Montana Drought Management Plan

Building Drought Resilience

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Photo and cover photo by Donnie Sexton

LETTER FROM THE DIRECTOR

To the Citizens of Montana,

Water is at the very heart of our lives here in Montana. We use water to irrigate fields, generate energy, support our industries and communities, ensure fishery habitat, and enjoy recreational opportunities. When drought unfolds in Montana, it truly affects us all. That is why I am pleased to introduce the Montana Drought Management Plan. The integrative and comprehensive plan demonstrates how Montana is already a leader in drought response and adaptation. It provides a reference guide to our state's extensive drought monitoring network, drought assessment, and response framework. Additionally, it presents stakeholder-generated recommendations for building resilience to future droughts.

The Montana Drought Management Plan, which was last updated in 1995, was completed through a three-year, stakeholder-driven planning process. While the Department of Natural Resources and Conservation (DNRC) coordinated the planning process, this was far from a solo effort. The planning process brought together hundreds of Montanans to share their personal experiences with drought and ensure that the plan is true to lived experiences across Montana. In addition, a Drought Task Force, led by representatives from seven state agencies, guided plan development.

The 36 management recommendations presented in the plan come directly from the ideas, concerns, and solutions brought forward by stakeholders. Recommendations span a wide range of topics – water storage, water policy, funding, monitoring, community governance, and agency coordination – because building resilience to something as complex as drought will require a multi-faceted and strategic approach. As we transition from planning to the implementation stage, the diverse menu of options provided by these recommendations will form the starting point for efforts to improve drought resilience.

Thank you to everyone who contributed to the development of the Montana Drought Management Plan. I am excited to see the collaboration continue as we move forward together to build drought resilience and protect future water supplies for generations to come.

Sincerely,

Amanda Kaster

Amanda Kaster
Director, Montana Department of Natural Resources and Conservation

Photo by Donnie Sexton

EXECUTIVE SUMMARY

The Montana Drought Management Plan (Plan) represents a significant, stakeholder-driven overhaul and modernization of Montana's previous Drought Response Plan (1995). Montana's Drought and Water Supply Advisory Committee (Drought Committee), comprising representatives from seven state agencies and convened by the Montana Department of Natural Resources and Conservation (DNRC), is authorized by statute to develop a state plan for drought. This multi-year drought planning effort, from 2020 to 2023 and led by DNRC, engaged hundreds of Montanans from across the state who represented diverse water uses and interests. It also relied on insights and guidance from the Drought Committee, technical experts, and numerous partners, including representatives of local, state, tribal, and federal governments, universities, non-profits, and businesses. In addition, DNRC sought public feedback and engagement through a 45-day comment period during the summer of 2023.

The goal of the Plan is to build drought resilience across Montana. Although drought has always been a natural feature of Montana's climate, rising temperatures associated with a changing climate are predicted to exacerbate the intensity and frequency of future droughts. Specifically, the Plan includes five main sections that collectively will aid Montana in drought preparedness and resiliency:

SECTION 1: Drought Monitoring and Assessment

- Outlines Montana's processes for monitoring and assessing drought and explains how recommendations for the U.S. Drought Monitor classifications are developed. This robust system, which incorporates stakeholder input on local conditions, is a national model on how to assess drought.

SECTION 2: Drought Vulnerability and Adaptation

- Assesses Montana's vulnerability to drought with a focus on five primary water-use sectors: agriculture; conservation and land management; energy and industry; recreation and tourism; and planning and community development.
- Provides a spatial representation of how our social and ecological systems are impacted by drought and a foundation for planning at local, county, regional and state levels.

SECTION 3: Operational and Administrative Framework for Drought Management

- Identifies the key players involved in state-level drought management and delineates the pathway from drought monitoring and assessment to state-level (emergency) declarations and federal-level (disaster) designations that trigger state and federal actions.
- Documents roles and responsibilities across the many state, federal, tribal, and local entities involved in managing drought, providing clarity on a complex system, as well as a baseline for future improvements.

SECTION 4: Drought Response

- Provides state-level drought management triggers for five drought stages and current agency response actions associated with each stage.

SECTION 5: Drought Management Recommendations

- Collects 36 drought management recommendations, also known as adaptation strategies, to increase drought resiliency in Montana.
- These stakeholder-generated recommendations are the starting point for deciding where to invest time and resources over the coming decade. Staff, budget, and policy considerations will refine which of the recommendations are prioritized for implementation on the road to preparing Montana for future drought.

Building drought resilience, in a broad sense, means ensuring the state is prepared for drought at all phases of the drought cycle: before a drought occurs, as it develops, once it materializes, and as it recedes. The Plan provides a comprehensive management framework to improve drought preparedness throughout the whole drought cycle, and it outlines a pathway to create a more drought resilient Montana in the years to come.

KEY MESSAGES

DROUGHT IS A NATURAL, RECURRING FEATURE OF MONTANA'S PAST, PRESENT, AND FUTURE CLIMATE.

