector, these data can help predict their season start times and navigate bookings. Even with snowpack maps, this can still be a challenge, as discussed by a participant discussing the challenge of timing bookings:

*Like, how soon do you start fishing when runoff ends? If it's a drought year, you start fishing earlier. But then it might make for a really hard August or late July. So if we get into March and we're really behind on snow, and we still have some bookings to go, sometimes if someone has a choice, we might steer them towards October versus early August, you know? So it does impact to a certain degree. It's difficult because we book so far in advance. Often, a lot of what we're booking is before we even know what will happen.
– Fishing Outfitter, Southwestern Region*

Sometimes, even with good snowpack data, it can still be hard for outfitters to make bookings, such as this past year, where one outfitter was *“pushing everybody into July because the snowpack was so dismal. And then of course, and in April looked the same way, but then, May hit and the world changed. So that's kind of the challenge.”* Therefore, most outfitters use a combination of data sources, like *“the drought monitor maps, soil moisture maps, the snowpack maps, and stream gage flows”* to try and make decisions. As discussed with one participant who mentioned:

I've been watching those for years and years and years, so I usually have a pretty good idea of where we're at real time, and then we use that to guess what's the probability of the future knowing that we're within a certain ... You know, the farther out you go, the more of a guess it is. But I feel like those are pretty good gages on giving you an idea of what's actually happening out there in real time. – Fishing Outfitter, Southwestern Region

While the data and information available in the stream gages, SNOTEL stations, and the U.S. Drought Monitor are useful for outfitters and guides who rely on those resources for their profession, it was noted that *“the consolidation of that into a place that an average person can look at, just like they open their phone and they look for the forecast on the weather, that is absent, totally absent in the water world.”*

This is an area where some members of this sector feel there could be improvement to be able to provide information “*to the consumer in a simple way.*”

Within the people who were interviewed in the recreation water use sector, most were fishing guides or outfitters, who are on the rivers every day of the peak season. The above data tools and monitoring resources are mostly helpful for gaining an understanding of future conditions for a season, based on knowledge of the snowpack and trends in recent conditions. Although the stream flow gages are used on a more daily basis compared to some of the other tools, a majority of the monitoring of drought conditions in this sector come from direct observations, lived experiences, and on the ground monitoring as a result of the amount of time spent on the water. As mentioned by one long time outfitter, “*we've seen changes over the last 20 years, and we're sort of making the guess that, based on the best science, that some of those trends will probably continue, and adjusting accordingly.*”

There is some evidence from interview participants, that as a result of being on the water every day, fishing guides may be able to respond to and observe drought conditions before data or state agencies do. This allows them to make decisions and appropriately respond to poor conditions even before restrictions such as hoot owl closures are implemented. For example, one outfitter stated,

I think we can make pretty darn good choices, especially our guides are basically doing R&D out there every day. We get feedback from them all the time. Last year when it was super-warm, starting basically the entire month of June, we knew that there were dead fish long before that was being published in the papers or on the news or anything like that. And so, we're adjusting where we're fishing based on all of that feedback that we get from our guides. – Fishing Outfitter, Western Region

Part of this ability to respond to conditions is because many fishing guides carry tools, such as temperature gages to measure the temperature of the water. One of the outfitters who was interviewed stated, “*our guides now, almost all of them have a thermometer. So they're checking river temps. And we try not to fish anytime the rivers get anywhere close to 70 degrees, that's when we call it. So, those are the ways that we monitor it.*” It was clear from the interviews that closely monitoring conditions and only fishing in areas where conditions are favorable, both for fishing success and the health of the ecosystem, are priorities for most outfitters. The continuation of their profession is reliant on the health of the fisheries and being able to accurately monitor conditions is a key aspect of that.

Drought planning

Planning for drought conditions has become a consistent aspect of life for members of the recreation water use sector, as some form of drought has become expected at some point during the peak recreational use seasons. The main adjustments made by fishing outfitters and guides is “*booking earlier in the spring*” and changing their daily fishing times later in the summer. One outfitter stated, “*we've really focused on fishing in those morning hours.*”, while another said, “*when water's too warm, we don't fish. Not because it's bad on the fish, but the biggest reason we don't fish is because the fishing's no good.*” Of course, as mentioned above, avoiding areas with warm water means that “*you try to go find some other place to fish with a little cooler water, but what that does is tends to really make those spots with cool water, a lot more crowded and then those fish get hit too hard.*” Even with adjustments made to timing, more people out fishing and a shorter number of fishing hours and locations to safely fish can quickly lead to crowding, which also had adverse long-term impacts on the resource.

The shift in fishing times during the summer and focusing on the morning hours is also a response to a change in the ecosystem and timing of bug hatches on many rivers too. One outfitter elaborated on these changes and shifts in schedule:

I mean, back when we first started, the meet times for morning outfitted trips were almost always 8:30, nine o'clock sometimes. There was no need to get off the river early. Usually, we would almost fish till dark, which if anybody's been to Montana, sometimes dark in June isn't until about 10:30. And we would see great evening hatches on the Lower Clark Fork, and the fishing would be great. And that doesn't really exist as much anymore. One, the river, it's just too warm in the evenings to do that. So, we've really focused on fishing in those morning hours. – Fishing Outfitter, Western Region

These long-term changes also make future planning for outfitting businesses challenging, as the investment in new properties or lodging areas becomes tricky with the uncertainty of future conditions.

When I talk about long-term planning, I'm talking about multiple-year investments, something like buying a property for a lodge. We are guessing that there'll be more frequent droughts. We are guessing that runoff will, on average, continue to move up earlier, which means we'll have longer windows of low and warm flows. And on rivers that are ... Every fishery's different, but on those rivers that have more temperature exposure, we're predicting that fish counts will probably decline, the moving average. We're predicting we'll probably have more intense fire seasons, which affects everything. That's not really one river at a time. So we're a little nervous about investing in any operations that we're depending on a river that is more impacted by a bad drought year than others. That's the long term. – Fishing Outfitter, Southwestern Region

For other recreation sector professionals, the consideration for drought conditions is simply “*annual business planning.*”

While changes in scheduling and long-term business planning is one way that recreation sector members plan for drought, collaborative efforts through local groups and coalitions are another important component for drought planning, as these allow viewpoints from different water use sectors to come together and plan. As stated by one participant, “*the only way to mitigate in a drought in a positive manner is to work within your local watershed group.*” Part of working in a positive manner means “*you've got to find a way to build a relationship where you can communicate. One, you need the structure, which is a watershed group or committee. Two, you need the commitment to get legitimate stakeholders involved.*” even if they have different viewpoints that may conflict with yours. There is an understanding that these working groups may take time to develop, and that the relationships will take time and require discussion and understanding of all views:

You need anybody that uses water to start sitting down and figuring out your system. Again, it's a time component where for the first year or two years, you're just trying to have a discussion so you can slowly move the ball forward and consider your options. You can't make it work by saying, "I want this and the hell with you." You got to create a win-win. You got to figure out how you can work with other organizations. You got to figure out what other organizations and resources are at your disposal. – Fishing Outfitter, Southwestern Region

Watershed groups are well formed in most parts of Montana, and some of the interview participants referenced their success, particularly in tough drought years.

The only way to mitigate in a drought in a positive manner is to work within your local watershed group. So whether it's the big hole or the Ruby or the Black Foot, is those local people understand those conditions. A lot of times, last year would be an example, with both the Ruby, the big hole, and the Jefferson watershed group, where irrigators kept water in the river to the benefit of all users. They took a pay cut. What local water groups do not want, is they do not want to lose control and by feeding it to Helena. Having local

watershed groups is the most effective way to manage water. – Fishing Outfitter, Southwestern Region

There is certainly interest in the expansion of watershed groups throughout all areas of the state, with one participant stating, “*you need those in every drainage in the state*”, and another from the Western region stating, “*it would be nice if there was more of that, I think, in the Missoula area, for sure.*”

One final issue that is brought up that is a consideration in drought planning is the growing demand for water, both in use and for recreational purposes. One participant has been concerned about sustainable use of water and the need to make changes and have the discussion to fix some of the problems immediately:

The frustration is none of it's sustainable. If we would've been having this conversation in 1995, we would've been better off today. Having this conversation in 2022, to a degree is fine, but no, none of it's sustainable. You're going to see an increased demand for water and a smaller supply. I would put that in capital letters. You're going to have an increased demand for water and less supply. It's not sustainable. – Fishing Outfitter, Southwestern Region

Education and outreach

Building adaptive capacity and resilience to drought is closely related to planning for drought, as much of the drought planning, such as earlier fishing times and shifting seasons, is a direct adaptation to drought conditions in the recreation sector. In addition to planning, being able to engage with and educate people on effective drought response strategies creates relationships and the idea that we are “*collectively scaling water back*” and that no one is alone or can be alone in doing this work. One outfitter mentioned, “*I think coordinating relationships so that when there is drought, everybody is invested in leaving some water in the river. Collectively scaling back water usage.*”

Part of the education and information channels could be through improvements on understanding hoot owl restrictions, and better coordination between outfitters and recreational users during drought to spread people out so overcrowding or overfishing of a certain section of river does not occur. For example, one outfitter discussed some of the issues on the Blackfoot river, and the importance of communication between shuttle drivers and other outfitters:

I mean, anytime there's any kind of a closure or these hoot owl things, we're all gauging what everybody else is doing. And honestly, I think that most of these guys are trying to do the right thing. Trying to stay in business, but also know that we depend on these trout and these rivers to be healthy. And so, we've got to do the best we can do. But really when we're just super busy, June, July, August, it's really communicated. A lot of it is through the shuttle guys. Right. And everybody knows, we don't want to pack a bunch of people into one stretch. And if you do that, you get a bad name out there. – Fishing Outfitter, Western Region

Hoot owl restrictions are a well-known adaptation strategy to minimize impacts on the fishery for outfitters, and outfitters know that “*if we're going to have hoot owls and early restrictions, then we go back, and sometimes, some trips where we have the ability to move, we adjust where they go.*” Additionally, even in times where there may not yet be hoot owl restrictions in place, if conditions are approaching that threshold, outfitters frequently communicate to make sure they are not impacting the resource or fishing in dangerous water conditions for the fish. One outfitter discussed this, saying “*we're all networking, and everybody's trying to do the right thing for sure. So as soon as we see that the water*

temps are coming up, and the rivers are dropping to a level that we think is low, and the fish are having issues in the heat of the day. Everybody's on board with the 5:30 am meets."

However, the communication that occurs among outfitters is not happening with the general public who also use the rivers for recreation, which is viewed as somewhat of a problem by some outfitters and an area where education efforts and consistency in messaging and restrictions could improve. While the communication channels between outfitters and the general public may not be available, the communication about hoot owl restrictions and when it is dangerous water temperatures to be fishing at could be improved by agencies. One outfitter discussed this issue, using hoot owl restrictions in the Missoula area as an example.

I think there's certain stretches of water that are open and closed. Why the Middle Clark Fork would be open right now after two to fishing is beyond me. It's not okay. Now that being said, none of the outfitters, none of the guides that I know are going up there and fishing. We get it, but the public doesn't know that. They don't know. So that would be one thing I think that would be a bit, and I think all the outfitters, the guides would appreciate that. We're already on that schedule anyway. And honestly, we're usually a couple weeks ahead of any kind of a closure, because we get it, right. We know what's happening out there. So that would be super-helpful. – Fishing Outfitter, Western Region

The key point here is that the outfitters know they shouldn't be fishing certain stretches of river, even if they are not closed, but the general public may not have as much knowledge about this. To make things easier, this outfitter suggested that *"it would be great if FWP would just say once one of the rivers in this area is under hoot owl restrictions, just do it on all of them. Don't have certain stretches, just call it. Just say the Blackfoot, the Bitterroot, the Clark Fork ... the three major rivers, just shut them all down at two."* Doing this would take the guess work out of which sections or which rivers are closed and provide a consistent message to the public that would also be of benefit to the health of the river and fisheries.

Another interview participant who owns a lodge and also manages a small agricultural operation discussed the benefit of improving soil health and how that leads to an increase in plant life and wildlife. While the investments in soil moisture are an adaptation strategy for agriculture, the ecosystem benefits are a plus and something that draw people in for tourism as well. As he mentions, *"the cool thing for me as a lodging business, if I work on my soil hard, you get the plants, then you get the insects, then you get the birds, then you get the wildlife. If you have all of those, people pay you a lot of money to come see it."*

Some participants also referenced some of the successes that can be seen in areas that are addressing drought or that have watershed groups. Even in tough drought years, there is evidence that having a plan in place can work, and that there is a recognition of the shared sacrifice from all water use sectors. This is evident, according to one participant, with the *"success in Southwest Montana with water users, and again, a ton of credit goes to landowners that take a financial haircut to keep water on their property instead of draining the river dry ... So wherever you see water in a super dry year running, there's a lot of people that made that successful."*

Another example of success is in areas where there is capacity for water storage, which allows for flows to be managed and increased if needed in the summer. A southwest Montana outfitter used the Ruby River and Ruby reservoir as an example, where *"the Ruby reservoir is having meetings about increasing the storage in the reservoir, which when they built it, they have the capacity to increase the storage at a cost-effective price. That discussion is going on. That's an example of, there's a discussion, there's an*

action involved, and then we'll see what happens.” Having extra water storage is a clear benefit for water users over multiple sectors.

What's needed to build and support drought resilience in the recreation and tourism sector

Resources that can decrease vulnerability should mitigate sensitivities and build adaptive capacity, and in this section, we provide thematic description of some resources that could build resilience in the recreation and tourism sector.

General reflections on state plan

In reflecting on the state plan as a whole and what is needed, participants strongly recognized that drought will be ever present, and that climate change is a contributing factor that will likely lead to the spread and intensification of drought. Many of these participants recognize that *“the weather is just the weather, and so you change, and you adapt, and you go forward.”* But that the climate change issue contributing to that is *“a whole different scenario that's global, and it's scary.”* Participants *“would like to see a better acknowledgement of the role of climate change in western drought,”* and also a recognition that *“we're all part of the problem and the problem is that we don't have enough water to go around, and we just need to figure out how”* as first steps to being able to look toward solutions.

To begin to address the problem, many participants discussed having equal representation for all stakeholders and water use sectors in planning. Many people expressed the importance of tourism and recreation, and *“recognizing the very important economic value of river-based recreation in Montana, and particularly our trout fisheries. Tourism, depending on how you gage it, if you count in-state tourism as tourism, tourism is the number one driver of the Montana economy.”* Some participants also feel that the state does not do enough to listen to stakeholders in the recreation and tourism sectors, and that it is unfairly geared towards agriculture. This is not to say that agriculture is not important, but that they would like *“to have representation from the tourism economy in your decision making.”*

Ultimately, members of the recreation and tourism industry currently feel that the state could be doing more, and what they want to see from the plan are actionable strategies to address drought. As one participant stated in regard to the discussions and drought response, *“none of it is important unless the plan comes up with some bite to it.”*

Improvements to public policy, relief, and payment programs

Many stakeholders discussed ways they would like to see state agencies and public policy improvement in responding to drought. One clear improvement that is desired is the continued investment into the creation of watershed groups. Members of the recreational sector consistently stated the success of watershed groups across the state and how it gives them a seat at the table and allows for collaboration that ultimately works to the benefit of all stakeholders. There is a desire from the state to help with the development of these watershed groups, and to help bring people together, provide funding, or help facilitate meetings. One interview participant noted that facilitation is extremely helpful from the state, stating that *“DNRC, or a government agency, has been good as a facilitator, because you do need somebody to facilitate saying, “We're not going to raise our voices. We're not going to scream at one another. We're going to respect one another.” Those are important things.”*

Getting people together and establishing relationships is important for cohesive messaging and education outreach, according to participants, and watershed groups can help with that. One participant stated, in response to being asked what would be helpful, *“I think coordinating relationships so that when there is drought, everybody is invested in leaving some water in the river.”* Another participant thinks that *“the most effective thing you can do is work within your local community.”*, and that *“what would be a benefit*

from the governor's office is to be a cheerleader on these local watersheds.” With that being said, this interview participant went on to say that what they “think is necessary is for DNRC to start, DNRC or the governor's office, to create watershed groups throughout the state.”

The implementation of watershed groups would also likely help with a larger issue that was brought up frequently, which is lack of enforcement of water use or water rights. For example, one outfitter who guides on the Smith River brought up the fact that on the Smith, a watershed group could help with a variety of these problems:

There's no watershed group. There's no water commissioner. There's no ditch rider. There's no enforcement. So, FWP has money, or the state has money that comes off as something called a Smith River enhancement corridor fund. So every non-resident that goes down with an outfitter contributes so much money into that fund. We would have the possibility to broker with landowners, just to say how much money... if they produce a ton of hay, we can just say, "Why don't we just pay for a ton of hay somewhere else and the money that we you'd use to grow it, we'll leave in the river." So those are those possibilities.
– Fishing Outfitter, Southwestern Region

Another suggestion from another participant to help with watershed groups and enforcement is to “catalog where are there watershed groups or water districts? Where are their water commissioners/ditch riders?” With the reasoning that “a problem with the state of Montana, is that certain drainages do not have a ditch rider/water commissioner. There is no enforcement authority.” From that statement, there were very clear suggestions from several participants that enforcing water rights and having water commissioners or ditch riders to enforce and regulate use is important. To make this most effective it was also noted that it is vital to recognize that “we are all water users. I would like to see that defined, that water users are not singularly irrigators.”

A benefit to more enforcement is that enlisting ditch riders or water commissioners is also a way to lessen the tension and conflict that sometimes arises between water users, as one participant stated that “there's a lot of venting about people that take water out of the river” amongst the recreation sector stakeholders. It would be helpful to have someone there to facilitate “at least a conversation that gets started where we talk about just trying to keep as much water in the river as possible.”

Water rights were also another issue where recreation sector stakeholders would like to see improvement, both through better enforcement as just discussed above, and through the acquisition of water rights. As pointed out by one interview participant, “if somebody's got a water right. That word right, means quite a bit in this world. I don't have a recreational right. They do have a water right. That's kind of a tough rub for fishermen to swallow, but it makes sense.” With the obvious power that water rights hold, some recreation sector members would like to be able to secure some water rights to be able to keep water in the rivers, as well as see better water usage in other sectors. One participant stated, in reference to what would be helpful, that “if you can have better water usage through ag, if you can secure some water rights to leave those in the river in really bad years.”

Part of the challenge with the water rights issue is that water rights are based on a system and laws that were created well before there was much consideration for the ecological or recreational value of the rivers and are more based on irrigator needs. With so much change to the Montana economy and ecosystems over time, many participants believe water law should be reevaluated. One survey respondent left a comment stating that the state needs to, “reevaluate water management practice and law at the state level - we are stuck in an antiquated, last century water permit system that does not have the flexibility needed to allocate available water where it is needed.”

Finally, some participants also wanted the state to explore ways to generate additional revenue so that more funding could be allocated to watershed improvements and drought impacts. Some outfitters and guides feel that they and fishermen are the only ones paying for the resource through fishing license fees and guide permits, despite the fact that casual floaters and other recreationists also use the resource an equal amount. One outfitter stated as an idea that *“it's like implementing hoot owl on all the rivers, I think is a big deal. And pay to play. That's what I think too. And then take that money and do some good things for the river. Be it drought, overuse, making those access sites safe.”* This participant feels that if there are some sort of access fees or permits, and *“that when people pay to play, I think they take just a little bit better care of it. And maybe it weeds some of those people out. And I don't even care if it was a dollar if it's a dollar a tube or whatever.”* In relation to this, a survey participant suggested that drought restrictions be enforced with fines. To do this, however, there would need to be clearly defined drought restrictions in addition to hoot owl put in place.