Although drought can simply be thought of as a lack of precipitation over an extended period of time, it is a complex phenomenon that is often described by its impacts – to streamflows, crops, natural ecosystems, and even local economies. In Montana, drought is a recurring event that can last for multiple years, sometimes even decades. Future drought is projected to be more severe and longer lasting due to warmer temperatures caused by long-term shifts in temperatures and weather patterns. Shifts in the amount and timing of precipitation and changes in temperature will present new adaptation challenges.

DROUGHT MONITORING AND ASSESSMENT ARE COMPLEX AND REQUIRE INTERPRETATION.

Monitoring and assessing drought are complex and rely on robust scientific data, plus well-reasoned interpretations of it. Montana's state-level drought assessment process is both collaborative and systematic, incorporating a variety of drought metrics, interpretation by scientists, robust peer review, and reports of on-the-ground conditions from Montanans. It is nationally recognized as a model approach.

MANAGING DROUGHT REQUIRES BOTH RESPONSE AND PREPAREDNESS.

Modern drought management, especially at the state level, emphasizes both responsiveness and preparedness (often called adaptation). Holistic management examines political, social, and ecological systems to find underlying weaknesses that, if fixed, can help Montanans cope more effectively with the next drought.

UNDERSTANDING DROUGHT VULNERABILITY CAN HELP US MAKE PROACTIVE CHANGES.

Understanding how our social, economic, and ecological systems are impacted by drought can help us identify key actions to reduce vulnerabilities and lessen drought impacts. A systematic look at the state's drought vulnerability provides the foundation for smart planning at local, county, regional, and state levels.

DROUGHT PREPAREDNESS IS DIFFERENT AT STATE VS. LOCAL LEVELS.

Adapting to or coping with drought requires both state and local action. At the state level, preparedness includes big-picture planning, smart policy, and robust programs that offer data, technical assistance, capacity, partnerships, and funding to local communities. Critical, on-the-ground drought resilience work (e.g., planning and project implementation at the watershed or farm scale) is locally driven and implemented.

LIST OF AGENCY ACRONYMS

DOA Montana Department Agriculture

DEQ Montana Department of Environmental Quality

DOL Montana Department of Livestock

DES Montana Department of Military Affairs – Disaster and Emergency Services

DNRC Montana Department of Natural Resources and Conservation

DPHHS Montana Department of Health and Human Services

FSA Farm Service Agency

FWP Montana Department of Fish, Wildlife and Parks

MBMG Montana Bureau of Mines and Geology

MCO Montana Climate Office

MSL Montana State Library

MWCC Montana Watershed Coordination Council

NIDIS National Integrated Drought Information System

NRCS Natural Resources Conservation Service

NWS National Weather Service

SBA Small Business Administration

USACE United States Army Corps of Engineers

USBR United States Bureau of Reclamation

USDA United States Department of Agriculture

USDM United States Drought Monitor

USFS United States Forest Service

USGS United States Geological Survey

INTRODUCTION

In Montana, drought is a given. Whether we farm, fish, run a business, or raise a family, drought affects us all — our landscapes, livelihoods, and even our health.

Drought is often described as a hazard, but it is helpful to think of drought as something to expect — a regular and recurring part of Montana's past, current, and future climate. Drought is not a hazard we can avoid, like a lightning storm or an avalanche, nor is it sudden, like a tornado or flood. Instead, drought is often an annual reality that gradually develops over time, and we must do our best to prepare for it.

Coping with drought means we must adapt and build resilience — the ability to withstand drought and still function — into our man-made and natural systems. To do this effectively, we need strategic actions at both state and local levels. At the state level, drought preparedness includes big-picture planning, smart policy, and robust programs that offer data, technical assistance, capacity, partnerships, and funding to local communities. Critical, on-the-ground drought resilience work (i.e., planning and project implementation) is locally prioritized, driven, and implemented. The state's main role in building local drought resilience is to support local communities in managing drought.

The goal of the Montana Drought Management Plan (Plan) is to build drought resilience in Montana. Each of the five sections accomplishes this in a different and complementary way:

- The **Monitoring and Assessment** section details Montana's systems and processes for determining when a given location is at risk of or experiencing drought;
- The **Vulnerability Assessment** section provides a foundation for planning at local, county, regional and state levels with insights into how our social and ecological systems are impacted by drought;
- The **Operational and Administrative Framework** section sets forth who does what – and when – across the many state, federal, tribal, and local entities involved in managing drought, providing clarity on a complex system as well as a baseline for future improvements;
- The **Response Actions** section details the five stages for drought management and the corresponding triggers and responsibilities associated with each;
- The **Management Recommendations** section collects a menu of options for programs, policies, and other long-term strategies that could help Montanans prepare for future drought at state and local levels.

Photo by David Hanson

DROUGHT PLANNING IN MONTANA

Drought planning has progressed markedly since 1995, when Montana last developed a holistic, state-level drought plan. Notably, the development of the U.S. Drought Monitor (USDM) in 1999 provided a standardized method for identifying and classifying drought conditions across the United States. USDM classifications are currently used by the U.S. Department of Agriculture (USDA) to trigger federal drought relief programs. They are also used, in conjunction with other drought indicators, to support local and state decision-making, and they inform Montana's drought response stages. Our ability to monitor and assess drought conditions continues to improve as measurement networks expand and climate science advances. Ongoing research by climate scientists to develop and improve drought monitoring metrics, combined with statistical models to determine where and when to apply them, continuously advances our drought knowledge. Finally, the focus of modern drought planning has shifted, from emphasizing reactive, response-based actions to generating innovative, proactive adaptation strategies that build drought resilience.

Statutory Authority for Planning

Under § 2-15-3308, Montana Code Annotated (MCA), statutory authority for drought planning in Montana lies with the Drought and Water Supply Advisory Committee (Drought Committee), a multi-agency group coordinated by the Montana Department of Natural Resources and Conservation (DNRC). Among other duties, the interagency committee is responsible for developing and implementing a state plan that considers drought mitigation and response.

PLANNING PROCESS (2020 – 2023)

This Montana Drought Management Plan (Plan) is the product of a comprehensive and collaborative three-year (2020–2023) planning effort (Appendix A). DNRC Water Resources Division staff led the effort in conjunction with seven regional stakeholder groups and the Drought Committee, convened as the Drought Task Force for the purpose of the planning process. The Plan incorporates the expertise and input of a wide range of water users from across the state, as well as state and federal agencies, tribal partners, non-governmental organizations, university researchers, and other experts in natural resources policy, climate science, hydrology, and social science.

The planning process was supported by an appropriation from the 2019 Montana Legislature, a Drought Contingency Planning Grant from the U.S. Bureau of Reclamation (USBR; 2020), and in-kind support from DNRC, the Drought Committee, and hundreds of stakeholders across the state.

Drought Task Force

The Drought Task Force comprised representatives from seven executive branch agencies involved in drought response and management in Montana, who were already serving on the state's Drought Committee. Their role on the Drought Committee positioned them to offer well-informed perspectives on their agency's drought management activities and critical public needs. Members provided input, leadership, and insight on behalf of the Montana Departments of Agriculture (DOA); Commerce; Environmental Quality (DEQ); Fish, Wildlife and Parks (FWP); Livestock (DOL); Military Affairs – Disaster and Emergency Services (DES); and DNRC.

The Drought Task Force met regularly throughout plan development, including a series of eight meetings between fall 2021 and spring 2023. Outside of meetings, members reviewed and updated their respective agencies' response actions and provided valuable insight through one-one-one discussions about sector-specific drought impacts and constituent needs.

Regional Stakeholders

To facilitate stakeholder engagement and ensure systematic evaluation of drought vulnerability, impacts, and adaptation strategies, the planning team engaged diverse stakeholders across seven geographic regions based on the National Oceanic and Atmospheric Administration's (NOAA) climate divisions (Figure 1). Approximately 150 stakeholders participated from across Montana, and they provided insight on their experiences with drought, as well as strategies for adaptation, through facilitated meetings, one-on-one interviews, and an online survey.

FIGURE 1. Map of climate regions used to organize regional stakeholder groups.

Technical Experts

DNRC contracted with seven consultant teams who worked closely with DNRC, stakeholders, and the Drought Task Force on different elements of the Plan. Consultants assisted with the following tasks: co-designing and facilitating a multi-year public engagement process; researching and modernizing the state's operational and administrative framework for drought management; conducting a statewide drought vulnerability assessment; profiling and photographing seven diverse and representative Montanans adapting to drought in their communities; and updating and recording Montana's process for drought monitoring and assessment. Additional consultants assisted with technical editing, graphic design, and web development.

CLIMATE AND DROUGHT IN MONTANA

Montana's Climate

Much of Montana has a semi-arid climate, where drought is a recurring, natural, and cyclical feature that presents in a variety of forms and intensities. Montana's broad geography and diverse landscapes create a wide variety of climatic conditions across the state. Topographically, the state's mountain and prairie landforms span elevations ranging from over 12,000 feet in south-central Montana to 1,800 feet in the northwest corner. West of the Continental Divide, the climate is generally maritime—wetter than that to the east. In the west, inversions, low clouds, and fog often form in valleys, and the region generally sees ample annual precipitation. This relatively moist climate supports vast forests and numerous riverine ecosystems that drain into the Columbia River Basin. East of the Continental Divide, the prairies experience a semi-arid continental climate, with warmer summers, colder winters, and less annual precipitation. Here, major rivers like the Missouri and Yellowstone thread across vast rangelands.

The diversity of Montana's climate, ecosystems, and landscapes leads to highly variable weather conditions. Precipitation amount, air temperature, humidity, and wind speeds can vary dramatically from region to region and can change quickly. Fluctuations in the magnitude and rate of change have important ramifications for drought onset and intensification. In short, Montana experiences many forms of drought and impacts can vary considerably depending on location and type of water use (Box 1).