Additional monitoring needs

Overall, members of the recreation sector had similar monitoring needs as many of the other water use sectors. Improvements to data tools and monitoring sites such as stream gages, snowpack, and drought monitoring and forecasting were all areas where improvements and investment would be helpful. Of these tools, stream gages were likely the most important for this sector as many stakeholders rely on these daily, particularly during peak tourism season. One participant stated, *“you have to have gages. You have to have gages that are telling you where the water is, when it left, and where it's going.”*

In addition to monitoring tools and data, there was also a desire from some stakeholders to try and have better long-term forecasting, or outlooks for the upcoming year. One participant compared the long-term forecasting to weather forecasting and how he thinks they should go beyond just short-term forecasting, stating, *“you think of it with weather it's like, once you get past 10 days, the quality goes down, which is why they don't really give you past 10 days. I think they should.”* He went on to say that there is an understanding that the accuracy long term may not be as good, but that it could be helpful to supplement other information.

Planning and community development

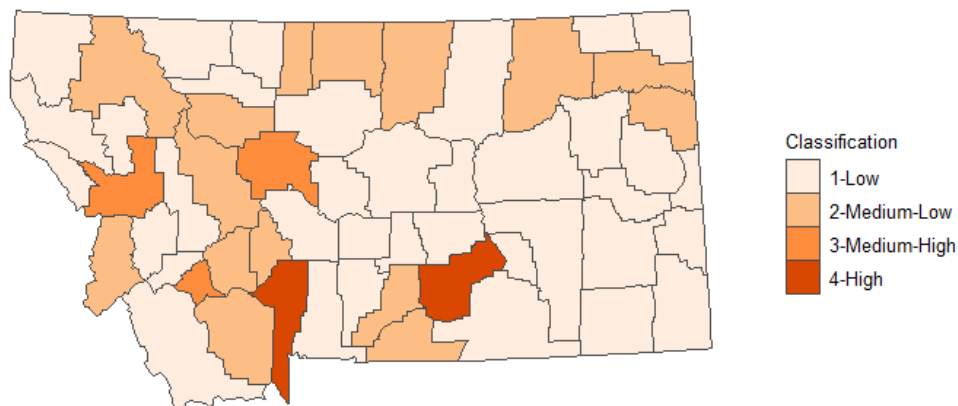
During the interview and survey outreach phase of the vulnerability assessment, “planning and community development” and “municipal water supply” were defined as two separate water use sector categories. However, in analyzing the qualitative data for these sectors, the distinction between them was less apparent, as there was often considerable overlap and similarities between the two sectors. As such, and for the purposes of clarity, the narrative presented here includes qualitative findings from both sectors. In total, 19 interview participants and 63 survey participants identified planning and community development or municipal water supply as their primary water use sector. Most participants in this sector work for municipalities or counties. Positions among participants in this sector included a water commissioner, county commissioners, water resource managers, land use planners, and other similar positions. Interview participants represented five of the seven state climate regions, the South Central and Southeastern regions were not represented in the sample. All climate regions were represented by the survey sample for this sector.

Although planning and community development and municipal water supply were combined for the qualitative analysis, they remain separate for the vulnerability index classifications, as there are well defined differences between the data indicators for each of these sectors. Planning and community development data captures county wide growth and total water use, which includes both personal wells and public supplies within the whole county. Municipal water data captures data more specific to municipalities and public/city water supplies. While both sectors face many of the same challenges and members from these sectors often work together (which is the reason the qualitative data are combined), it is still important to note the differences in vulnerability between municipalities and more broad county planning and growth challenges related to drought, which is what the separate index maps below display.

Planning and community development vulnerability index

Figure 9. Drought vulnerability index by county for the planning and community development sector

Planning and Community Development Drought Vulnerability Classification



The planning and community development water use sector includes community members involved in county wide planning, development, and local politics. Therefore, the two counties with the highest

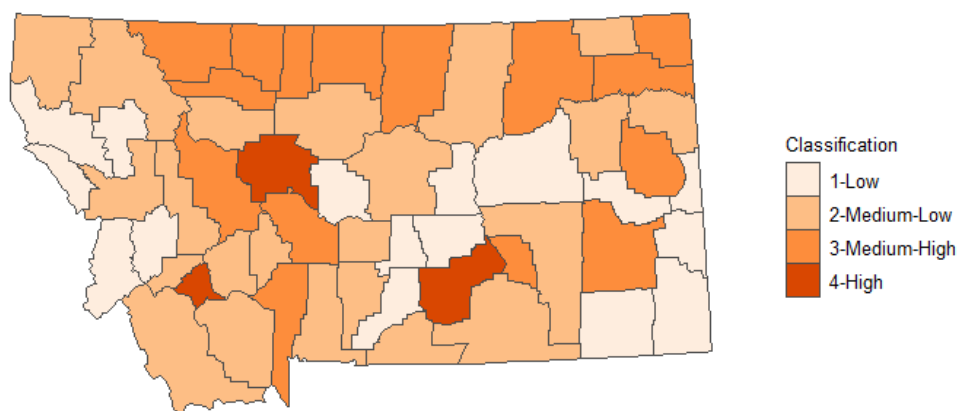
vulnerability in the state in this sector compared to all other counties, Gallatin, and Yellowstone, are two counties with relatively high populations and high growth rates. Accommodating growing populations and balancing competing demands requires local planning and administration to avoid drought-related emergencies.

Three counties have medium-high vulnerability to drought: Missoula, Cascade, and Silver Bow. These counties are experiencing similar issues with growth as Gallatin and Yellowstone counties but are either experiencing that growth at a lower degree or have better access to water resources and less drought exposure.

Figure 10. Drought vulnerability index by county for the municipal water sector

Municipal Water

Drought Vulnerability Classification



Silver Bow, Cascade, and Yellowstone counties all have high vulnerability to drought compared to the rest of the state for the municipal water supply sector. More than half of the rest of the counties in the state have either medium-high or medium-low vulnerability to drought for municipalities. Significant contributing factors to vulnerability include having a high percentage of people that rely on a municipal system rather than a personal well, high per capita municipal water use and, in some areas, higher exposure to drought. All of these can present challenges to municipal water systems, especially if there is substantial population growth occurring in the county or municipality.

Coping with and responding to drought in the planning and community development sector

Sensitivity can be conceptualized as experiencing and responding to the impacts of drought, and in this section, we present thematic description of sensitivity in the planning and community development sector.

Impacts to profession

Participants in this sector have a unique role in addressing drought in that, as population growth and climate change have and will likely continue to exacerbate drought conditions and impacts, there is a growing demand and *“greater focus and attention on policy and planning.”* In some ways, these circumstances result in a positive impact on livelihoods within this sector, and *“it is easier to talk about these subjects,”* as there is a growing consensus and understanding among the community about the importance of planning and public policy efforts to mitigate drought. In other ways, drought conditions generate new and complicated challenges that individuals in this sector are often tasked with creating

solutions to. With the health, safety, and wellbeing of communities at the center of their work, drought generates a number of environmental and economic concerns for this sector, including threats to water quality and increased frequency and severity of wildfires.

Ensuring reliable access to clean water is, of course, essential to communities and is one of the key ways that water management and drought intersect with community planning and policy. Several participants suggested that access to clean water was an increasing planning concern as many communities in Montana are growing and looking to develop more land. One survey participant explained, *“The county has no water/sewer infrastructure so drought also has the potential, and in some cases already is limiting areas for residential/industrial development.”* Another participant described water as the limiting factor in residential development:

It's whether they're willing to put money into fixing infrastructure, expanding infrastructure, you can't just drill a well anywhere. There's a lot of places where people are hauling water. No one wants to buy a spec house somewhere beautiful with a view of the Rocky Mountains if they've got to haul water. So, if you can find water, you can secure water, you can take care of water, then development will happen, then responsible growth will happen. And so, it all comes down to water. It all comes back to water. And I think that's something a lot of people are overlooking until they go to try and build a house somewhere. – County Planner, Central Region

Furthermore, one participant suggested that there is a shared expectation among individuals and communities across the state that Montana provides access to clean water and recreation opportunities. Ultimately, that expectation and the idea that Montanans are *“counting on those recreational and quality of life opportunities to continue”* impacts how professionals involved in planning and policy for communities engage in their work and prioritize planning strategies.

Multiple participants also mentioned concerns around the economic impacts that drought has on various water use sectors, particularly those that are a major economic driver for the particular community that they serve. For example, a survey respondent explained, *“Our community relies on agricultural income. Drought can have severe consequences on our economy.”* Similarly, another participant working in a community that significantly relies on recreation and tourism shared:

Certainly, my mind goes to those instances where the water temperature and flows have been water temperature so high, flows so low, that we have a stressed fish population that closes our major rivers to recreational or even guided fishing. And the impacts that has, that ripple through the community, that doesn't impact me necessarily professionally, but definitely have an impact on our local economy and our business industry. – Municipal Water Employee, Western Region

Several participants described concerns around water infrastructure and the impacts that drought has on key water resources. Multiple participants representing communities with a strong agricultural focus described instances where drought has caused producers to attempt to drill new wells, but they cannot always find reliable access to clean water. Another participant described producers' attempts to slow stream flows, *“Some people are blocking them off with hay bales and trying to back it up. That causes problems.”* In other areas where drilling wells is not an option and drought has diminished stream flows, some producers are forced to haul water to meet their needs.

In addition to discussing the more immediate impacts of drought, several participants connected drought to wildfires and flooding, phenomena that are often key to planning efforts across the state given the threats they pose to human health and safety and community infrastructure. Flooding events are a

common concern among participants in this sector, as the impacts can take an enormous toll on communities and have considerable policy and planning implications. One participant noted the changes they have seen in flooding events, *“We see our flooding events becoming more common and more frequent than they have in the past, largely not because we have more water, but because we have these just rapid changes in temperatures that cause the faucet to get turned on in a more violent way than we've historically seen.”* Another participant, speaking about a particular watershed, described a kind of alternating effect between drought and flood conditions:

[20]16 was a really bad drought year and '17 had a good snowpack, but it was... like 90 days in a row of 90-degree heat in the summer of '17. We had to do an entire river call. We had to shut down all irrigation... it hasn't been bad since then, we had two big flood years, '18 and '19, were ridiculous flood years. And, that's why I say, on any given year, there's water available. I think we passed 400,000 acre-feet out of the river system between those two years. So, we could have filled up, I don't even know how many reservoirs, that would've been nice to have in '20, '21, and '22. – Water Commissioner, Central Region

Wildfires were often discussed as a key consideration and concern among participants in this sector. One participant engaged in emergency management described wildfires as the primary drought-related impact of concern for the western Montana region, *“Wildfire continues to be our biggest threat that we face in Western Montana. The relationship to a poor snowpack or just really dry fuels or prolonged drought is pretty obvious, and so it is one of our early indicators of what we might be expecting or that we should be preparing for from a wildfire event.”* Other participants noted wildfire risk as an important consideration in subdivision reviews, particularly in areas within the wildland-urban interface. As one participant described, *“wildfire risk increases seemingly every summer, it just is one more thing that we need to plan for with the future.”*

A few participants also noted water quality as a concern in the context of drought conditions. While drought-related impacts to water quality have not yet been significant, they *“anticipate seeing more degradation of water quality when there's less water in our surface waters,”* particularly as population grows and the presence of drought conditions become more prolonged. Participants described potential impacts to groundwater as a result of reduced surface water and more frequent algal blooms impacting recreators. One participant who works as a long-range planner also suggested that drought and reduced stream flow could have serious implications for their community's sewage treatment capacity:

The city's ability to discharge sewage, treated sewage... If there's a heavy drought and the discharge stream goes down and we're discharging a given quantity allowed by our permit, then that affects the water quality and the receiving stream. And there's ramifications to the city for our permit compliance. And then again, no sewer plant, no city. – County Planner, Southwestern Region

In general, participants in this sector were more focused on the potential and future impacts of drought, rather than current or historic impacts. Many participants were also focused on disasters more broadly in their work and considered drought to be one of many factors with the potential to affect their community, though communities historically affected by drought were more likely to be engaged in drought-specific planning efforts.

Contributing factors

Changing futures

Climate change was commonly discussed by participants in this sector as a contributing factor to drought and key consideration in planning for future conditions. Participants working in communities that have been less impacted by drought than in other parts of the state did not discount drought as a future concern

given predicted changes to precipitation and temperature patterns. One participant explained, *“I know it's coming. It's going to change our weather patterns, it's going to change our precipitation patterns, which are going to have real drastic effects on how we allocate water for irrigation, subdivisions, community expansion, things like that.”* Other participants described climate trends that have already shifted in recent years: *“in the last 20 years, we've had the wettest years on record, we've had two or three of the wettest years on record. We've had two of the driest years on record. They're seeing the change in climate in front of them.”* Participants suggested that these more extreme conditions have already started to affect how individuals and communities within this sector engage with drought mitigation and planning and will likely generate an increased urgency and focus on drought in the future.

While many of the participants in this sector noted concerns around climate change and the potential for drought conditions to become more extreme in the future, some noted that drought, and even extreme drought, is not a new experience in Montana and many Montanans impacted by drought are familiar with the need to adapt to it. In this context, a couple participants described drought as a cyclical process. A water commissioner explained, *“Everybody has lived through X number of years of drought at this point. That's why I say, [the landowners] consider it to be a cyclical thing, and they have for a long time, been in the business of adapting year to year, their expectations, and what exactly they do on a given year.”* This participant felt that climate change was less of a concern for the community's ability to adapt to drought conditions than the intergenerational changes that will come with experienced landowners aging out of agricultural production and either passing on their land to younger family members or selling it individuals with less direct experience of drought.

Access to water

Depending on their source for drinking water, some communities represented in this sector were more concerned about having reliable access to water, and therefore, more focused on water conservation than others. For example, one city planner explained:

Water conservation has been an issue for decades for the city. And so, we have been working overtime reviewing our own local regulations to make sure that we are not asking people to use water unwisely, that we are encouraging people to use good conservation approaches, those kinds of things. That's been a multi-decade process. – Municipal Water Employee, Southwestern Region

Another participant engaged in municipal water conservation observed significant increases in municipal water demand during the most recent drought in their community, further underscored the importance of water conservation programs: *“But last summer, I mean, seeing our demands in June last summer hit just about 13 million gallons a day. And for context, [the city's] winter demands are four and a half [gallons]. And so, it was insane. I mean, it was higher than we've ever seen in July or August when you expect to see those peak demands.”*

Other participants based in communities in western Montana described feeling less concerned or sensitive to drought impacts as a result of having a reliable source of groundwater and fewer large agricultural producers, though they expressed some caution for future circumstances. One participant described, *“We're very fortunate. What I learned from talking with subject matter experts is that we're very fortunate in our aquifer as it relates to the ability to access clean drinking water.”* Another participant suggested, that while the city's aquifer has not been impacted by drought yet, *“if the aquifer were to go through a really prolonged drought, we don't really know how it will respond, because it's never seen that before, but we can anticipate that something like that will happen in the future.”*

Other users

When asked about conflict among water users and how this may affect their work, participants suggested that conflict does occur and is more likely to occur in the future among different water use sectors, which emphasizes the need for thoughtful, community-based planning around drought and water management. For example, one participant mentioned how many agricultural producers in their region rely on surface waters for irrigation purposes, but flow releases from an upstream dam are managed to support the health of a fish population and often conflict with the needs of producers and can impact irrigation infrastructure. This type of conflict is likely to be more common under drought conditions.

In one participant's experience, engaging in discussions around water consumption with different water use sectors "can be a political football," where highlighting how much each sector consumes can be more harmful than helpful. Instead, this participant felt that building water conservation strategies around solutions and highlighting how much water can be saved by particular actions helps to avoid conflict among users. In another participant's experience, discussions between water users about drought often start out as contentious but, through frequent facilitated multi-stakeholder meetings, users reach a common understanding and are able to build constructive response strategies. This experience seems to support what another participant shared about the potential for conflict among water users as the state continues to experience population growth: *"There's more people and we're sharing the same resources and the resources are only going to become more limited. So, it will inevitably drive conflict unless there is that community or more holistic approach. And unless there's buy-in for that approach, then that could spur conflict as well."*

Population growth

Participants in this sector consistently brought up population growth as a key factor in drought planning, and a likely exacerbator of drought impacts. In general, population growth has numerous implications for communities and is an inevitable focus of community governance and planning for many communities across Montana. In thinking about drought specifically, participants in areas already impacted by drought felt that the population growth they have started to experience will likely increase existing management challenges, while participants in less impacted areas felt that it may cause their community to begin to experience drought impacts more acutely. Simply put, more people results in higher demand for water and greater strain on water resources. One long-range planner described some of the impacts that population growth and subsequent development are having on their community:

But building and growth in [the county] definitely impacts our water resources, and it's a closed basin, so the digging of septic systems and the digging of wells and just storm water runoff, and all the things related to development, have an impact on water quality and quantity, and I think are tied to drought conditions. – County Planner, Southwestern Region

A couple participants also mentioned the additional factor that new residents and landowners may not have experience with or understanding of drought, which could also impact how effective water conservation strategies are. One of these participants, who works as a long-range planner, explained that people have certain expectations around water, which impacts their work:

Both on the recreational standpoint and aesthetic standpoints, people like green grass and rolling streams and catching fish and that kind of stuff, but they really like being able to flush their toilet and turn on their shower... So, when they're thinking about future growth in the community and what it takes, water is a significant part of that. – County Planner, Southwestern Region

One participant who works as a water conservation program coordinator also expressed grappling with existential questions at the intersection of population growth and limited water resources:

The one kind of difficult question I get all the time is, okay, well, you're asking us to conserve all this water, but you're still letting everyone move here. And where's the balancing point between limiting growth, and then of course recognizing we have a limited supply? And clearly that's a really difficult question to answer and it has a lot of other things kind of rolled into that. – Municipal Water Employee, Southwestern Region

For many of the communities represented in this sector, population growth presents complex challenges related to water resources and is often increasing the urgency of drought planning.

Monitoring data and resources

Regarding accessing and utilizing monitoring data in their work, participant responses were somewhat mixed. Some participants actively access monitoring data and apply it in their work, while others are aware that resources exist, but are not necessarily using drought-related data in their work or know the easiest way to find that data. On one hand, one participant felt that *“those data sources and those agencies that maintain those data sources are very good about reaching out,”* while on the other hand, another participant had a different experience, suggesting *“the connection between those technical resources and our county or city governments is poor or non-existent.”* Regardless of their individual knowledge and use of monitoring tools, a common sentiment among participants was that the resources that are available could be more accessible for other stakeholders and the general public. As one participant pointed out, *“It's one thing for the person who's a specialist to say, ‘Oh, I can trot out there and find X, Y, Z resource.’ It's another thing for an average person to say, ‘I know where to find it and it's configured in such a way that I can readily understand it.’”*

Among those participants that frequently access monitoring data, commonly used resources included DNRC updates, U.S. Drought Monitor, and weather services through NOAA. Other resources mentioned included NRCS SNOTEL sites, stream gage networks, Montana Mesonet stations, and local monitoring. One participant also described following social media and connecting with local weather spotters as an effective way of getting a pulse on the types of drought conditions and impacts individuals and communities are experiencing. As they described, *“A picture is a thousand words, and having those pictures of the grasshoppers or the videos of the grasshoppers eating a field away really says a whole lot more than it's a D2 versus a D4 drought on a map.”*

Between interview and survey participants, ten mentioned utilizing the DNRC dashboard and the U.S. Drought Monitor to track drought conditions. One participant described consulting the DNRC drought webpage frequently, and that it *“had great resources for being able to identify current status of drought in the state.”* Others similarly described the U.S. Drought Monitor and DNRC's related resources as providing good, useful information. One participant, however, felt that the drought monitor is limited in the information it can provide, particularly in terms of scale:

It doesn't necessarily give you the anecdotal stuff you need locally. It doesn't... You can look at the drought monitor, and you can zoom into a county level. And it wants to put all those stations together in one report. But it doesn't tell you that the north half of the county has been way drier than the southern half of the county. – former Federal Agency Employee, Western Region

In addition to consulting existing monitoring resources, a few of the communities represented in this sector operate monitoring infrastructure that tracks local conditions such as well water conditions,

groundwater, tributary stream discharge, and soil moisture, often with the funding and infrastructure support of other organizations, such as National Center for Appropriate Technology and Montana Bureau of Mines and Geology.

A few participants follow weather observations through NOAA services such as National Weather Service and National Center for Environmental Information, a service that aggregates local observations. One participant explained, *“We rely heavily on the National Weather Service and their hydrologic folks that can help give us predictions and accurate historical data, but also futuristic probabilistic modeling.”* These data were particularly helpful in planning efforts around disaster mitigation, including drought.

A few participants also described accessing NRCS SNOTEL data in their work, using snowpack data as a signal for potential drought conditions. One participant who works as a director of emergency management explained what a lower-than-average snowpack means for their work:

When we see an average snowpack, we just say, okay, we'll just keep on keeping on. But when we see a remarkably low snowpack, it does click something on in our brain to say, well, maybe we need to spend a little bit more time in the off season of ensuring that our mass notification systems are working and our wildfire resources are hyper-coordinated going into a fire season. – Municipal Emergency Response Employee, Western Region

Similarly, some participants described using stream gage data in their work as a means for tracking when certain water restrictions may be triggered due to drought conditions. One participant also mentioned that multiple Montana Mesonet stations are expected to come online in their area, and they anticipate utilizing the data generated by those to monitor drought conditions.

In addition to current monitoring resources, a few participants discussed the importance of having access to historical data and being able to understand changes over time to precipitation trends and drought conditions. But other participants noted some limitations related to historical data, such as the temporal extent of the data and how current data are compared to historic “averages.” In discussing how NRCS reports 30-year running averages for snowpack, one participant explained how it can be misleading as current averages are not compared to all-time averages, but only the averages of the preceding 30 years: *“So, losing the eighties and just having the nineties, aughts, and teens as your 30-year record, changed what 100% of snowpack is, and for the worse. So, 100% snowpack is like 90% or 85% pre-2020. And I expect that'll get potentially worse.”* Another participant questioned the usefulness of comparing one drought to a previous drought as, *“no two droughts are alike and no two floods are alike. So, when people try to compare, it's okay to remember how high that river level was, but this flood is not going to be the same as that flood was. And this drought, 2017 was not the same as 2005 and '06s, '07 timeframe.”*

Overall, the most useful monitoring information described by participants in this sector was DNRC resources and the U.S. Drought Monitor. Many participants in this sector primarily use monitoring data when developing formal plans and policies, but often do not reference drought monitoring data in their day-to-day work. Several participants highlighted the importance of having localized data and the limitations of existing regional or statewide monitoring resources.

Drought response

Public policy, relief, and payment programs

When asked about public policy and programs that support their efforts to respond to drought, few participants in this sector were aware of or utilized programs that specifically support drought response, though several are involved in local planning efforts related to drought that allow them to receive federal and state funding. For example, one participant mentioned that their county is included in a Multi-

Jurisdictional Local Hazard Mitigation Plan for their region, which makes the county eligible for state and federal funds in the event of a disaster, including drought. Similarly, one participant mentioned working with DNRC and other state agencies to do “whatever we can do to get the state to help with drought assistance” and ensure that their county is able to access federal programs when possible.

Drought planning

Planning for drought in this sector was primarily done through formal written plans and procedures. Some of the plans discussed had a more specific focus on drought and climate conditions, while other local plans and policies included water usage and drought as part of larger planning efforts, such as hazard mitigation plans, emergency response plans, or growth policy and long-range planning documents. The extent to which individual communities explicitly focus on drought in their community planning efforts seemed to depend on a number of factors including the frequency and severity of drought impacts experienced in recent years, the cumulative economic risks posed by drought impacts, and the community’s existing access to water and water-related infrastructure. For example, a survey participant located in a county without water and sewer infrastructure and where agriculture is a key economic industry expressed that drought is, “a planning priority in our county. The potential impacts of long-term drought could significantly impact the producers in our county.”

One participant involved in facilitating emergency response planning for municipalities across the state, explained that drought is often one of the key considerations in this type of planning, encouraging communities to think through and plan for a variety of water-limited scenarios. For example, emergency response plans may grapple with such questions as, “What do you do if you don’t have any more water?... [Do] we do reduced use, contingency use, do you have ordinances? Can you control the use of water, odd-even irrigation? Can you shut down your irrigation within a municipality? These types of broad emergency planning efforts seem to play a key role in how many communities across the state prepare for drought.

While most of the communities represented in this sample included drought as a component of a larger planning effort, a couple of the communities had plans in place with a specific focus on drought. One city located in a closed basin with limited groundwater resources has had a comprehensive drought plan in place for several years. The plan outlines specific strategies based on the severity of drought conditions:

The city has a formal policy where we’ve identified the criteria that we use to measure drought. We have a four-stage system that’s already adopted and in place and says, “All right, at stage one these kinds of standards start kicking in,” all the way up to stage four which is basically don’t use anything you don’t absolutely have to. That includes potential for watering restrictions, includes changes to water rates. There’s a price signal for folks. The authority to apply that is laid out clearly. Who makes the decision? What’s the basis of the decision? Undo the decision. All that kind of thing. – Municipal Water Employee, Southwestern Region

Another participant engaged in water resource management in Montana’s northeast climate region, where drought has had severe impacts in recent years and agriculture is a dominant industry, explained that their community has had a drought management plan in place for many years, often mirroring the statewide planning efforts, and recently updated the plan. As part of this planning effort, the community is partnering with the Montana Climate Office to establish several new Montana Mesonet stations to strengthen their data collection efforts related to drought.

Other participants explained that drought was included in broader policies related to community planning, such as zoning and subdivision regulations. Water availability and use was mentioned as a consideration

in subdivision reviews by a few participants. A few participants also mentioned that their community's disaster or hazard mitigation plans included strategies for drought-induced impacts. One participant located in a rural county in the northeast climate region explained that their county's planning efforts around drought are currently somewhat informal, *"just more informational and getting groups together and getting the key players together that if we have to do a resolution on a drought or whatever to do that."*

Adapting to drought in the planning and community development sector

Adaptation includes many types of proactive planning for drought, and in this section, we present thematic description of adaptive capacity in the planning and community development sector.

Education and outreach

The primary way that participants in this sector engage in adapting and building resilience to drought, aside from community planning efforts, is through community education and outreach. Participants described both education efforts that were aimed at preventing and preparing for drought impacts. One participant described engaging in general water use education campaigns to encourage more water-conscious behavior:

So, I think it all comes back to water and educating everybody you can on water use, water location, how the water systems are impacted and affected by development. That is what this all comes down to. It should. And even lack of water. Drought is just as critical because the water table gets low enough, then we get some storms moving in, and then everything just kind of goes to crap after that. So, I think it's important for everybody to just be as educated as possible about water, and wildfire fighting, and everything else is impacted too. – County Planner, North Central Region

Similarly, another participant explained that a lot of their department's budget is dedicated to education and outreach around drought and water conservation, efforts which have become increasingly important as their community sees an influx of new residents. They explained:

A lot of new residents don't realize we have water supply issues, so that's a hurdle. But we're doing outreach all the time. I mean, frankly, probably most of our budget goes toward outreach. And so, we do try to educate people about our water supply issues, about drought, and the fact that even when it looks like everything's good, drought, can't predict it, and at the flip of a hat it could change. And so, we're always trying to message that. – Municipal Water Employee, Southwestern Region

Another participant who formerly worked with several communities to help them learn about and plan for drought echoed this observation and felt that their job was often focused on keeping communities engaged with drought planning even when drought conditions were not present:

My job was to bring them back. All right. Here's all the years that you had drought, here's the bad wildfire years that we had in the last decade, just to refresh them. I never want to tell them this should be your top one, two, three, four because it's not my community, it's theirs. But I was able to make them think a little bit and maybe reevaluate what those top priorities were. – former Federal Agency Employee, Northeastern Region

Similarly, a participant who frequently interacts with agricultural producers described passing *"information along to the farmers, to help them make planting decisions,"* and because many of them *"are not particularly computer savvy...a lot of them rely on us for that information."* In general,

participants in this sector felt it was incumbent upon their colleagues and them to transmit information about drought conditions and educate their communities about local water management and conservation strategies.

Water conservation

Some participants mentioned working on water conservation measures to encourage their community to use less water, primarily through voluntary measures. These efforts largely focused on encouraging water-wise landscaping, such as planting drought-tolerant species and altering watering schedules. A couple communities represented in this sample are also developing or have already developed some regulatory restrictions for residential water use under specific drought conditions. One participant underscored the significance of having a water conservation program in place, suggesting that it provided a foundation for building a drought plan.

And I think that in terms of municipalities across the state, it's my understanding that there's not a lot of conservation programs out there. And I don't even know if there's other city staff and other municipalities that have conservation. And I think in looking back at sort of how the city did this, I wonder how well set up we would've been to have a drought plan if we didn't first have conservation programming. – Municipal Water Employee, Southwestern Region

A handful of survey respondents who identified municipal water supply as their primary water use sector also described changing their habits to conserve water, activities such as “*Landscaping my home property to conserve water, need less irrigation, and capture rainwater,*” “*drip irrigation to grow food,*” and “*replacing lawn with native plants.*”

What's needed to build and support drought resilience in the planning and community development sector

Resources that can decrease vulnerability should mitigate sensitivities and build adaptive capacity, and in this section, we provide thematic description of some resources that could build resilience in the planning and community development sector.

General reflections on state plan

What is most needed for participants in the planning, policy and community sphere is accurate and realistic representation of water availability. Knowing accurate availability helps the drought planning and adaptation process because participants can. According to a survey respondent, “*Science needs to be the driver behind all decisions being made. Water should be managed in a way that reflects the reality of where it actually exists.*”

Participants underscored that the collection and reporting of drought data must be accurate to properly allocate planning resources and energy. As one participant who works as a source water protection manager described, the availability of water and information alike is crucial to being able to plan:

I think you need to have that conversation, because we have seven large cities in the state, and we've got a lot of other communities that all require water. And if they don't have water, guess what, they're all moving into the seven larger cities. And I don't know that there's room for everybody. Everybody calls their place home. So do we have enough water for everyone to be where they want to call home? But we need strategic planning for some of these areas that, more people want to call it home than probably should be there. – Consultant, North Central Region

A consistent theme that emerged among participants was using science for better clarity in planning,

policy and community work. Participants also expressed interest in getting more comfortable with talking about climate and drought together. As one survey respondent shared, “*We cannot solve a problem if we cannot name it and use science.*” The challenges around making a state plan useful to the variety of agencies and localities is that there are such a variety of stakeholders involved. Another theme that emerged as helpful to building a successful state plan is that there must be a shared goal or overarching vision at the state level:

But I think so much of it is that statewide vision needs to happen in order to drive down to the details of subdivision, the details of water rights, and the details of what the state legislature empowers county and local governments to do on behalf of their communities. And so, if that message is taken up across the state, then that's more likely to bring Missoula along with the ability to actually make that happen. – Municipal Water Employee, Western Region

In addition to a shared vision, participants felt that the state plan must be adaptable and scalable to work on a community level across varying town, city, county and regional structures. From one participant who works as a director of emergency management, a scalable or adaptable plan means being more hyper-localized: “*The more regionalized you can get it and the more tailored it is to the impacted stakeholders, I think, the better and stronger the plan will be because you'll have better engagement.*”

Participants also suggested that an effective state plan must include the perspectives of a variety of stakeholders, as well as incentives for multi-stakeholder planning approaches.

Improvements to public policy, relief, and payment programs

Participants recommended developing policy and programs that encourage community-based approaches to drought management and planning. As one city planner pointed out, “*It would be really nice to see some recommendations that local communities can use from a regulation standpoint.*” Another participant echoed the desire for community-based strategies:

So I think the approach and response to drought and/or flooding needs to be a community approach and so much of what can be enacted currently is on an individual basis and that doesn't provide enough flexibility or new boldness to respond appropriately. So throughout response plans and collaborative drought approaches are great and it would be useful to have incentives or the ability to generate buy-in for longer term improvements. – Municipal Water Employee, Western Region

Participants in planning and policy are tasked with advocating for the benefit of the whole community and including multiple stakeholder’s needs in their plans. For counties with a large agricultural focus, this often centers the community conversation, and having a state level crop insurance program was an idea shared by a few participants. One county commissioner spoke to the improvements needed for drought relief and hay assistance programs for agricultural producers:

The biggest drought thing here was the hay costing so much. They're \$300, \$350 a ton delivered hay, and it was not that great of quality hay. And I know there was some payments from the government on some hay. I don't know exactly what they all were, but that's a big thing that needs to be addressed. If there's ways we can bring more hay in at a better price, or if there's some programs there to partner with an area closer to us that isn't in a drought. – County Commissioner, Northeastern Region

Participants also expressed wanting to see more financial assistance when drought affects the local economy.

Additional programming

Several survey participants expressed an interest in seeing more regulatory and planning tools to support drought-wise development, particularly for future developments as many communities in Montana, continue to experience rapid population growth. Participants also expressed interest in expanding education programming for responding to drought, including guidance and critical feedback for incorporating drought management practices in planning documents at the local level.

In addition to education, participants shared that more technical and regulatory support would be helpful in developing drought management plans and strategies. One survey respondent indicated a need for more development regulations that direct water use (e.g., lawns) and the number of wells in a given watershed. From another survey respondent came a recommendation for fire protection systems by statute as a drought response program: *“Require by statute, subdivision past and present to install, maintain, and repair fire protection systems and plans to meet drought conditions - not just adequate typical conditions.”*

Water restrictions

Participants in this sector consistently shared a desire for more options to implement or strengthen municipal water restrictions during periods of drought. Regulations and/or incentives to conserve water and adopt drought resilient practices for landowners that were suggested by participants included landscaping water restrictions (e.g., golf courses, lawns, car washing, winter ski snow making) and increasing the price of municipal water via utility fee increases for peak usage.

Additional monitoring

In general, participants would like to see more funding to support drought monitoring: *“Our resources are limited, based on funding. So, when we have available funding, we can actually partner with the USGS or Bureau of Mines and actually work on some of that. Otherwise, it doesn't get done. It all depends on funding.”*

One long-range planner spoke to the need for improved water use monitoring in new subdivisions:

For some of our subdivisions that are on shared well systems, or even at individual wells, we have conditions of approval that often require monitoring and tracking and reporting of water usage. But that is really not an effective way to track water usage at such a fine grain level, and subdivisions across the county. And there's been subdivisions, I'm sure, that are 20 years old or more that, maybe when they were first developed, they tracked those things, but homeownership changed, and who knows if those things are even monitored or tracked anymore? So, there's just one thing that comes to mind, but in terms of a larger countywide water management tracking data, there's none that I know of. – County Planner, Southwestern Region

Expanding stream gage networks was also a common topic from participants in the planning and policy realm. One participant mentioned funding support for stream gages, as the data they collect are essential to *“determine effectively when we reach flow and temperature triggers.”*

Predictive tools, precipitation projections, and more snowpack data would also be valuable to planners and policy makers, specifically mid- and low- elevation snowpack. A land use planner spoke to how more monitoring would inform drought and climate predictions:

And that's the other thing I think that the state could provide is over and over and over again, say, oh yeah, okay. Today's 2022. In 2030, this is what we're expecting. In 2050, this is what we're expecting. – County Planner, Central Region

Communication and outreach

Consistent, coordinated messaging around drought and changing conditions through a variety of communication channels and strategies was a key message shared by participants in regard to an effective statewide effort to manage for and adapt to drought. Participants suggested a few methods for encouraging effective communication, including social media, short-videos, and text alerts. One participant recommended videos as a concise means for communication, and another community facilitator recommended utilizing a variety of digital tools:

I'm thinking about audio visual. I'm thinking about social media. I'm thinking about consistency in newspapers. I'm thinking about public service announcements. I'm not aware of any coordinated branded campaigns that capture all of that for a watershed, really well. And I don't know what's going on everywhere, but... I think we could do better there. – County Planner, Southwestern Region

Some participants also suggested that there is a need for facilitation support within small communities to increase the effectiveness of outreach and communication efforts: “So, *making sure that somehow this isn't just a statewide approach, but it actually involves local governments that can actually be real leaders in terms of making differences, at least within their municipal or county boundaries.* Funding support and educational resources for local governments are necessary to do this work.

Tools and resources

Participants in this sector expressed wanting to be able to encourage and highlight the best available practices for adapting and planning for drought. Understanding the challenges that arise from drought conditions can help inform the best practices in terms of growth and development. These best practices could be put into a public resource and made available for many: “*Certainly a document that we could reference would be valuable, and a document that would have some best practices and recommendations, and things like that.*” One water conservation program manager spoke to the utility of these best practices and how that might help engender positive change:

Really just supporting the idea of these best practices. I'm trying to think of a concise way to say it, basically essential use is something that needs to be obviously prioritized, and then let's not wait until we run out of water or let's not wait until we have a stage four drought, but proactively implementing some of these changes, like limiting turf and just limiting non-essential uses in general, I think would be really helpful. Having that in a state plan would just be one more thing for us to lean on and leverage off of to make more positive change here. – Municipal Water Employee, Southwestern Region

Drought data and forecasts were also noted as being helpful resources. One participant working for a municipality highlighted the importance of the Montana climate office and suggested that stream gaging be continued, while the NOAA Atlas needs to better reflect rainfall – a consistent recommendation across sectors but mentioned here in the context of road and infrastructure planning.

I think the climate office is important. We get to see that move forward. I think that the stream gauging is important. I think ensuring that we continue to have that level of data is important. It's also important that the NOAA Atlas for this region is updated to reflect rainfall because that's where road designs and everything that will be what's needed to accommodate stormwater and things is updated as well. – Municipal Water Employee, Western Region

Support for local planning

The implementation of a state plan needs to be replicable and scalable to smaller communities; this is something participants in this sector consistently expressed. A long-range planner spoke to the capacity challenges that smaller communities have and what kind of support they may need:

Smaller communities don't have the wherewithal to actually do the research and to promote things and to find the funding to help that kind of stuff. So I think providing examples of how even smaller communities can consider water conservation in their system and in their plans and in their infrastructure plans and in their promotion of what they do for individual residents and businesses and industry. – County Planner, Central Region

Another method to best support local planning suggested by participants was to highlight existing and developing new funding sources at the federal or state level that can be used to support local drought mitigation planning. One participant spoke to how funding for local planning specific to drought could better adapt and utilize the tools that are available:

Funding to support the development of those local plans. So, if there was a fund where local communities could say, "Hey, we're going to spend the next year convening all the key stakeholders and our technical people, and we are going to assemble the data that we need and we are going to have professional facilitators help us develop these plans." There's so many great templates out there already, because we have great examples of drought plans across the state. But whether it's to develop those plans or to update them, if there was a funding source to support the resources that folks need to do that, that would be really helpful. – County Planner, Southwestern Region

Financial and capacity support for watershed groups also emerged in survey responses as a way support local planning.