Drought – Past and Future

As described in the 2017 Montana Climate Assessment, analyses of tree ring width – as a proxy for moisture availability – indicate that the megadroughts of Montana's past were prolonged, in some cases lasting for multiple decades.[1] More recent observational records have documented periods of persistent drought throughout the last century, including 1917-1919, the late 1920s to early 1940s (Dust Bowl), the 1950s, the late 1980s to early 1990s, and the early 2000s. The Assessment authors expect, based on available evidence, that multi-year droughts will continue to be a regular feature of our climate, but higher temperatures resulting from climate change[2] will exacerbate drought when and where it occurs.[3] This means droughts may have more rapid onset and greater intensity, and patterns of snowpack accumulation and runoff will shift, increasing the likelihood of drought in late summer and early fall.[4] The Greater Yellowstone Climate Assessment (2021) echoes this conclusion by documenting declines in the amount of precipitation falling as snow since the 1950s and projecting earlier spring snowmelt and runoff, with concurrent decreases in soil moisture, in the future.[5]

BOX 1. *DEFINING DROUGHT*

Though a familiar term, *drought* can have different meanings in different contexts. According to the National Integrated Drought Information System (NIDIS), drought is usually defined as "a deficiency of precipitation over an extended period of time (usually a season or more), resulting in a water shortage." NIDIS goes on to describe categories of drought that scientists have identified based on the resources or systems impacted:

Meteorological drought – a period of unusually dry or hot weather resulting in drought impacts.

Hydrological drought – when below normal precipitation or above normal temperatures impact surface and groundwater systems.

Agricultural drought – when reduced soil moisture impairs growth of crops, range, or forest resources.

Ecological drought – when drought impacts ecosystems and associated ecosystem services.

Drought can also be described in terms of its intensity, cause, or duration; for example:

Flash drought – occurs rapidly with the onset of high temperatures, exceptional aridity, and lack of wetting rains.

Snow drought – occurs when low snowpack accumulation over winter reduces spring streamflow and soil moisture.

Persistent drought – is defined as multiple years with ongoing impacts resulting from below-average precipitation, much above-average temperature, or both.

Seasonal drought – when seasonal deficits in precipitation or above-average temperatures result in short term drought impacts.

Megadrought – severe drought lasting for decades.

REAL COWBOYS, VIRTUAL FENCING

A Malta rancher's pilot program with virtual fencing—and its potential to enhance herd health, wildlife habitat and grasslands— shows promise

Writing and photography by David Hanson

The house of Leo and Darla Barthelmess sits like an islet in the sea of sage 30 miles east of Malta, MT. A garage and small addition adjoin the original structure built of stones plucked from this arid, rocky land. Inside, Leo, 67, sits at the kitchen table with a mug of black coffee and an iPad, the tool he needs to move his virtual fences, keep tabs on his 450 cattle and, ultimately, maintain a thriving ranch.

"I can build a fence right here on my iPad," he says. "The programming that I implement goes to Vence, the virtual fencing company in San Diego. And whatever magic they work means I can control the herd and better manage the grasses without having to build and maintain actual fences."

Barthelmess moved with his parents to this ranch in 1964. He and his brother raise cattle on 25,000 acres of private, federal, and state land amidst one of the largest contiguous grasslands in North America. For almost 60 years Barthelmess and his family, like every other rancher in the west, used hardwire fencing to delineate pastures and manage grass and water resources. It's worked, but Leo understands the need to adapt: steel prices have doubled recently and drought and warming temperatures have forced him to drill two wells as once reliable reservoirs diminish to mud holes. When your capital is not only your cattle, but the natural grasses they eat, there's always the fear of over-grazing.

Leo switches to his iPhone and zooms into a map where a few dozen black cow icons appear against the brown topography of Pasture 21. We head outside and climb into Leo's side-by-side. A coiled rope hangs behind my seat. Despite the radio collars, cell signals, and San Diego software engineers, this remains a large, dynamic ranch, and Barthelmess is still a cowboy. We drive out onto the range.

Berthelmess is running a pilot program with Vence. The company has proven success in warmer climates and wanted to test their equipment and software on the frigid northern Montana plains. Government grants and a willingness to experiment afforded Barthelmess the opportunity to shift to the virtual fencing. Each of the five repeater stations on the ranch offer a six-mile radius so the radio signals cover the entire ranch and most of the neighboring ranches.

“The amount of temporary or permanent fence you’d have to put in to move the cattle in the optimal way is an astronomical cost and the amount of work is significant,” Barthelmess says. “The virtual fencing allows the arid regions to participate in intensive soil and grass management.”

Managing cattle and pasture for intensive, concentrated grazing provides more time for the soil to transfer nutrients to the grasses during recovery periods. The combination of cattle hooves, manure, and longer recovery times fosters the growth of healthy soil microbes. Healthier soils act as a “carbon sponge” that absorbs more rainwater while also storing carbon rather than releasing it to the atmosphere.

“We have huge migratory movement through this region: antelope, mule deer, and sage grouse. And so that’s another reason to reduce the miles of barbed wire fences. It’s not that any one thing in itself is reason to do the virtual fencing, but all of it combined—the grazing management, the livestock management, the wildlife movements—is a tremendous reason to do what you can.”