Opportunities for water storage

A few participants mentioned that they would like to see more opportunities for improving and/or expanding water storage infrastructure and management. As one participant shared:

I would say we need to think more about harnessing what we already have when we have it. That would be the abundant water in the spring, which of course with the reservoir, you can do that. But again, naturally we can do that too in these aquifers. So, we could be using our infrastructure, whether it's the irrigation ditches, or pipes of some sort. The beauty of the irrigation ditches is they have seepage so that water doesn't get wasted. It seeps into the ground and it comes out somewhere else in a stream. – County Commissioner, Western Region

Cross-cutting themes

Many common themes emerged across water use sectors, particularly in regard to what is needed to improve the tools, resources, and strategies available to help communities and water use sectors across Montana cope with and adapt to drought.

Expanding monitoring sites

Expanding monitoring sites and tools was consistently highlighted as a way to better inform drought plans and designations. Participants felt that more monitoring data can only be helpful in understanding and preparing for drought. Given Montana's vast geography and diverse climates, participants often felt that existing monitoring data is not always able to accurately reflect the experience on the ground. The need for more monitoring sites was identified across water use sectors as way to support drought planning and building more adaptive strategies. Securing long-term, reliable funding sources for monitoring infrastructure emerged as clear interest among participants.

Supporting watershed groups

Supporting watershed groups was discussed by participants across sectors as an effective and valuable way to support localized drought planning and collaborative water conservation strategies. For those participants with experience engaging in local watershed groups, it was clear that there is a significant benefit in being able to communicate and cooperate with other water users within the same watershed. Watershed groups were also mentioned as being effective means for disseminating local drought information and supporting regional and state coordination. As many participants noted, any kind of statewide drought management effort must be applicable to the local level for it to be effectively implemented. Furthermore, watershed groups can also serve as important spaces to build social networks through which individuals can share their experiences of drought and coping and adaptation strategies.

Land stewardship education

Many participants across water use sectors identified education and outreach to encourage **better land stewardship** as a potential way to build resilience to drought across the state. As participants noted, best practices for land stewardship may include implementing soil health practices, grazing management plans, drought resilient landscaping, and preserving or restoring riparian areas. Several participants expressed concerns with an influx of people moving to Montana and acquiring land who may have no understanding of land stewardship in general or drought management in particular, suggesting that there is an opportunity for state and local agencies to provide consistent messaging and education to new residents. Some participants also felt that there is a need for more regulatory or financial tools at the local level to conserve water during drought periods, such as limits on landscape watering, incentives for water-wise residential upgrades, and price increases for water consumption.

Funding for drought relief and resilience-building

The need for state-level **funding sources to respond and build resilience to drought** was mentioned by participants in various sectors as key to supporting individuals and sectors in both coping with drought-related impacts and building resilience to future drought conditions, and often intersected with the other needs mentioned by participants. Participants across sectors suggested that financial incentives to support individuals and sectors in implementing water conservation strategies and funding for local drought planning efforts would be beneficial in helping communities to adapt and build resilience to drought. Agricultural producers frequently mentioned the increased operational costs incurred as a result of drought conditions (e.g. buying and hauling hay) and the value as well as the limitations of existing programs for drought-related financial relief. Participants in the community planning sector similarly expressed the need for additional or improved financial relief programs for industries that are financially

impacted by drought. A few participants in various sectors also expressed interest in a funding source for projects that build resilience to drought, such as restoring riparian areas and enhancing natural and built water storage.

Streamline of information on web

Streamlining and making information more accessible was another key priority among participants. Many participants felt that drought information exists, but for many who may benefit from drought information and data, it can be hard to find or keep up to date with due to frequent changes with how and where information is shared online. Several participants also felt that more education and information about how to actually apply drought monitoring data to their professions would be helpful. In general, it was clear that making drought monitoring data more accessible and user-friendly would be beneficial to individuals across sectors and climate regions.

More accurate predictions for weather and drought

Predicting weather patterns or periods of drought is difficult. Forecasting services exist but are often not accurate enough to support decision making on the ground. Participants have learned to not rely on such predictions, but many across sectors mentioned that more accurate predictions would be helpful for drought planning.

Utilizing storytelling for communication

Many participants expressed interest in hearing **the experiences and stories of individuals who have adapted to drought** in particular sectors and climate regions. In general, there was sense that drought monitoring data and technical information alone are not as effective as hearing from the people who are experiencing, coping with, and responding to drought. Participants in most sectors highlighted storytelling as being a helpful way to communicate and encourage adaptation techniques.

Addressing climate change

Finally, all sectors acknowledged that **climate patterns are changing**, and all water users need to adapt. The culmination of more frequent and intense drought periods, wildfires, and floods contributed to stakeholders in each sector expressing concern for worsening climate conditions and a need for state agencies to directly address climate change in their management plans and policies.

Existing structures and systems to build resilience and decrease vulnerability

Throughout the state, there are a variety of existing structures or tools in place at the local level to help address and respond to drought. While many of these are very specific to local needs and not captured in widely available public information sources, others are valuable examples that could be replicated in other regions with the support of the state. Some examples include local watershed groups or coalitions, monitoring tool networks, or resources that respond to issues that can be exacerbated or impacted by drought.

Watershed groups and drought management plans

Across water use sectors, one thing that interview participants noted as being a successful piece in responding to drought are local watershed groups, as they bring multiple stakeholders together, which builds understanding of different water needs and allows for collaboration across sectors. Additionally, watershed groups provide a local resource for information and can address needs or help to provide drought relief specific to the local resource and area. Table 6. below provides a list of all of the watershed groups across the state. Of these groups, eight have specific information relevant to drought, and four have drought management plans in place already.

Table 6. Existing watershed groups in Montana

Name	Drought Region	Drought Planning
Beaverhead Watershed Committee	Region 2	
Big Hole River Foundation	Region 2	
Big Hole Watershed Committee	Region 2	X*
Big Spring Creek Watershed Council	Region 4	
Bighorn River Alliance	Region 5	
Bitter Root Water Forum	Region 1	
Blackfoot Challenge	Region 1	X*
Boulder River Watershed Alliance	Region 5	
Centennial Valley Association	Region 2	X
Clark Fork Coalition	Region 1	
Clark Fork Watershed Education Program	Region 1	
Clearwater Resource Council	Region 1	
Flathead Lakers	Region 1	
Friends of the Missouri Breaks Monument	Region 3	
Gallatin River Task Force	Region 2	
Gallatin Watershed Council	Region 2	X
Granite Headwaters Watershed Group	Region 1	
Haskill Basin Watershed Council	Region 1	
Jefferson River Watershed Council	Region 2	X*
Kootenai River Network	Region 1	
Lake Helena Watershed Group	Region 4	
Lolo Watershed Group	Region 1	
Lower Clark Fork Watershed Group	Region 1	
Lower Jefferson Watershed Council	Region 2	
Madison River Foundation	Region 2	
Madison Valley Ranchlands Group	Region 2	
Milk River Watershed Alliance	Region 3 & Region 6	
Musselshell Watershed Coalition	Region 4	X
Ranchers Stewardship Alliance	Region 3	
Rattlesnake Creek Watershed Group	Region 1	
Shields Valley Watershed Group	Region 5	
Smith River Habitat Project	Region 4	
Stillwater Valley Watershed Council	Region 5	
Sun River Watershed Group	Region 4	
Swan Lakers	Region 2	
Swan Valley Connections	Region 2	
Upper Missouri Watershed Alliance	Region 4	
Upper Yellowstone Watershed Group	Region 5	X*
Watershed Education Network	Region 1	
Watershed Restoration Coalition	Region 1	
Whitefish Lake Institute	Region 1	
Winnett ACES	Region 4	X
Yaak Valley Forest Council	Region 1	

Notes: List of all watershed groups in Montana as determined by Montana Watershed Coordination Council (<https://www.mtwatersheds.org/montanas-watersheds/>). X denotes watershed group who has drought resources and/or planning. X denotes watershed*

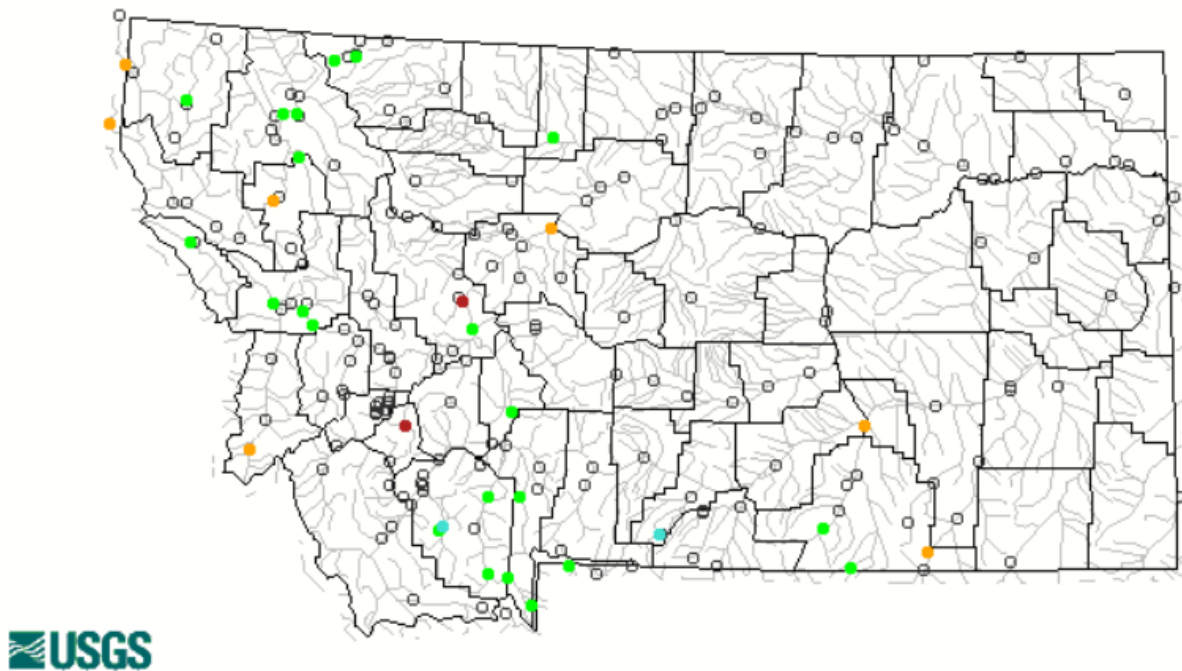
groups that have drought management plans in place (the Upper Yellowstone Watershed Group is in the process of creating a drought plan).

Monitoring gages and stations

Stream Gage networks

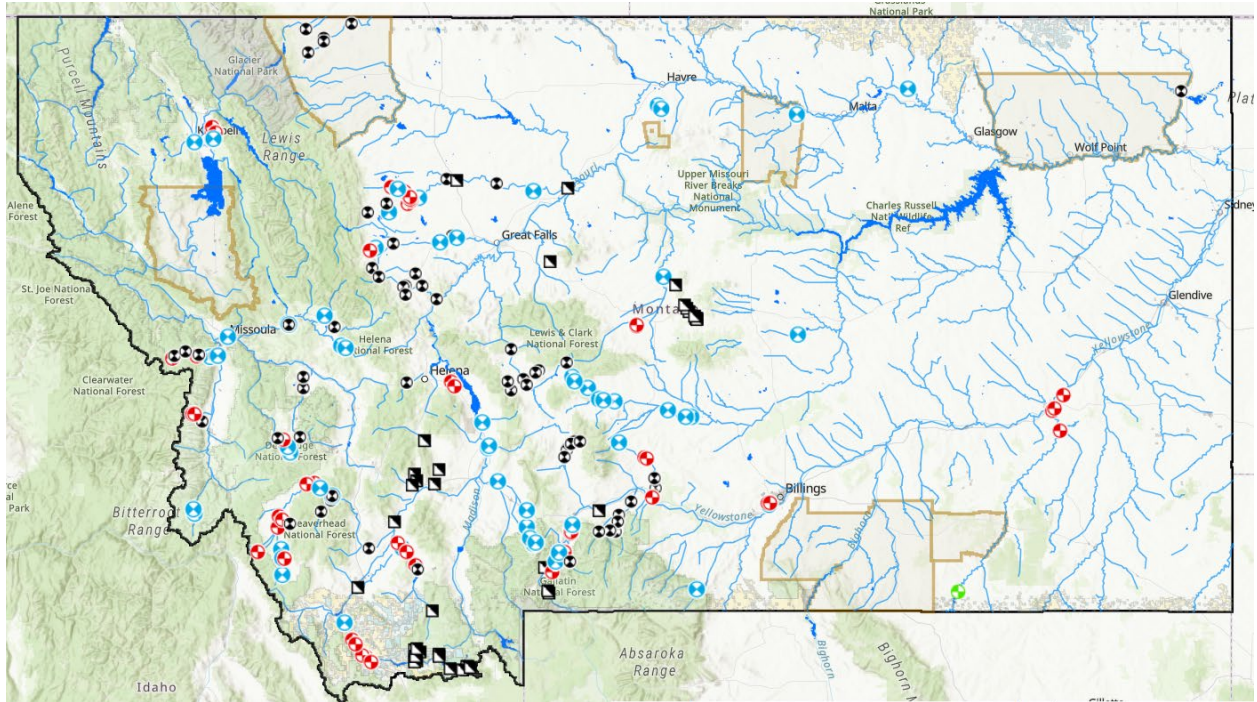
Another tool that many water users referenced using to help track drought and water conditions are USGS stream gages, which provide real time information as well as historical data on stream flows and/or water temperature. This tool was one of the most frequently used tools by participants across water use sectors and was important in daily decision making as well as for forecasting and understanding drought conditions over time. Often times, funding for USGS gages comes from local watershed groups or conservation organizations, which was cited as a significant challenge for many participants. Resources to provide funding for the maintenance of current USGS gages and for adding new gages was deemed as highly important across water use sectors. In addition to USGS gages, Montana DNRC also runs a stream gage network to provide water users additional hydrologic information beyond the USGS network. The maps below shows the location of USGS gages and DNRC gages across the state.

Figure 11. USGS gage locations in Montana



Retrieved from: <https://waterdata.usgs.gov/mt/nwis/rt> on 12/9/2022

Figure 12. DNRC Stream Gage Network

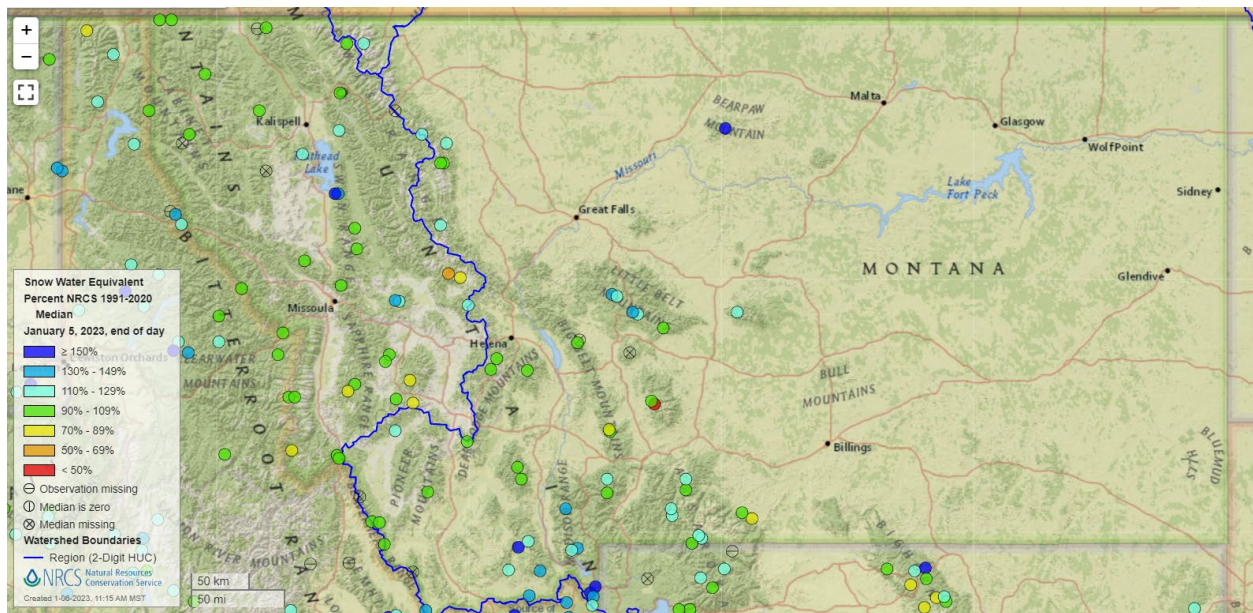


Retrieved from: <https://gis.dnrc.mt.gov/apps/StAGE/#> on 2/9/2023

NRCS SNOTEL sites

One of the other primary tools used across water use sectors as a drought monitoring tool according to many participants are NRCS SNOTEL sites for snowpack monitoring. These provide a picture throughout the winter of current snow water equivalent in the mountains, as well as a way to monitor snowpack throughout the season compared to the past, which can help in planning and forecasting for future conditions through the summer. Although this is a useful tool, many participants stated that more sites would be helpful and that more sites at mid to lower elevation would also provide a more complete picture of the snowpack situation. The map below shows the location of the SNOTEL sites across the state.

Figure 13. NRCS Snotel sites in Montana

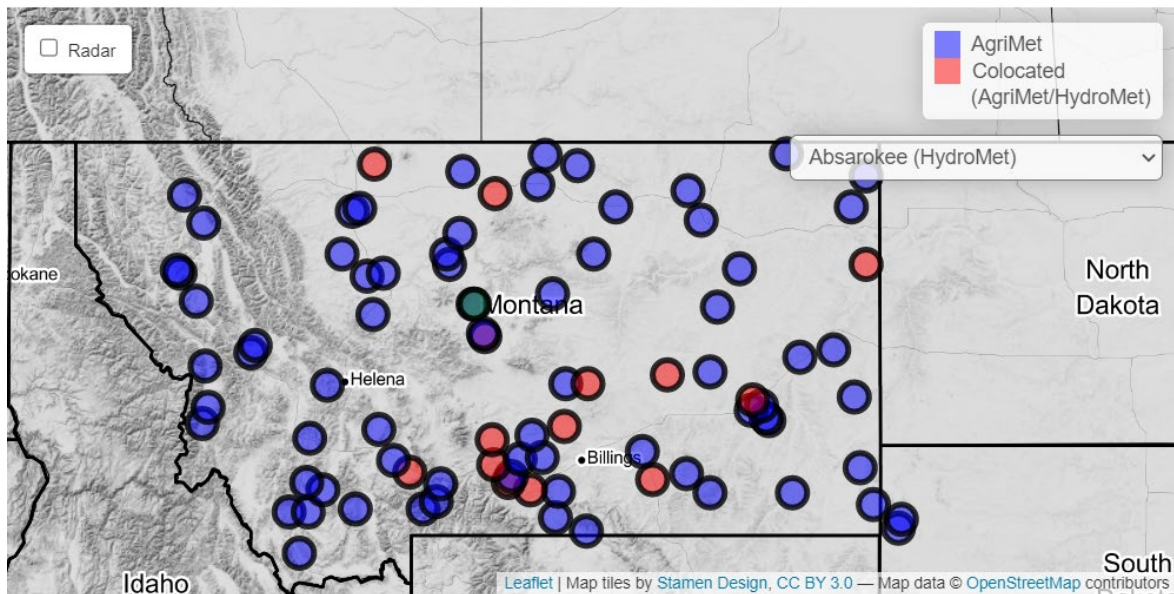


Retrieved from: [NRCS SNOTEL Sites](https://www.nrcs.usda.gov/snotel/) website on 12/9/2022

Mesonet Station locations

Another monitoring tool that is frequently used, particularly by members of the agriculture water use sector, are Mesonet stations. The Mesonet station network development is led by the Montana Climate Office, with the goal of having a comprehensive statewide soil moisture and meteorological information system to help people make decisions, particularly within agriculture. The map below shows the current network of stations, and there are plans to expand the network throughout the state.