For now, due in large part to the drought, residual grass storage is shrinking more quickly than Leo would like. Ideally, the ranch would support its cattle on pasture for all twelve months, but the reality usually involves relying on trucked-in (and increasingly expensive) hay during the 1-2 lean months. With the control of virtual fencing, Leo can reap more nutrients from a smaller pasture and then allow longer recovery times for the pastures to regrow. In this way, Leo anticipates that they can maintain a residual storage for a full year of grass. In the long run, he hopes better grazing management will support more soil moisture and a thriving grassland. ■

> **“I can control the herd and better manage the grasses** without having to build and maintain actual fences.”
>
> — LEO BARTHELMESS

Photo by Montana Climate Office

SECTION 1: DROUGHT MONITORING AND ASSESSMENT

Accurate, localized drought monitoring and assessment are critical to Montana's ability to quickly assess drought onset, location, and severity. The state's monitoring infrastructure and drought assessment process help agricultural producers and other water sectors make management decisions in response to current and forecasted conditions. Timely localized assessments ensure that Montanans can be connected to federal disaster relief funding during severe drought years as soon as conditions warrant support.

A Convergence of Evidence Approach

Drought monitoring is a multi-faceted and complex process. It is a function of both science and art that relies on drought metrics and data, as well as local and regional observations of conditions and impacts. In short, *monitoring* is the process of documenting data on drought conditions. Montana's drought monitoring process gathers drought metrics, observations of conditions, and impact reports from water users across the state. (See Appendix B, Guide for Drought Monitoring and Assessment.) A team then uses that monitoring data to complete a weekly drought *assessment*—an interpretation of the data to classify current drought intensity. The assessment evaluates patterns and associations across a range of variables. This is known as a "convergence of evidence" approach, and it enables drought managers and scientists to combine the many drivers, types, and impacts of drought into a single assessment.

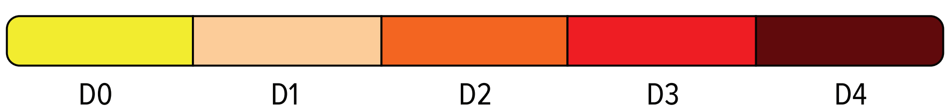
Drought metrics are not perfect representations of current on-the-ground conditions and often do not account for complex processes, such as the movement of water through different soil types. Various drought metrics (and/or the same drought metric calculated over different timescales) may depict drought conditions differently. This is because drought metrics differ in how they represent drought drivers (e.g., precipitation shortfall). The convergence of evidence approach considers both quantifiable and non-quantifiable variables that are at the core of drought assessment and provides a comprehensive and defensible method to define drought severity across Montana.

Drought Monitoring Subcommittee and Collaborative Monitoring Network

In Montana, the Drought Monitoring Subcommittee (Monitoring Subcommittee) assesses statewide drought conditions each week, all year round. The Monitoring Subcommittee currently consists of five Montana-based "leads" (or map authors) from the Montana Department of Natural Resources and Conservation (DNRC), the Montana State Library (MSL), the National Weather Service (NWS), and the Montana Climate Office (MCO). The leads take turns developing recommendations for the U.S. Drought Monitor (USDM), and they are supported by a collaborative monitoring network of scientists, land and water managers, drought specialists, extension agents, agricultural producers, tribal resource managers, watershed practitioners, and interested members of the public. The Monitoring Subcommittee and network work together to evaluate drought conditions using an iterative process (Box 2) that has proven to be an exemplary approach to collaborative drought assessment within such a large and climatically diverse state.

U.S. Drought Monitor

FIGURE 2. U.S. Drought Monitor Categories from D0 (abnormally dry) to D4 (exceptional drought).



Montana's drought assessment process provides weekly drought classification recommendations to the USDM, which is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the U.S. Department of Agriculture (USDA), and the National Oceanic and Atmospheric Administration (NOAA). USDM drought classifications are the national standard for documenting drought presence and intensity, and they trigger various federal risk mitigation and disaster relief programs, as well as state-level response actions. Drought classes range from moderate (D1; tan) through exceptional drought (D4; reddish/brown) and are shown on the weekly USDM map of the United States (Figure 2). Abnormally dry (D0; yellow) is not a formal drought classification, but it is used to identify areas of concern prior to the onset of drought conditions.

Montana’s Drought Metrics

Drought arises from a combination of weather processes that suppress precipitation, increase evapotranspiration, and increase snow melt. These interactions reduce available soil moisture, surface water and groundwater, and stress vegetation. Monitoring changes in water movement and accumulation can indicate when and where drought is occurring. However, drought impacts will vary depending on the region, season, and timescale, so understanding the context is important. The Monitoring Subcommittee uses a variety of metrics (physical indicators and modeled indices) to assess and characterize drought. The interpretation of these metrics depends on both the season and timescale of interest, and consideration is also given to the standardized thresholds used by the U.S. Drought Monitor.

Drought indicators are measured variables or parameters used to monitor drought conditions. Examples include measured precipitation, temperature, soil moisture, and streamflow. **Drought indices** are computed numeric representations of drought intensity that rely on climatic or hydrological inputs like those listed in Table 1. Examples of drought indices include precipitation percentiles, the Standardized Precipitation Index (SPI), and the Evaporative Drought Demand Index (EDDI). Drought indices compare historical data with current conditions and recent anomalies to measure drought intensity.

BOX 2. *WEEKLY DROUGHT ASSESSMENT PROCESS*

The state of Montana uses a collaborative, weekly process to submit drought classification recommendations to the U.S. Drought Monitor (USDM). The weekly assessment process begins each Monday when one of five drought leads (they rotate this duty every two weeks) evaluates a suite of physical drought metrics and indicators and reviews recent drought impact reports submitted by Montanans from across the state.