Figure 14. Montana Mesonet Station locations

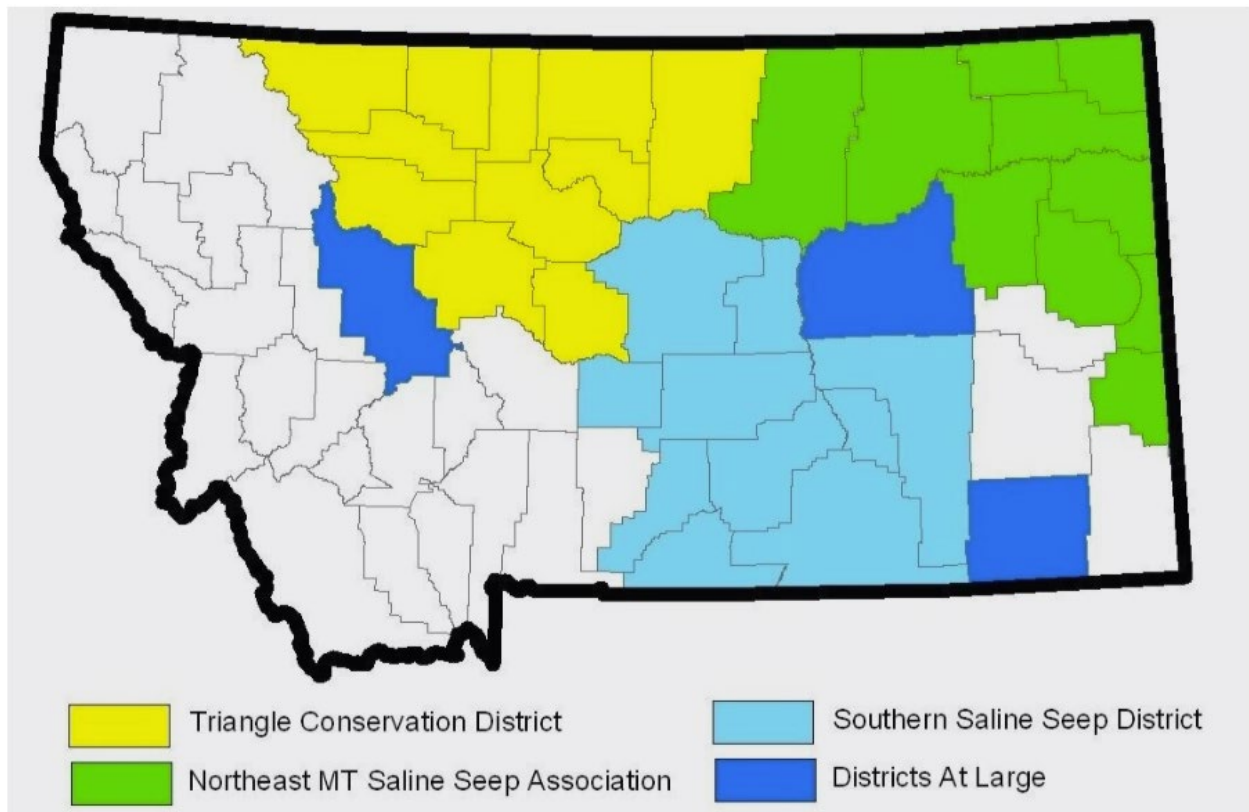


Retrieved from: <https://climate.umt.edu/mesonet/> on 12/9/2022

Salinity Control Districts

The Montana Salinity Control Association has started a network of salinity control districts across the state, in conjunction with local conservation districts. Saline seeps are a frequent issue that can be impacted by drought, across the state. This network provides another potential resource for farmers and ranchers to deal with the negative impacts of drought.

Figure 15. Montana Salinity Control Districts



Retrieved from: <https://www.montanasalinity.com/what-we-do>

Conclusion

The 2022 Montana Drought Vulnerability Assessment provides a comprehensive study of each of the three components of vulnerability: exposure, sensitivity, and adaptive capacity. Information and data were gathered both through statewide outreach and engagement via interviews and an online survey with stakeholders affected by drought, and through publicly available quantitative data which informed a drought vulnerability index. The goal of using a combination of qualitative and quantitative data was to provide a full overview of vulnerability that provides sector and geography specific needs directly from stakeholders, as well as a way to quantify and compare the vulnerability to drought across these water use sectors and geographies.

In general, county level drought vulnerability rankings within the vulnerability index varied substantially across water use sectors in the state, as the exposure to drought and relative size of water use sectors are highly variable. It is important to consider both the drought exposure and presence of stakeholders or businesses from each water use sector by county when viewing the vulnerability index. Overall, it is important to understand that **all counties and stakeholders are vulnerable to drought**, and that the index is a way to compare the relative vulnerability across counties within water use sectors.

Many consistent themes arose from participant interviews and surveys regarding drought planning, relief, and resources. These themes include expanding monitoring sites, such as stream gage networks and SNOTEL sites, providing technical support and funding for watershed groups, increasing land stewardship and drought education, streamlining of drought information on the web, working towards more accurate predictions for weather and drought, addressing the reality of climate change and the role it plays in future drought, and finally, utilizing storytelling for communication to relay drought messaging across stakeholders and the general public.

The intent for this vulnerability assessment is to provide a useable resource that gives policy makers, federal and state agencies, NGOs, universities, and other partners insight into the direct needs of stakeholders impacted by drought, as informed by actual stakeholders. The vulnerability index supplements those findings by showing relative vulnerability comparisons by water use sector across counties, which can support resource allocation and decision-makers in managing Montana's water for the benefit of all.

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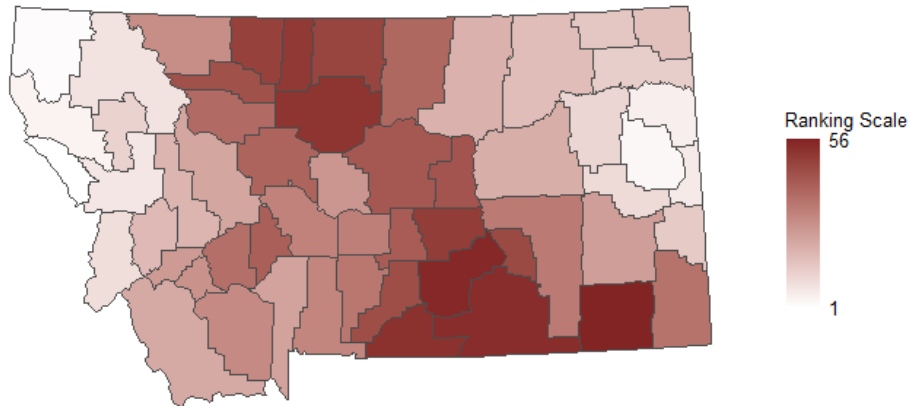
Appendix A: Seasonal vulnerability maps by sector

Winter – December, January, and February

Drought Exposure

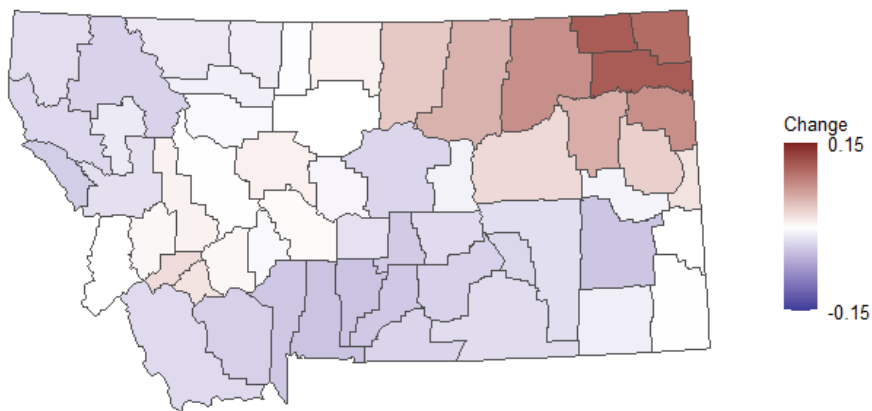
Montana

Drought Exposure Frequency - 2000 to 2022 - Dec, Jan, Feb



Montana

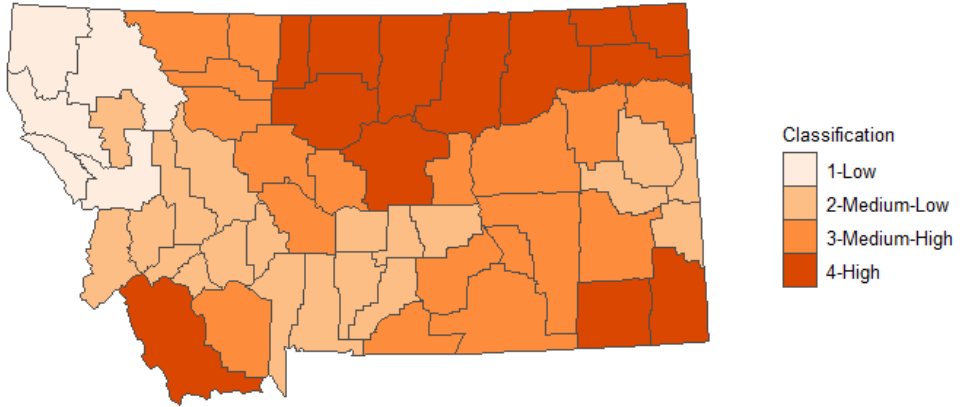
Drought Exposure Change - 2000 to 2022 - Dec, Jan, Feb



Agriculture

Agriculture

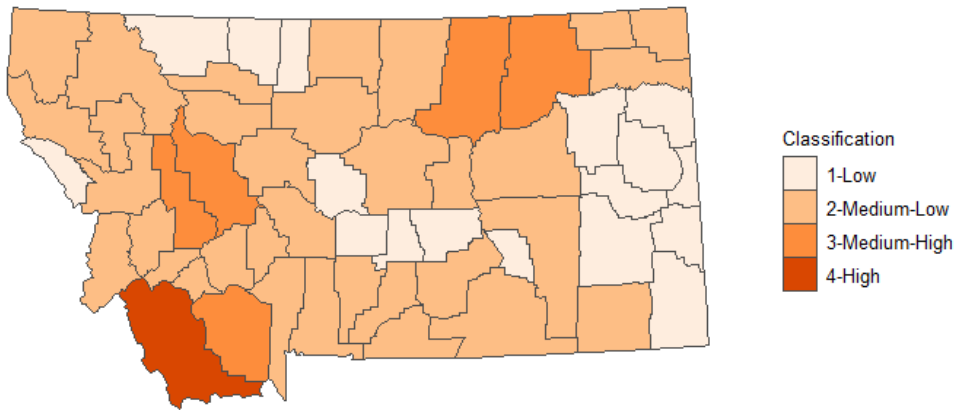
Drought Vulnerability - Dec, Jan, Feb



Conservation and Land

Conservation

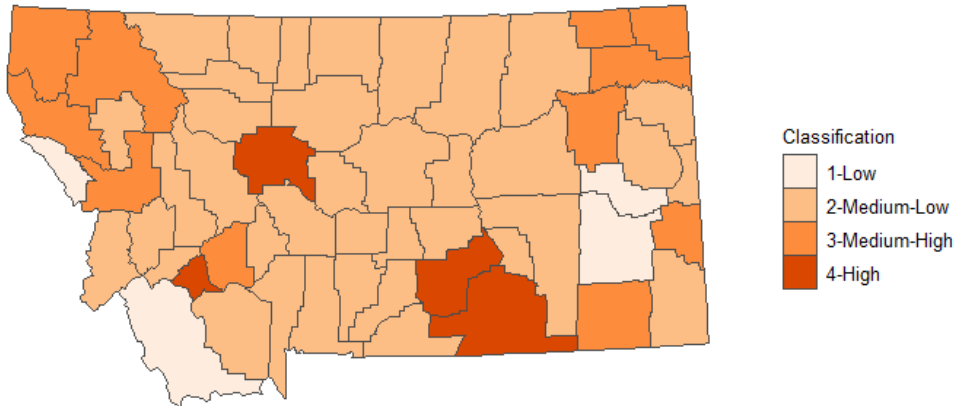
Drought Vulnerability - Dec, Jan, Feb



Energy

Energy and Industry

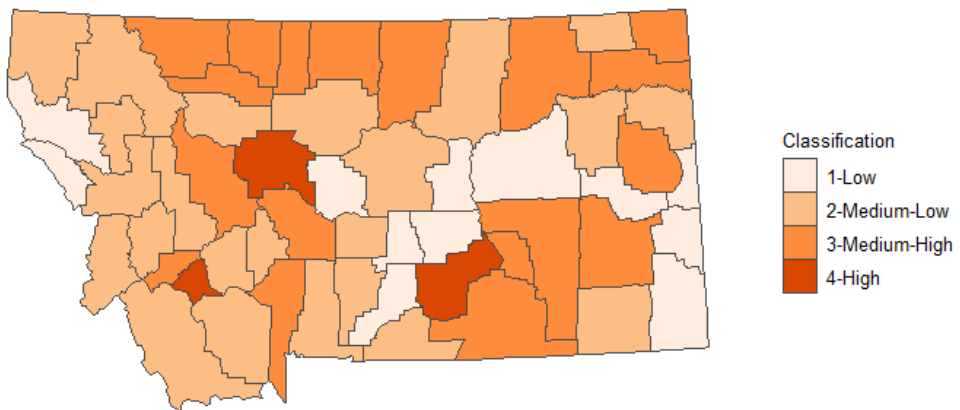
Drought Vulnerability - Dec, Jan, Feb



Municipal

Municipal Water

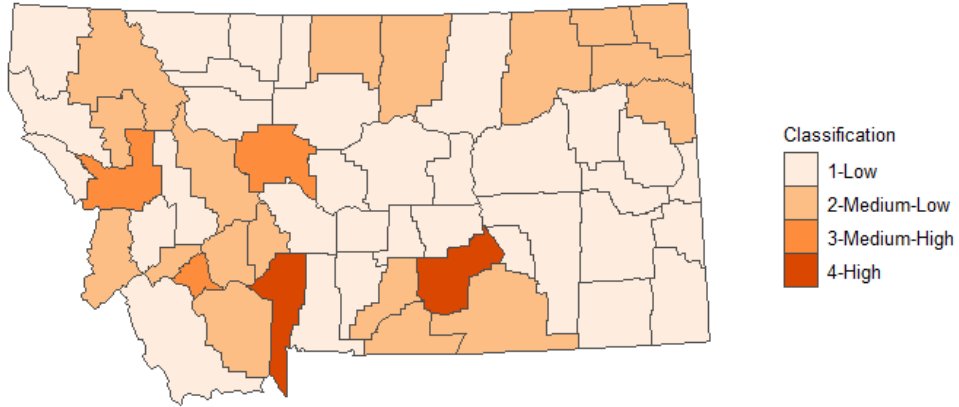
Drought Vulnerability - Dec, Jan, Feb



Planning and Community Development

Planning and Community Development

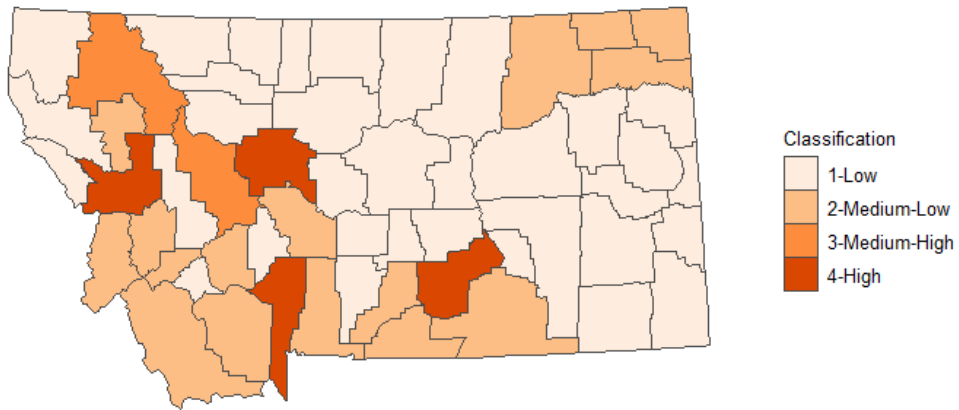
Drought Vulnerability - Dec, Jan, Feb



Recreation

Recreation

Drought Vulnerability - Dec, Jan, Feb

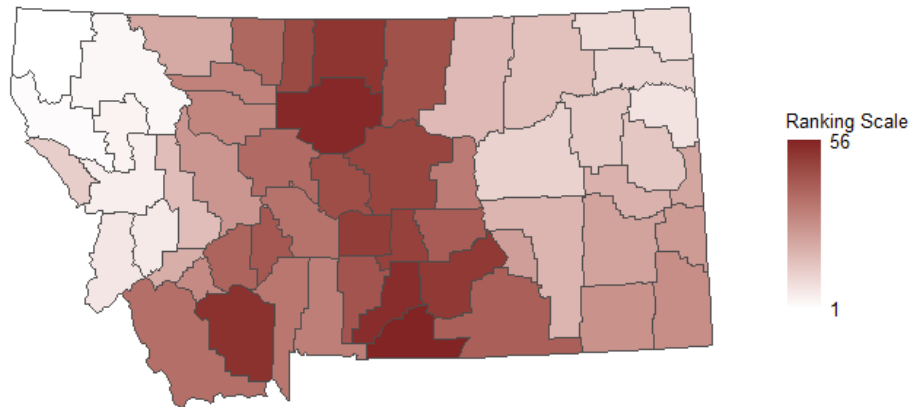


Spring – March, April, and May

Drought Exposure

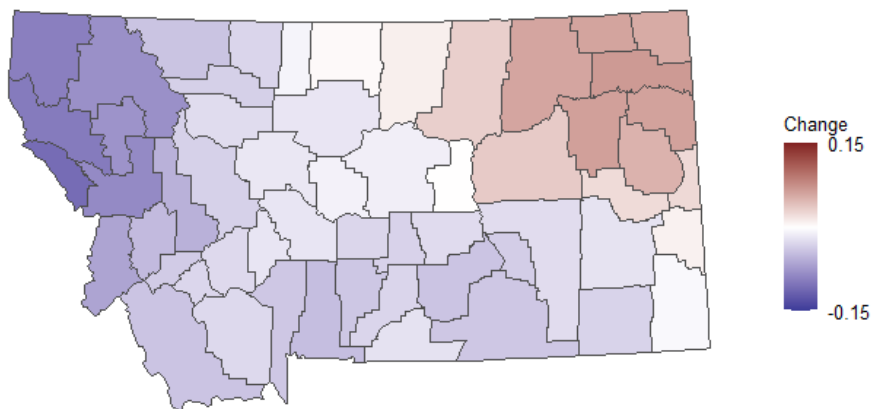
Montana

Drought Exposure Frequency - 2000 to 2022 - Mar, Apr, May



Montana

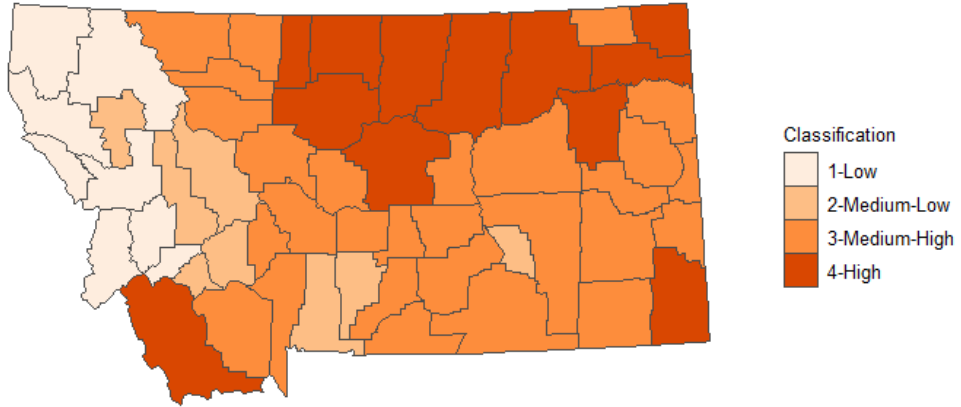
Drought Exposure Change - 2000 to 2022 - Mar, Apr, May