By midday, the drought lead sends an initial assessment of drought conditions to the network via email to a 50-person Listserv of subject matter experts. This initial assessment uses the prior week’s drought map as a starting point and includes three components:

- The USDM drought map from the week before with depictions of any proposed changes to drought class or extent;
- Indicator/index and other data supporting the recommended changes; and
- A narrative description of the proposed recommendation.

The drought lead may also recommend maintaining “status quo” if the evidence does not support any changes from the previous week (e.g., if there was some precipitation, but not enough to improve the drought class).

The network then provides email feedback that validates or refutes the drought lead’s assessment. This is an iterative process that often generates robust email discussion, and it provides space to change or refine the drought lead’s initial assessment. Once the network achieves consensus, the drought lead prepares and sends a final recommendation (a map plus supporting evidence – usually in the form of power point slides depicting different metrics and a narrative) to the national map author at USDM (the national leads also rotate every two weeks). If the network does not achieve consensus, the drought lead makes the final decision on the recommendation.

Recommendations to the national map author are usually submitted by midday on Tuesday, and they must be supported with multiple forms of evidence, typically in the form of objective (physical) drought indicators or indices. The national author and the Montana lead then have a short window of time to discuss any discrepancies in recommended changes before the weekly USDM map is finalized and released on Thursday morning.

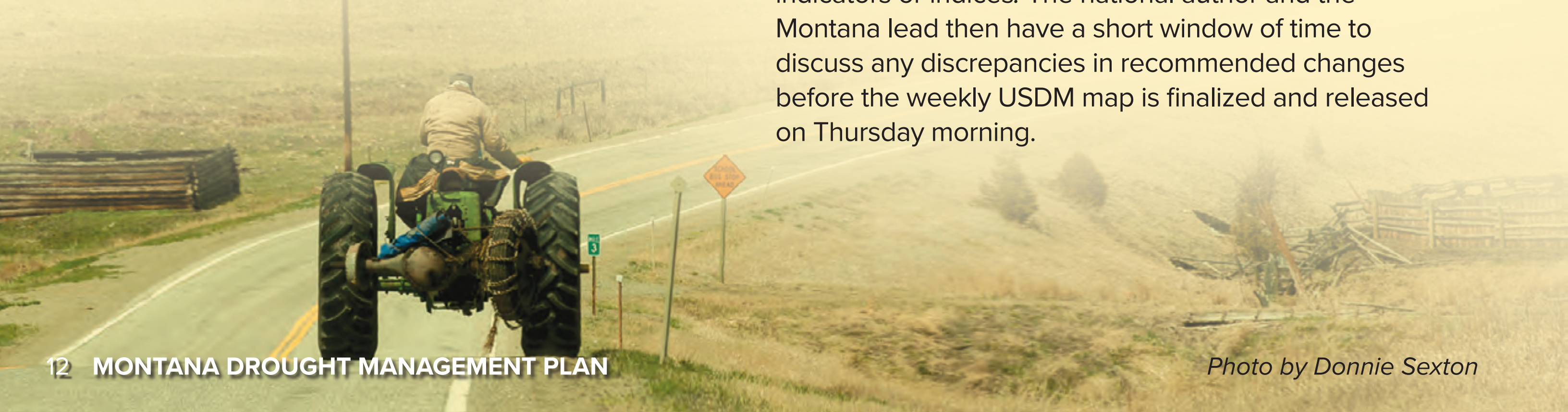


Photo by Donnie Sexton

TABLE 1. Primary drought metrics used by the Montana Drought Monitoring Subcommittee. Other metrics, such as station data or reports from the Montana Drought Impacts Reporter, are incorporated into drought assessments opportunistically. Montana uses a 30-year period of record as the computational foundation for drought indices. Most of the metrics listed below appear on the Upper Missouri River Drought Dashboard, which serves as the primary source for drought metrics in Montana.