Agriculture

Agriculture

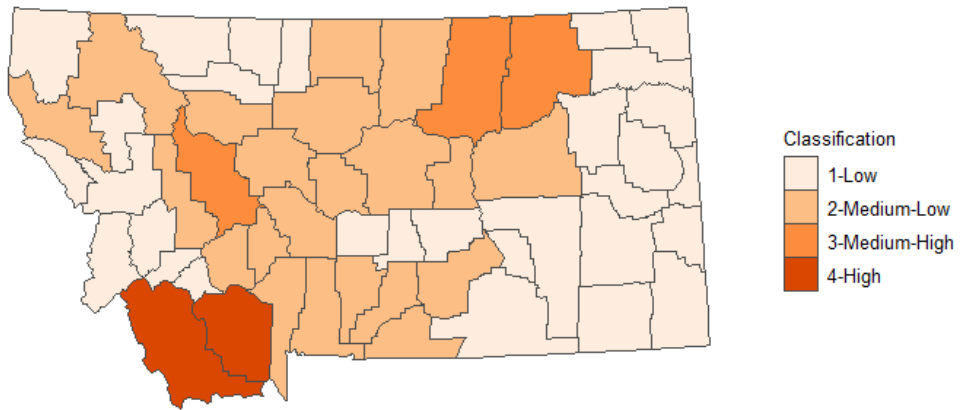
Drought Vulnerability - March, April, May



Conservation and Land

Conservation

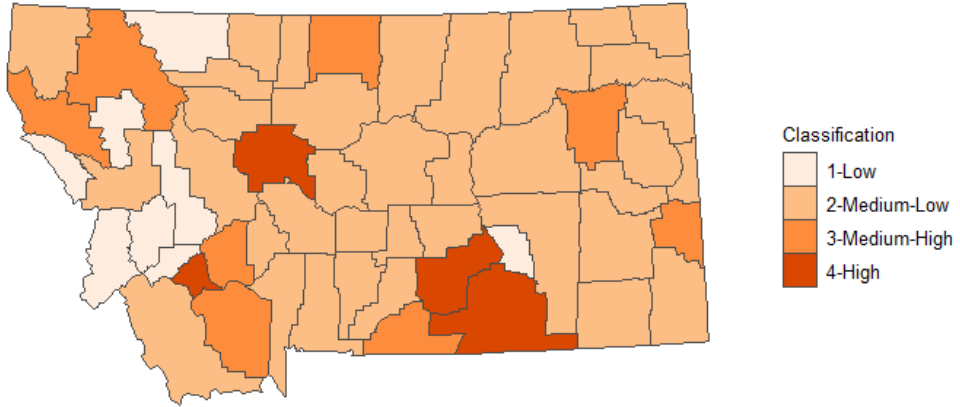
Drought Vulnerability - March, April, May



Energy

Energy and Industry

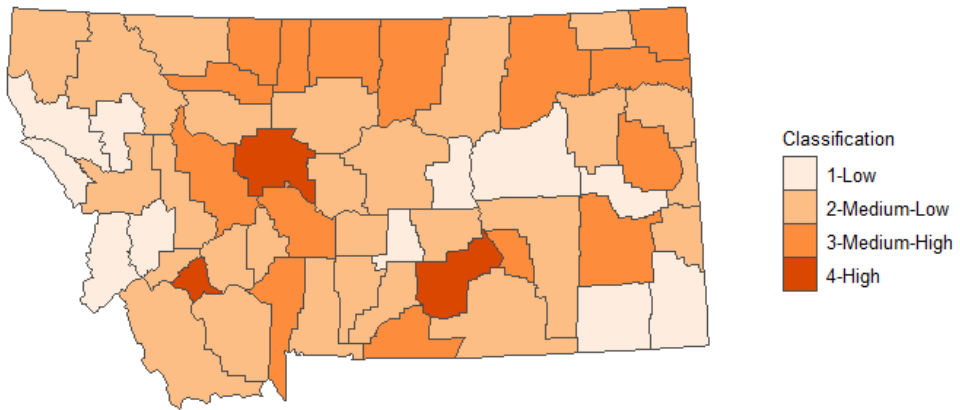
Drought Vulnerability - March, April, May



Municipal

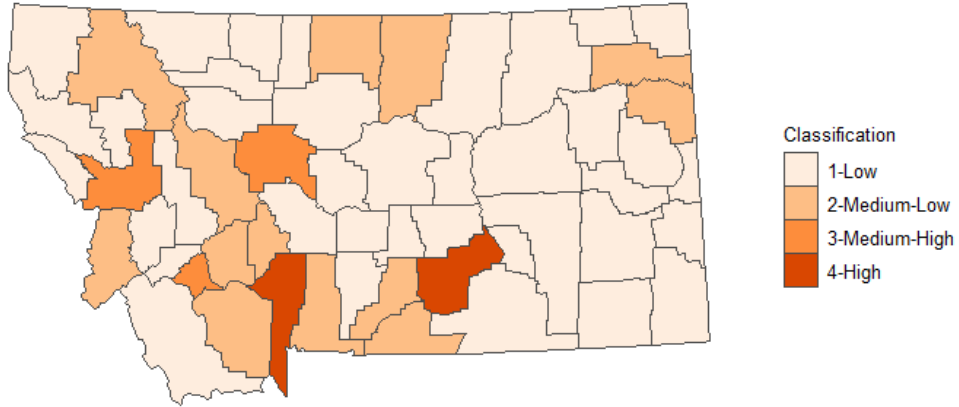
Municipal Water

Drought Vulnerability - March, April, May



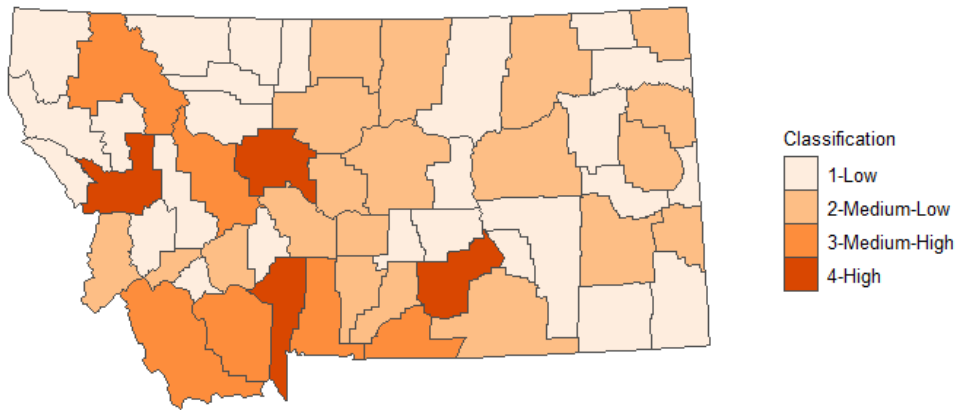
Planning and Community Development

Planning and Community Development
Drought Vulnerability - March, April, May



Recreation

Recreation
Drought Vulnerability - March, April, May

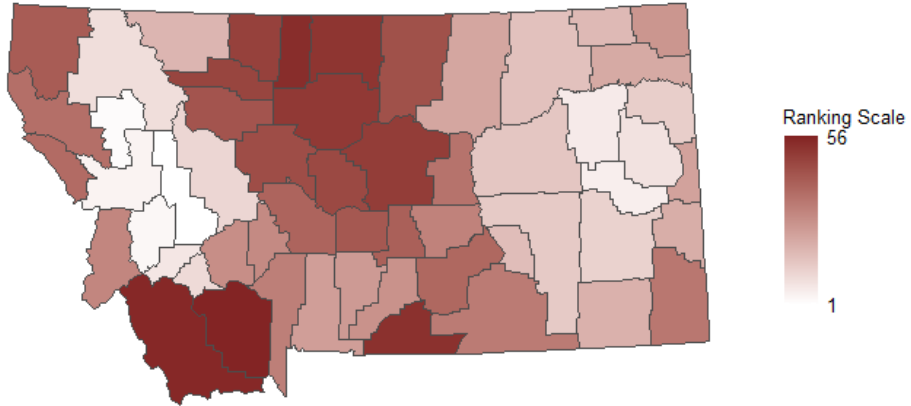


Summer – June, July, and August

Drought Exposure

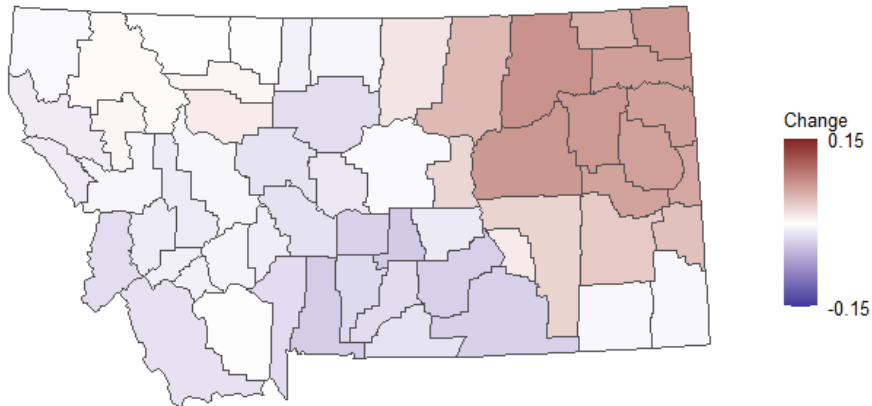
Montana

Drought Exposure Frequency - 2000 to 2022 - Jun, Jul, Aug



Montana

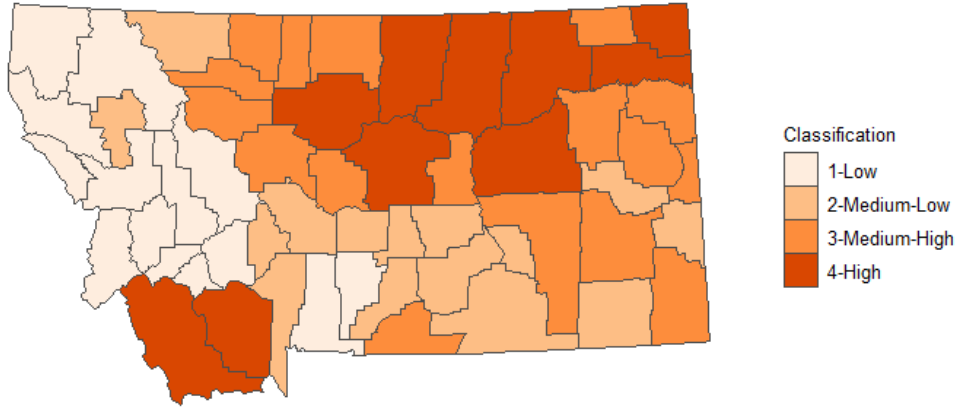
Drought Exposure Change - 2000 to 2022 - Jun, Jul, Aug



Agriculture

Agriculture

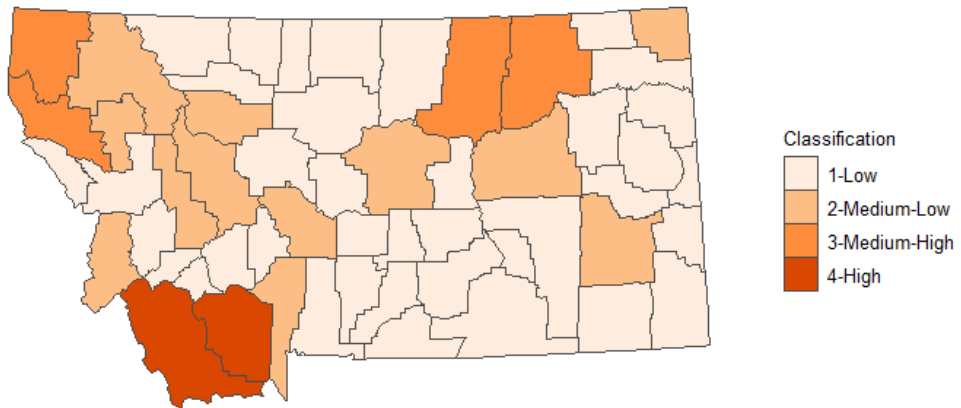
Drought Vulnerability - June, July, August



Conservation and Land

Conservation

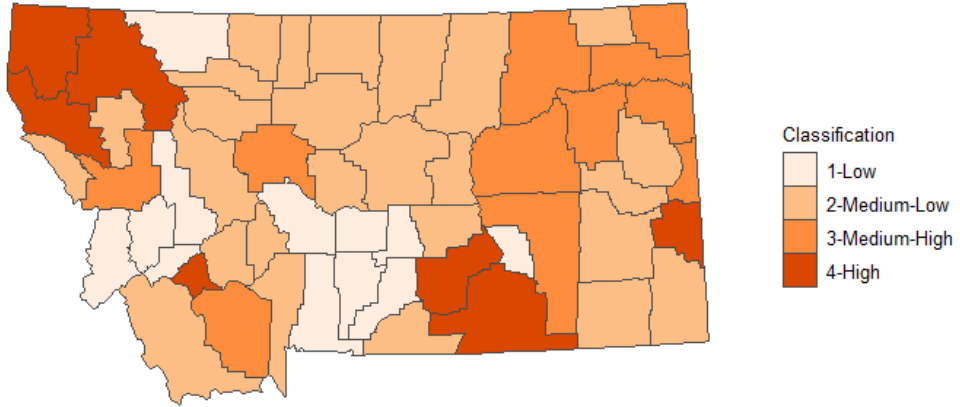
Drought Vulnerability - June, July, August



Energy

Energy and Industry

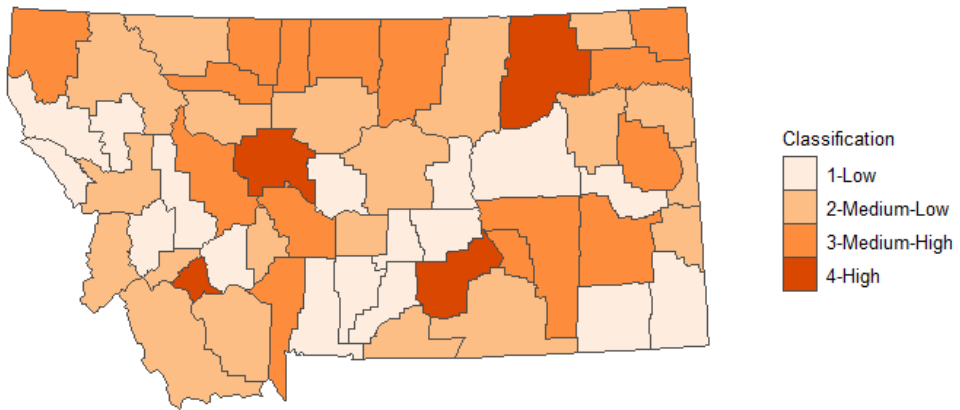
Drought Vulnerability - June, July, August