METRIC	INPUT DATA AND DESCRIPTION
METEOROLOGY	
Precipitation Percentile	**Precipitation** Precipitation percentiles describe the amount of precipitation received relative to what is expected over a period of interest. Percentiles are calculated against a historical record (reference period) to estimate expected precipitation amounts.
Percent of Normal Precipitation	**Precipitation** Percent of normal precipitation describes precipitation anomalies with respect to the climatological average defined by the reference period. This metric is more valuable at longer timescales, e.g., 90+ days, especially during dry periods, where one precipitation event could appear unduly beneficial. For example, 1" of precipitation in a dry month that typically accumulates only 0.5" represents 200% of normal. However, in the context of the season and the water year, that amount may be inconsequential.
Standardized Precipitation Index (SPI)	**Precipitation** SPI was designed to standardize precipitation time series across a reference period to normalize precipitation anomalies in both time and space. SPI is different from precipitation percentiles as it explicitly models the *probability* of observing a specific amount of precipitation over a time scale of interest.
Standardized Precipitation Evapotranspiration Index (SPEI)	**Precipitation and Reference Evapotranspiration** SPEI accounts for both precipitation and reference evapotranspiration to describe the wetness or dryness of a time period. During warmer times of the year, SPEI is advantageous to SPI since it accounts for atmospheric demands on moisture as well as precipitation inputs.
Evaporative Demand Drought Index (EDDI)	**Reference Evapotranspiration** EDDI is similar to SPI and SPEI in its formulation; however, EDDI only accounts for reference evapotranspiration. EDDI describes anomalies in reference evapotranspiration over a timescale of interest with respect to a historical reference period.
Temperature Percentile (daily maximum or minimum)	**Temperature** Temperature percentiles describe the average daily maximum (or minimum) temperature experienced relative to what is expected over a timescale of interest. Percentiles are useful as they provide a historical context of any particular anomaly with respect to how it compares to observed variability.
Snow Water Equivalent (SWE) Anomaly	**Snow Telemetry (SNOTEL) or Snow Data Assimilation System (SNODAS)** SWE is an indicator of liquid water stored as snow. SWE anomalies describe the observed SWE measured (or estimated) at a site relative to what is expected for a day or season of interest.
Basin-Scale Snow Water Equivalent (Standardized SWE Index and Hypsome-SWE)	**SNODAS and a digital elevation model** The standardized SWE index is an indicator of SWE anomalies across Montana. It is helpful for understanding the spatial distribution of SWE and for identifying locations with lesser than average snowpack given the time of year. Hypsome-SWE estimates the cumulative SWE that occurs across elevation bands within Montana's HUC 8 watersheds and calculates a percentage of normal. This analysis is useful for understanding high- vs. low-elevation snow water accumulation throughout the snow season.
SOIL MOISTURE	
Soil Moisture Percentiles and anomalies	**Soil Moisture** Soil moisture percentiles or anomalies describe the amount of soil moisture in the soil reservoir relative to what is expected for period of interest.

HYDROLOGY	
Streamflow Percentiles and Streamflow Averages	**Streamflow** Streamflow is an indicator of hydrological drought. Daily, weekly, and monthly streamflow percent of averages and percentiles are tracked as indicators of current hydrological conditions. Streamflow percentiles represent a ranking of current streamflow as compared with historical flow readings. Percent of average streamflow represents the current flow compared to the historical average for the day or period of interest.
Groundwater Percentile	**Water Table Depth** Groundwater is an indicator of longer timescale hydrological drought. Groundwater table height percentiles represent water table deviation from normal and can be computed over various timescales. This metric is important to understand the availability of stored subsurface water but must be used in conjunction with storage characteristics of the aquifer.
VEGETATION	
Greenness Anomaly	**The Normalized Difference Vegetation Index (NDVI)** NDVI is a commonly used indicator of ecosystem photosynthesis and provides an indication of vegetation status. NDVI greenness anomalies are useful indicators of vegetation stress (or vigor) and can be calculated over various timescales, similar to other drought metrics.
Vegetative Health	**The Vegetative Health Index (VHI)** VHI is a proxy that characterizes vegetation health or a combined estimation of moisture and thermal conditions. Vegetation health is often used to estimate crop condition and anticipated yield. If the indices are below 40 (unfavorable), vegetation stress and losses of crop and pasture production might be expected; if the indices are above 60 (favorable conditions), plentiful production might be expected.

Photo by Michael Downey

Seasonality of Drought Metrics

Montana's climate exhibits strong seasonal variability that affects interpretation of drought metrics (Table 2). Conditions change dramatically from cold, snowy winters to hot, dry summers. This annual cycle between cold and hot means that the drought metrics' usefulness will differ, depending on the season. Keep in mind that drought can occur in any season (including winter), even if precipitation is ample throughout the rest of the year.[6]

TABLE 2. Guidance for drought monitoring by season. See Table 1 for metric abbreviations.

SEASON	METRICS OF INTEREST	OTHER CONSIDERATIONS
WINTER **(snow accumulation)**	**Temperature** influences snowpack volume and runoff. **SWE as recorded by SNOTEL** represents high elevation observations of snowpack and helps inform forecasts of spring runoff. However, observations at SNOTEL sites are not indicative of low- or mid-elevation snowpack. The representation of SWE as percentage of average can be misleading in fall and spring, when minor variations in SWE can appear dramatic when expressed as a percentage of average. **Standardized SWE** is a modeled estimate of snowpack across a basin or watershed by elevation; this measurement offers greater insight into low- and mid-elevation snowpack.	SPI, SPEI, and precipitation percentiles are also important for tracking winter precipitation, especially during periods of unseasonably warm temperatures. Also, keep an eye on wind speed because high winds can exacerbate wintertime drought.
SPRING **(snowmelt and spring moisture)**	**SPI and precipitation percentiles** are key indicators for recharging soil moisture, surface water, and groundwater. **Temperature and evaporative demand indexes (e.g., SPEI, EDDI, and temperature percentiles)** help describe loss of moisture to the atmosphere. **Streamflow** percentiles and percent of averages at the watershed level are good indicators that help forecast streamflow through the summer and late season. **Soil moisture** is a key metric that shows how much winter precipitation entered the soil profile versus being lost to runoff or evaporation.[7]	Surface water storage, and vegetation indicators (e.g., greenness anomaly and vegetative health) are important to track when assessing spring conditions. Focus on shorter timescales (30 to 90 days).
SUMMER **(dry down and evaporative demand)**	**Temperature, SPEI (30 to 180-day), EDDI (30 to 180-day), soil moisture anomalies and percentiles, and streamflow percentiles and averages** are all important, especially in assessing rapid onset droughts (flash droughts).[8]	Generally, shorter-term timescales (30 to 90-day metrics) are good for assessing moisture recharge or depletion in summer, while longer-term timescales (90 to 180-day metrics) incorporate springtime moisture to better understand long-term drying trends.
FALL **(soil moisture recovery and freeze-up)**	**SPI, SPEI, precipitation percentiles (30 to 180-day timescales), temperature, and soil moisture** are important to assess moisture recovery and effective precipitation because conditions can remain hot and dry until November.	Streamflow is usually low in the fall but can respond to pulses of precipitation, causing one to overestimate the effect. Streamflow percentiles (28-day metric from U.S. Geolgical Survey, USGS) can help avoid this.