Municipal

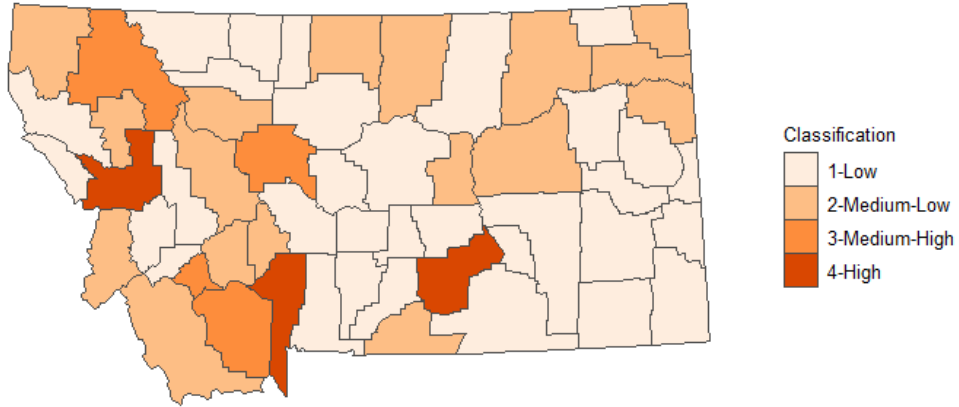
Municipal Water

Drought Vulnerability - June, July, August



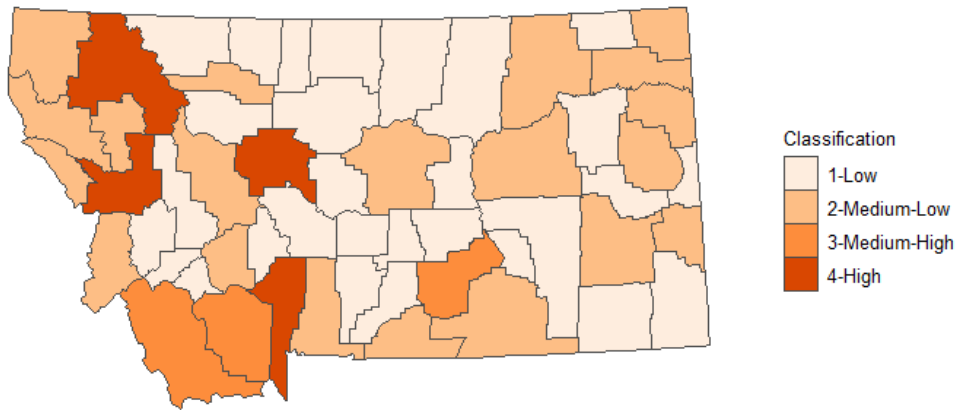
Planning and Community Development

Planning and Community Development
Drought Vulnerability - June, July, August



Recreation

Recreation
Drought Vulnerability - June, July, August

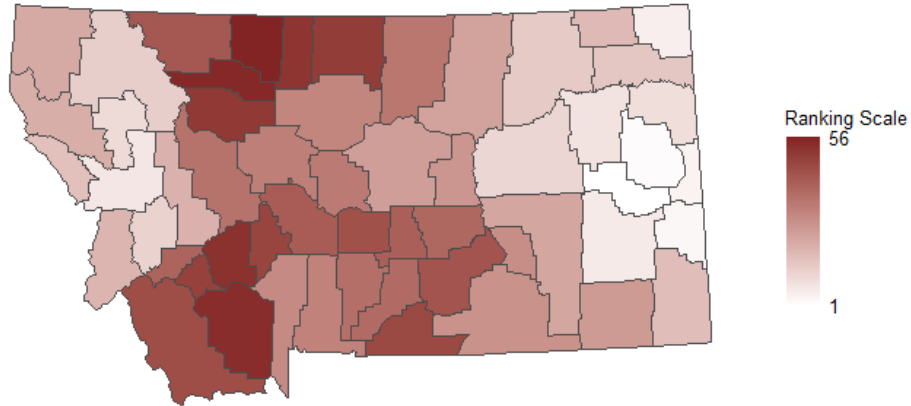


Fall – September, October, November

Drought Exposure

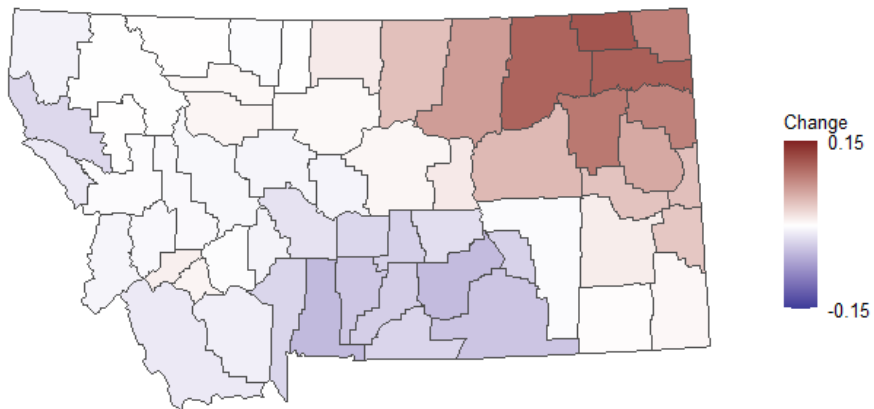
Montana

Drought Exposure Frequency - 2000 to 2022 - Sept, Oct, Nov



Montana

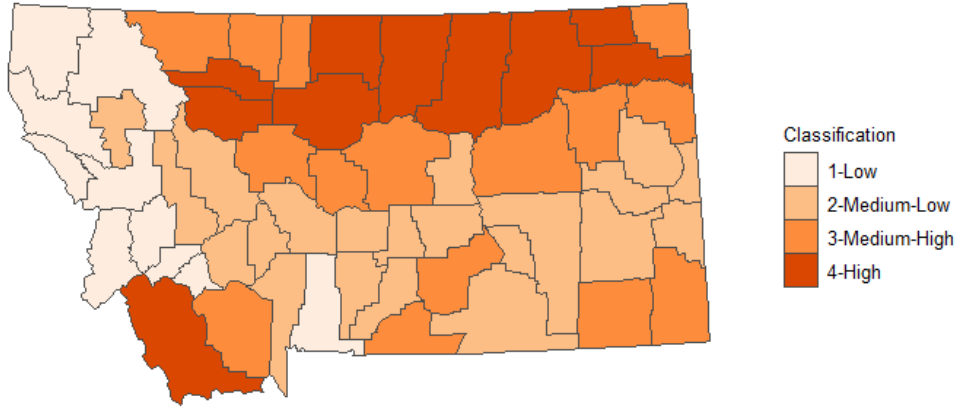
Drought Exposure Change - 2000 to 2022 - Sept, Oct, Nov



Agriculture

Agriculture

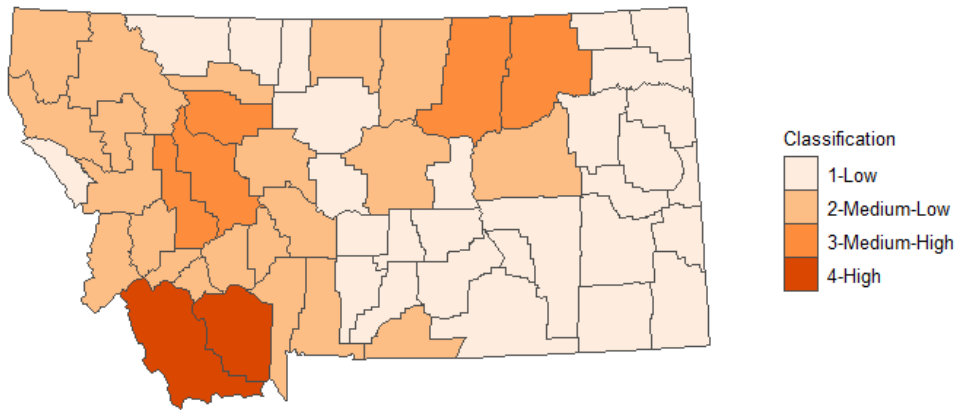
Drought Vulnerability - Sep, Oct, Nov



Conservation

Conservation

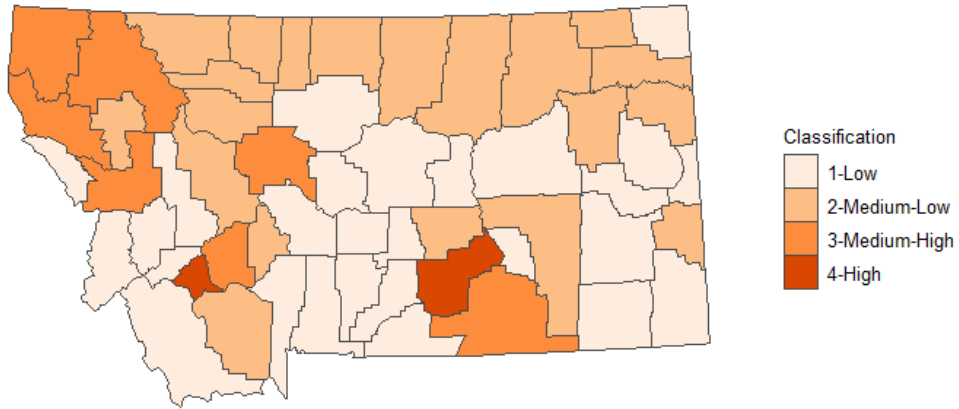
Drought Vulnerability - Sep, Oct, Nov



Energy

Energy and Industry

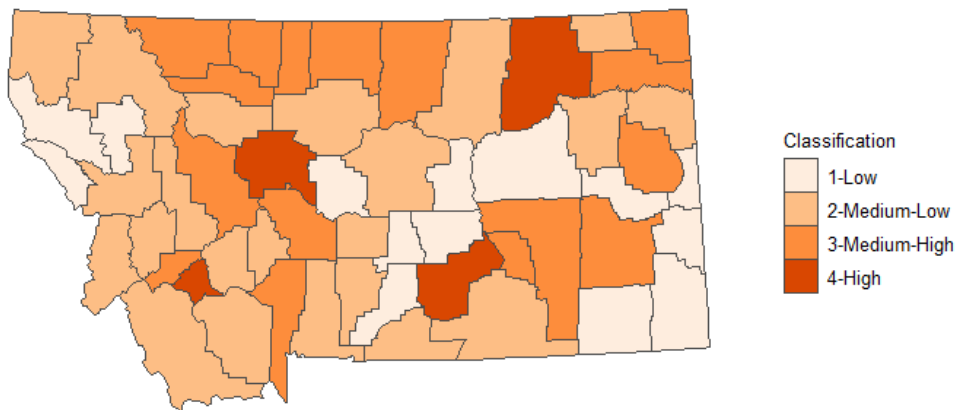
Drought Vulnerability - Sep, Oct, Nov



Municipal

Municipal Water

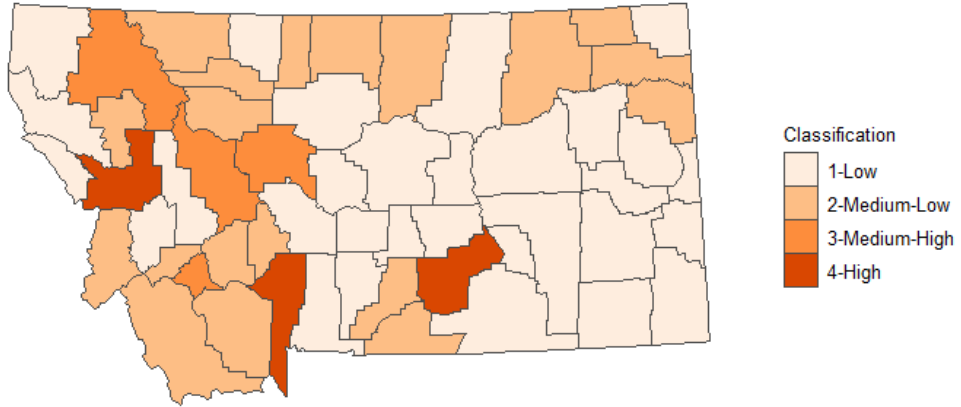
Drought Vulnerability - Sep, Oct, Nov



Planning and Community Development

Planning and Community Development

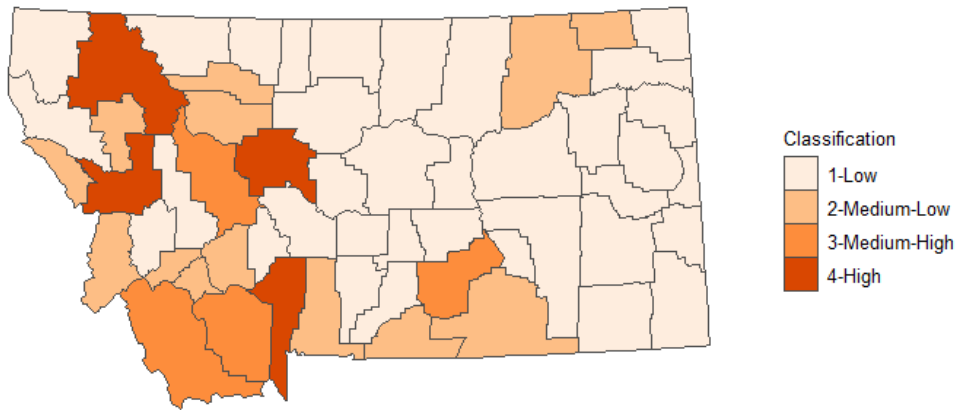
Drought Vulnerability - Sep, Oct, Nov



Recreation

Recreation

Drought Vulnerability - Sep, Oct, Nov



Appendix B: Survey Response Tables

This appendix presents results from each of the survey questions. It is important to note that water use sectors presented in these tables do not directly match with the sectors in the main results section of the vulnerability assessment. At the time of the survey distribution, all sectors in the below tables were defined. However, upon survey closure and coding of interview data, response rates for certain sectors were too low to warrant further analysis, leading to the combination of some sectors being combined for the analyses, which is explained in the main report. We present raw results before sector readjustment here to display which sectors survey respondents aligned themselves with at the time of the survey.

Summary of responses

Table 1: Drought Survey Responses by Drought Region

Region	N	%
Northwest	59	24.08
Southwest	48	19.59
North Central	45	18.37
Central	43	17.55
South Central	21	8.57
Northeast	16	6.53
Southeast	9	3.67
NA	4	1.63

Notes: The data include all survey respondents. Four respondents did not indicate their region.

Table 2: Drought Survey Responses by Primary Water Use Sector

Water Use Sector	N	%
Agriculture	96	39.18
Planning, Policy, and Community Governance	48	19.59
Other - Write In (Required)	32	13.06
Conservation and Ecological Services	22	8.98
Municipal Water Supply	15	6.12
Land Management and Fire	15	6.12
Recreation and Tourism	9	3.67
NA	3	1.22
Culture and Identity	3	1.22
Energy and Industrial Use	2	0.82

Notes: The data include all survey respondents. The water use sectors are the primary water use sector respondents are associated with or work in. Respondents also had the ability to indicate other water use sectors they were associated with in the next survey question they were presented with. Three respondents did not indicate their primary sector association.

Table 3: Drought Survey Responses by Secondary Water Use Sector

Water Use Sector	N	%
Agriculture	119	48.57
Recreation and Tourism	106	43.27
Municipal Water Supply	63	25.71
Conservation and Ecological Services	72	29.39
Land Management and Fire	71	28.98
Culture and Identity	29	11.84
Energy and Industrial Use	23	9.39
Planning, Policy, and Community Governance	73	29.80
Other - Write In	17	6.94

Notes: The data include all survey respondents. The water use sectors are the secondary water use sector respondents are associated with or work in. Respondents could choose more than one sector they were secondarily associated with, so one respondent may be counted within multiple water use sectors in this category.

Drought conditions

Table 4: Short Term Drought Conditions by Region - Survey Results

Region	Moderately dry	Very dry	About normal	Highly variable	Moderately wet	Not applicable	Very wet
Northwest	37	10	7	4	1		
North Central	9	31	2	2			
Central	16	23		3		1	
Southwest	19	20	2	5	1		
South Central	7	10		3			1
Northeast	5	8	1	2			
Southeast	4	4	1				

Notes: The data include all survey respondents. The water use sectors are the secondary water use sector respondents are associated with or work in. Respondents could choose more than one sector they were secondarily associated with, so one respondent may be counted within multiple water use sectors in this category.

Table 5: Long Term Drought Conditions by Region - Survey Results

Region	Moderately dry	About normal	Very dry	Highly variable	Not applicable	Moderately wet	Very wet
Northwest	36	8	8	5	1	1	
Southwest	31	8	4	2	3		
Central	24	6	3	3	4	2	
North Central	21	12	4	3	1	2	1
South Central	13	3	3			1	1
Southeast	6	3					
Northeast	5	5	1	5			

Notes: The data include all survey respondents. The water use sectors are the secondary water use sector respondents are associated with or work in. Respondents could choose more than one sector they were secondarily associated with, so one respondent may be counted within multiple water use sectors in this category.

Impact on work income

Table 6: Drought Impacts on Income by Sector - Survey Results

Water Use Sector	Yes, it impacts me in a negative way	No, it does not impact me	Not sure	Yes, it impacts me in a positive way
Agriculture	80	12		
Planning, Policy, and Community Governance	6	36	4	2
Other - Write In (Required)	4	21	4	
Conservation and Ecological Services	5	15	2	
Municipal Water Supply	2	13		
Land Management and Fire	3	7	2	2
Recreation and Tourism	6	3		
Energy and Industrial Use	1	1		
Culture and Identity		1	1	

Notes: The data include all survey respondents.

Table 7: Severity of Drought Impacts on Income by Sector - Survey Results

Water Use Sector	High, it has extreme impacts on my financial situation	Medium, it has substantial impacts on my financial situation	Low, it has some impact but does not severely change my financial situation
Agriculture	50	26	4
Planning, Policy, and Community Governance	2	4	
Conservation and Ecological Services		2	3
Recreation and Tourism	1	3	2
Other - Write In (Required)		2	2
Land Management and Fire		1	2
Municipal Water Supply	1	1	
Energy and Industrial Use			1

Notes: The data include all survey respondents.

Impact on work planning

Table 8: Drought Impacts on Work Planning and Engagement by Sector - Survey Results

Water Use Sector	Yes, it impacts me in a negative way	Not sure	No, it does not impact me	Yes, it impacts me in a positive way
Agriculture	84	1	1	5
Planning, Policy, and Community Governance	28	8	3	4
Conservation and Ecological Services	17	2	1	
Other - Write In (Required)	15	5	7	1
Land Management and Fire	10		1	1
Recreation and Tourism	8			
Municipal Water Supply	6	2	5	2
Culture and Identity	2		1	
Energy and Industrial Use	1		1	

Notes: The data include all survey respondents.

Table 9: Severity of Drought Impacts on Work Planning by Sector - Survey Results

Water Use Sector	High, it has extreme impacts and I need to alter the way I do things to be able to adapt to drought	Medium, it has substantial impacts and I have or am planning on changing the way I do things to adapt to drought	Low, it has some impact but does not severely change the way I do things
Agriculture	48	32	4
Planning, Policy, and Community Governance	6	13	9
Conservation and Ecological Services	2	10	5
Other - Write In (Required)	2	9	4
Recreation and Tourism	2	6	
Land Management and Fire	2	5	3
Municipal Water Supply	2	2	2
Energy and Industrial Use	1		
Culture and Identity		1	1

Notes: The data include all survey respondents.

Ability to adapt

Table 10: Severity of Drought Impacts on Work Planning by Sector - Survey Results

Water Use Sector	I have some capability to adapt, but need some support from outside resources	I have some capability to adapt, but need to be fully supported by outside resources	I have full capability to adapt and do not need outside resources	I have no capability to adapt and there are not outside resources that could help me
Agriculture	63	16	10	6
Planning, Policy, and Community Governance	26	11	9	2
Conservation and Ecological Services	15	4	3	
Other - Write In (Required)	12	3	15	2
Land Management and Fire	9	3	3	
Municipal Water Supply	6	4	4	1
Recreation and Tourism	4		4	1
Culture and Identity	1		2	
Energy and Industrial Use	1	1		

Notes: The data include all survey respondents.

Appendix C: Detailed Descriptions of Secondary Data

Indicator Variable: Cattle Population

Water Use Sector: Agriculture

Source: USDA 2017 Census of Ag via NASS Quick Stats

Description: This variable is the total cattle population by county in Montana.

Reason for Inclusion: Total cattle population is included as a drought indicator variable, as cattle and cattle land are likely to be impacted by drought. Impacts to cattle include water shortages that impact productivity of grazing and range land, as well as water supply which can impact cattle directly. Farmers and ranchers frequently need to reduce herd sizes due to drought, therefore counties with higher cattle populations are likely to be more impacted by drought because of the higher likelihood of cattle herds and land being affected.

Indicator Variable: Crop Sales (USD)

Water Use Sector: Agriculture

Source: USDA 2017 Census of Ag via NASS Quick Stats

Description: This variable is the total crop sales for all crops by county in Montana, as measured in US Dollars (\$).

Reason for Inclusion: Total crop sales is included as a drought indicator variable to indicate crop productivity by county, as measured by crop sales. Counties with a higher total value of crop sales are indicative of high agricultural productivity areas, which are consequently more likely to be impacted in times of drought.

Indicator Variable: Crop Land (acres)

Water Use Sector: Agriculture

Source: USDA 2017 Census of Ag via NASS Quick Stats

Description: This variable is the total crop land acreage for all crops by county in Montana.

Reason for Inclusion: Similar to total crop sales, total crop land is included as a variable to indicate agricultural activity and land by county. Counties with a higher crop land acreage are more likely to be impacted during drought.

Indicator Variable: Irrigation Withdrawals for Livestock (Mgal/day)

Water Use Sector: Agriculture

Source: 2015 USGS Water Use Estimates

Description: This variable is the total irrigation water withdrawals specifically for livestock use, measured in millions of gallons per day by county in Montana.

Reason for Inclusion: This variable is included for similar reasons as total cattle, as it measures the relative size and water use of livestock across counties in the state. This accounts for water use for

livestock, which supplements the total cattle numbers indicator and is likely to be influenced by drought conditions.

Indicator Variable: RMA Liability Payments (USD)

Water Use Sector: Agriculture

Source: USDA Risk Management Agency

Description: The USDA Risk Management Agency tracks crop insurance liability payments for every state and county in the U.S. and breaks out reasons for insurance claims and liability. This variable is the total liability payments specifically for drought in 2020.

Reason for Inclusion: This variable is included as an indicator of drought directly impacting agriculture, and captures areas where claims had to be made specifically for drought related losses recently.

Indicator Variable: Percentage Agriculture Employment

Water Use Sector: Agriculture

Source: Headwaters Economics – USDA Forest Service Tool

Description: Headwaters Economics maintains several tools that compile and track a variety of publicly available economic data related to federal agencies in Montana. The USDA Forest Service Tool has industry shares of total employment, which includes agriculture as one of the industries.

Reason for Inclusion: This is included as another indicator to capture the size of the agriculture industry in each county, under the assumption that counties with a higher percentage of agriculture employment will be more susceptible to drought impacts.

Indicator Variable: Irrigated Land

Water Use Sector: Agriculture

Source: Montana DNRC

Description: DNRC calculated total agriculture irrigated acres using a GIS layer from the 2015 State water plan, and then defining acreage specific to agriculture.

Reason for Inclusion: This is included as an indicator, as irrigation water availability can be directly influenced by drought. Therefore, counties with a greater number of irrigated acres may be more impacted in times of drought.

Indicator Variable: Native Trout Presence

Water Use Sector: Conservation, Ecological Services, and Land

Source: Montana FWP Species Distribution Maps

Description: This variable indicates the presence of a native trout species by county in Montana. There are four native trout species in Montana: Westslope Cutthroat (which is the state fish), Yellowstone Cutthroat, Bull Trout, and Arctic Grayling (Not a trout, but a closely related salmonid with similar characteristics). This variable is a count of how many native trout species are present in a county, therefore the range in value for this variable is 0-4.

Reason for Inclusion: Due to the fact that native trout species are highly sensitive to changes in water quality and temperature relative to warm water fish species and even other introduced trout, the presence of native trout can be included as a measure of how much of an impact drought may have on conservation or the ecological makeup of a county. Drought frequently leads to warmer water and decreased water quality, which in turn impacts native trout.

Indicator Variable: Wetland Areas (acres)

Water Use Sector: Conservation, Ecological Services, and Land

Source: Montana State Library

Description: This variable displays the total acreage of wetlands by county in Montana.

Reason for Inclusion: Wetland acreage is included as a variable to measure counties with a high amount of water resources and generally more “wet” areas, which are more likely to be impacted in times when drought is present. For example, a wetland area is more likely to dry up during drought, thus impacting the ecosystem in a greater manner relative to an area where no wetland exists.

Indicator Variable: MT Fish, Wildlife, and Parks owned land (acres)

Water Use Sector: Conservation and Land

Source: Montana FWP

Description: This is the total acreage of Montana Fish, Wildlife, and Parks owned land by county.

Reason for Inclusion: This variable is included because FWP land is frequently acquired to be conserved for the benefit of ecosystems and public recreational use. It is assumed that areas with more FWP land will be highly impacted from a conservation and ecosystem perspective in times of drought

Indicator Variable: Impaired Streams (miles)

Water Use Sector: Conservation, Ecological Services, and Land

Source: Montana DEQ

Description: This is the total mileage of streams classified as impaired in water quality categories 2, 4A, 4C, 5, and 5N by the Montana Department of Environmental Quality

Reason for Inclusion: This variable is included because it is assumed that streams designated as impaired will be more susceptible to ecological drought impacts such as warm water temperatures, low water, and poor water quality than non-impaired streams.

Indicator Variable: Impaired Lakes (% of total water area)

Water Use Sector: Conservation, Ecological Services, and Land

Source: Montana DEQ

Description: This is the total acreage of lakes classified as impaired in water quality categories 2, 4A, 4C, 5, and 5N by the Montana Department of Environmental Quality. The total acreage is then used to calculate the percentage of impaired designation to total water area.

Reason for Inclusion: This variable is included because it is assumed that lakes designated as impaired will be more susceptible to ecological drought impacts such as warm water temperatures, low water, and poor water quality than non-impaired lakes.

Indicator Variable: Water Area (sq. mi.)

Water Use Sector: Conservation, Ecological Services, and Land

Source: U.S. Census Bureau

Description: This is the total water area in square miles for each county.

Reason for Inclusion: This variable is included to calculate the percentage of impaired lakes relative to total water area.

Indicator Variable: Conservation Easements (acres)

Water Use Sector: Conservation, Ecological Services, and Land

Source: MT Legislative Fiscal Division

Description: The Montana legislative fiscal division compiled data on conservation easement acreage in the state by county. A conservation easement is an agreement between a landowner and a land trust that establishes a commitment to maintaining the property as open land, thus conserving the agricultural or natural state of the land.

Reason for Inclusion: This variable is included because it is assumed that areas of the state with a higher acreage of conservation easements will be impacted by drought from a conservation or ecological perspective.

Indicator Variable: Dewatered Streams

Water Use Sector: Conservation and Land

Source: Montana FWP

Description: MT FWP maintains a GIS dataset of chronically or periodically dewatered streams in Montana that support important fisheries or contribute to important fisheries. This variable shows total mileage of dewatered streams by county.

Reason for Inclusion: This variable is included because chronically or periodically dewatered streams are likely to be directly impacted by drought, and consequently have a negative impact on the ecosystem or fishery.

Indicator Variable: Hydropower Generator Capacity (MWH)

Water Use Sector: Energy and Industry

Source: MT DEQ

Description: This variable displays the presence of and maximum generator capacity of hydropower facilities by county in Montana.

Reason for Inclusion: Hydropower is an important energy resource for Montana and can be directly impacted by drought. This variable is an indicator of both the presence of hydropower and total potential

size of hydropower, as measured by generator capacity. In times of drought, areas with a greater hydropower presence are more likely to be impacted than areas with little or no hydropower.

Indicator Variable: Industrial Water Withdrawals (Mgal/day)

Water Use Sector: Energy and Industry

Source: 2015 USGS Water Use Estimates

Description: Total water withdrawals for industrial uses measured in millions of gallons per day.

Reason for Inclusion: This variable is included to measure industrial water use, under the assumption that counties with more industrial water use will be more likely to be impacted by drought.

Indicator Variable: Mining Water Withdrawals (Mgal/day)

Water Use Sector: Energy and Industry

Source: 2015 USGS Water Use Estimates

Description: Total water withdrawals for industrial uses measured in millions of gallons per day.

Reason for Inclusion: This variable is included to measure water use for mining, under the assumption that counties with more water use for mining will be more likely to be impacted by drought.

Indicator Variable: Wildland Urban Interface

Water Use Sector: Fire

Source: Headwaters Economics

Description: The wildland urban interface is tracked by Headwaters Economics and is forested private land within 500 meters of forested public land. The wildland urban interface is measured in square miles and includes both developed and undeveloped interface.

Reason for Inclusion: This is included because the more land area in the wildland urban interface will be more likely to be impacted by drought conditions, which are assumed to lead to higher costs in fire prevention, preparation, or suppression.

Indicator Variable: Wildfire Risk Analysis Score

Water Use Sector: Fire

Source: Montana DNRC

Description: The Montana wildfire risk analysis score measures a community's wildfire risk, the combination of the hazard and vulnerability to wildfires. The score is a standardized score that is measured across counties and geographical areas of the state to compare risk.

Reason for Inclusion: This is included for similar reasons to the wildland urban interface, under the assumption that areas with higher wildfire risk are going to be more impacted by drought conditions, which are assumed to lead to higher costs in fire prevention, preparation, or suppression.

Indicator Variable: Percent of Population on public water supply

Water Use Sector: Municipal Water Supply

Source: 2015 USGS Water Use Estimates

Description: This measures the percentage of the population by county that received water from a public water supply or municipality, as opposed to a personal well.

Reason for Inclusion: This is included to account for counties with a greater degree of people relying on municipality water, which are more likely to be impacted by drought relative to other counties with less of population on a public supply.

Indicator Variable: Per Capita Domestic Water Use – Public Supply (Gal/day)

Water Use Sector: Municipal Water Supply

Source: 2015 USGS Water Use Estimates

Description: This is the domestic water use per capita, measured in gallons per day, of the population on public water supply systems.

Reason for Inclusion: This is included to account for differences in typical water use between counties with municipal water supply systems.

Indicator Variable: Percent of Population Served by Surface Water for public supply

Water Use Sector: Municipal Water Supply

Source: 2015 USGS Water Use Estimates

Description: This variable measures the percent of the population that are on a public supply or municipal water that draws from surface water sources.

Reason for Inclusion: This variable is included under the assumption that surface water sources are more impacted by drought than groundwater sources.

Indicator Variable: Total County Population

Water Use Sector: Municipal Water Supply

Source: U.S. Census Bureau

Description: This is the total county population from the U.S. Census

Reason for Inclusion: This variable is included under the assumption that counties with higher populations will be more reliant on municipal water supplies and therefore more susceptible to being impacted by drought relative to counties with lower populations.

Indicator Variable: Percent Change in Population (2010-2020)

Water Use Sector: Planning, Policy, and Communities

Source: U.S. Census Bureau

Description: This variable measures the percentage change in county populations from the 2010 census to the 2020 census

Reason for Inclusion: This variable is included to account for counties that are experiencing substantial growth, which are assumed to present challenges in allocating and managing water resources in times of drought relative to counties with little population growth or declining populations.

Indicator Variable: Population Density

Water Use Sector: Planning, Policy, and Communities

Source: U.S. Census Bureau

Description: This variable is the population density in people per acre

Reason for Inclusion: This variable is included under the assumption that counties with a higher population density will have a greater demand for water resources, and therefore be more impacted by drought than counties with lower population densities.

Indicator Variable: Domestic Water Supply Withdrawals (Mgal/day)

Water Use Sector: Planning, Policy, and Communities

Source: 2015 USGS Water Use Estimates

Description: This variable is total domestic water supply withdrawals for domestic use measured in millions of gallons per day.

Reason for Inclusion: This variable is included as a measure for total water demand for domestic use in a county from all water sources. It is assumed that counties with a greater amount of water withdrawals will be more impacted by drought than counties with less water withdrawals.

Indicator Variable: Lodging Tax Collections (USD)

Water Use Sector: Recreation and Tourism

Source: Montana Department of Commerce

Description: This variable is the total lodging tax collections in U.S. dollars by county in 2021.

Reason for Inclusion: Lodging tax collections are an indicator of tourism revenue. It is assumed that tourism in Montana is impacted to some degree by drought, for example, fishing tourism being negatively impacted by low flows or warm river temperatures. Therefore, counties with higher lodging tax collections will be more impacted by drought than counties with lower lodging tax collections.

Indicator Variable: Fishing Access Sites

Water Use Sector: Recreation and Tourism

Source: Montana Fish, Wildlife, and Parks

Description: The number of fishing access sites by county

Reason for Inclusion: Fishing is likely one of the most directly impacted recreational activities by drought, therefore it is assumed that counties with more fishing access sites will be susceptible to greater recreation and tourism drought impacts than counties with less fishing access sites.

Indicator Variable: MT State Parks

Water Use Sector: Recreation and Tourism

Source: Montana Natural Heritage Maps

Description: The number of state parks by county

Reason for Inclusion: State parks are a popular tourism destination, and frequently have water resources such as rivers or lakes on them. Similar to with fishing access sites, it is assumed that counties with more state parks will be susceptible to greater recreation and tourism drought impacts than counties with less state parks.

Appendix D: Survey and Interview Guides

Drought VA Interview Guide

Date:
Interviewer:
Interviewee:
Phone #:
Email Address:
County:

Introduction:

Thank you for taking the time to speak with me today. These interviews are part of a drought Vulnerability Assessment that we are conducting on behalf of Montana Department of Natural Resources and Conservation (DNRC) as part of their comprehensive effort to update the state Drought Management Plan. The purpose of the Vulnerability Assessment is to systematically understand the impacts of drought within and across sectors and communities throughout the state. This assessment will be used to support identification of appropriate drought response actions and adaptation strategies that will be useful and accessible to Montana's diverse water users and build Montana's resilience to drought. The data we collect for this project will be summarized and included in the updated Drought Management Plan.

Before I get started, a couple logistical things...

- 1) Are you ok with me recording this? Your responses will be kept entirely confidential--the recording will only be used for analysis purposes and will only be accessed by our research team.
- 2) As I mentioned, your responses will be confidential and any quotes we may decide to use from you in the report will be anonymous.
- 3) Please feel free to skip any questions if you don't feel like answering them.
Do you have any questions for me?

Background information and sensitivity

- 1. Tell me a bit about yourself and the main ways that you use water.**
 - a. Describe what you do for your primary source of income. Has drought impacted your work and income? Could it in the future?
 - b. Are you associated with any other water use sectors in your work? Which ones? Has drought impacted those sectors?
 - c. How do you use water in your personal life? Do you see impacts from drought in how you use water?
- 2. What resources do you use to gather information about or monitor drought conditions?**
 - a. How do you use this information?
 - b. Are the information resources adequate? Are they clear or easily understood?
 - c. Are there additional types of drought information that would be helpful to you? If so, please describe.

Adaptive capacity

- 3. How do you plan for drought in your work?**
 - a. Relating to your primary source of income, describe specifically any changes or actions you have taken or other ways you deal with or plan for the direct impacts of drought on your business/operation.
 - i. Are these sustainable for you?

- ii. How long will they be sustainable?
- 4. **Relating to your primary source of income, describe any public policies, regulatory relief, or grant/payment programs that help you deal with drought impacts.**
 - a. How helpful have you found these programs/policies to be?
 - b. What could be changed about these programs to make them more supportive in times of drought.

Relationships

- 5. **In what ways, if any, do you work with other water users to respond to drought?**
- 6. **Do you feel like other water users impact you or the way you operate? If so, how?**

Personal impacts and reflections

- 7. **Has drought impacted your mental or physical health?**
- 8. **What resources or policies would you like to see from the state to help you plan for drought?**
- 9. **Is there any other information you would like to share?**
- 10. **Are there other people you think would be good for us to interview?**

Drought VA Survey Guide

- 1. In which county do you live in?
- 2. In which counties do you work? (Select all that apply)
- 3. With which water use sector are you primarily associated in your work? (Choose one)
 - a. Agriculture
 - b. Recreation & Tourism
 - c. Municipal Water Supply
 - d. Conservation and Ecological Services
 - e. Land Management and Fire
 - f. Human Health, Culture & Identity, and Research
 - g. Energy and Industrial Use
 - h. Planning, Policy, and Community Governance
 - i. Other (please describe)
- 4. With which other water use sectors are you associated? (Select all that apply)
 - a. Agriculture
 - b. Recreation & Tourism
 - c. Municipal Water Supply
 - d. Conservation and Ecological Services
 - e. Land Management and Fire
 - f. Human Health, Culture & Identity, and Research
 - g. Energy and Industrial Use
 - h. Planning, Policy, and Community Governance
 - i. Other (please describe)
- 5. From your perspective, what have drought and water conditions been like in your county over the past 3-5 years? Over the past 10 years? (Pose as two separate questions in survey)
 - a. Very dry
 - b. Moderately dry
 - c. About normal
 - d. Moderately wet
 - e. Very wet

6. Does drought impact your income from your work in _____ (insert water use sector from question 3)
 - a. No, it does not impact me
 - b. Yes, it impacts me in a positive way
 - c. Yes, it impacts me in a negative way
 - d. Not sure
7. Does drought impact you, your planning, or the way you work in your primary water use sector?
 - a. No, it does not impact me
 - b. Yes, it impacts me in a positive way
 - c. Yes, it impacts me in a negative way
 - d. Not sure
8. If you indicated that drought impacts the way you work, rank the severity of these impacts.
 - a. Low, it has some impact but does not severely change the way I do things
 - b. Medium, it has substantial impacts and I have or am planning on changing the way I do things to adapt to drought
 - c. High, it has extreme impacts and I need to alter the way I do things to be able to adapt to drought
9. Do you have the resources to be able to adapt to drought? (select one)
 - a. I have full capability to adapt and do not need outside resources
 - b. I have some capability to adapt, but need some support from outside resources
 - c. I have some capability to adapt, but need to be fully supported by outside resources
 - d. I have no capability to adapt and there are not outside resources that could help me

(Page 2) We are interested in learning of any additional information about how drought is impacting you and how you respond to it.

10. What strategies, if any, do you use to plan and prepare for drought?
11. How would you like to see state or local agencies support you in planning for and responding to drought?
12. Any other thoughts you would like to share?

Appendix E: Full Coding Scheme for Interviews

1. Adapting, building resilience
 - a. Education and outreach
 - b. Plant species
 - c. Protecting resource
 - d. Restoration efforts
 - e. Shifting practices
 - f. Water conservation strategies
 - i. Incentives
 - ii. Regulatory restrictions
 - iii. Residential
 - iv. Voluntary restrictions
 - g. Water storage projects
 - h. What's needed to adapt
2. Contributing factors (sensitivity)
 - a. Access to water
 - b. Reservoir management
 - c. Collaboration
 - d. Conflict between water users
 - e. Population growth
 - f. Water rights
 - g. Ditch riders, water commissioners
3. Drought planning
 - a. Coalitions, watershed groups
 - b. Local mitigation plans
 - i. Disaster mitigation
4. Drought response
 - a. New wells
 - b. Public policy, relief and payment programs
 - i. Limitations
 - c. Selling livestock
 - d. Talking to others
5. Impacts (Exposure)
 - a. Climate change
 - b. Ecological impacts
 - c. Flooding
 - d. Impacts to livelihood
 - e. Pasture and crop quality
 - i. Grasshoppers
 - f. Positive
 - i. Increased engagement
 - g. Impacts to water resource
 - h. Longevity of thinking about water use
 - i. Mental and physical health
 - j. Recreation
 - k. Water quality
 - l. Wildfires
6. Interesting quotes
7. Monitoring

- a. Accessing information
 - b. Application of data
 - c. Drought monitor
 - d. Forecasts
 - e. Historical trends
 - f. Lived experience observation
 - g. Talking with others
 - h. On the ground monitoring
 - i. Snow pack (SNOTEL)
 - j. Stream gages
 - i. Base flows
 - ii. Water temperature
 - k. Water storage
 - l. Weather stations
 - m. Montana Mesonet
8. Other states
9. State plan
- a. Additional monitoring needed
 - i. Expanding, supporting stream gages
 - ii. Groundwater monitoring
 - iii. More snowpack
 - iv. More weather, moisture stations
 - v. Predictive tools
 - b. Climate change
 - c. Collaboration, coordination
 - d. Communication and outreach
 - i. Diverse communication strategies
 - ii. Education for residents
 - iii. Localized outreach
 - iv. Message framing
 - v. Sharing stories
 - e. Implementation challenges
 - f. Leadership
 - g. Policy, regulations
 - i. Additional response programs
 - 1. Education
 - 2. Farm or ranch tours
 - ii. Infrastructure
 - iii. Loans
 - iv. Mental health resources
 - v. Restoration, mitigation
 - vi. Tech assistance
 - vii. Development, land use
 - viii. Improvements to existing programs
 - ix. Water restrictions
 - x. Water rights, leasing
 - h. Response triggers
 - i. Things to avoid (not effective)
 - j. Tools and resources
 - i. Best practices
 - ii. Drought data and forecasts

- iii. Drought resiliency support
 - iv. Local planning support
 - v. Opportunities for water storage
 - vi. Support for watershed groups
 - vii. Water conservation
 - k. What's effective
 - i. Actionable
 - ii. Adaptable, scalable tools
 - iii. Multi-stakeholder driven
10. Water use activities
- a. Agriculture
 - i. Irrigation
 - b. Energy generation
 - c. Municipal life
 - d. Recreation