WINTER: SNOW ACCUMULATION

Winter in Montana is cold, with most precipitation falling as snow. Mountain snowpack provides important storage that feeds streams and groundwater well into the summer. Prairie snowpack is equally important but typically melts off by mid-March. For this reason, east of the divide, spring and summer precipitation through June is critical. The timing and magnitude of peak snowpack across basins is important for predicting runoff in spring and summer. Warm temperatures in winter can decrease snowpack retention, increase sublimation (evaporation directly from snow to water vapor), and reduce the insulating effect snowpack provides for certain agricultural practices, such as winter wheat production.[9, 10]

Photo by Thomas Lee

SPRING: SNOWMELT AND SPRING MOISTURE

Spring in Montana brings snowmelt and seasonal rains. This period represents a critical time of moisture recharge across the state. Moisture released from snowpack infiltrates into the soil and groundwater to support vegetation and feed streams and rivers for months to come. If temperatures increase too quickly or if there was insufficient moisture the previous fall, soils may not be adequately recharged, which increases the likelihood that soil water reserves won't meet summertime demand. Timing and rate of snowmelt is most important in the mountains, while precipitation accumulation, timing, and onset of higher temperatures is most important in the prairies.

Photo by Michael Downey

SUMMER: DRY DOWN AND EVAPORATION DEMAND

Summer represents the driest and hottest period in Montana. Hot, dry, and windy conditions increase evaporative demand, which pulls moisture from the soil. The strong impact of evaporative demand is especially important to consider during this period.[11] Shorter-term metrics, 30 to 90-day timescales, usually describe moisture recharge or depletion in summer; however, 90 to 180-day timescales can help to describe longer term drying trends by incorporating springtime moisture. In Montana, unseasonably wet conditions in late July or August will not reverse the impacts resulting from unseasonably hot and dry conditions in May and June.

Photo by Donnie Sexton

FALL: SOIL MOISTURE RECOVERY AND FREEZE UP

The fall offers a time for soil moisture recharge that is critical prior to the "freeze up" (when soils freeze and soil moisture uptake is severely reduced until melt). Conditions can remain hot and dry during this period, especially prior to November. Practitioners should consider both SPI and SPEI for meteorological indices at short to medium time scales (30 to 180 days). Soil moisture data should also be used during this period as an indicator of effective precipitation as soils are likely to be very dry prior to recharge. Streamflow is usually low in fall but may respond to pulses of precipitation, so it is important to use longer timescales of streamflow percentiles (e.g., 28-day streamflow metrics from the U.S. Geological Survey (USGS) duration hydrograph toolkit) to avoid overestimating the effect from an isolated precipitation event.

Photo by Donnie Sexton

Drought Metric Timescales

Selecting the appropriate timescale is a crucial part of calculating and assessing drought severity using drought metrics. Timescales (also referred to as lags or aggregation periods) represent the period over which a drought metric is calculated (e.g., a 30-day timescale represents a 30-day aggregation period over which a given variable, such as precipitation, is analyzed). Tracking drought indices and indicators at various timescales allows us to identify short-term wet periods within long-term droughts or short-term dry spells within long-term wet periods.

Key considerations:

- **Large increases in drought severity classifications usually, but not always, require longer timescales.** The timescale for transitioning between drought classifications typically lengthens as drought severity increases. For example, the transition from D0 (abnormally dry conditions) to D1 (moderate drought) can occur in a matter of days or weeks, but the transition from severe (D2) to extreme (D3) drought usually (but not always, as in the event of a flash drought) takes more time and relies on a longer timescale (30 to 90 days or more). The longer timescale minimizes the effects of short-term weather variability. The same principle applies to the determination of drought recovery.
- **For short-term and extreme events, the right timescale is critical – and complicated.** The inclusion or exclusion or a short-term event, such as a large rainstorm, a week with high temperatures, or an unusual out-of-season event, may dramatically change the depiction of drought severity in the relevant drought metrics and indices. Inclusion of these types of extreme, short-term events into drought metrics and indices is not wrong, but it can unduly influence drought severity assessments. Practitioners must be aware of the effect of these events on the associated drought metrics (Box 3).
- **Beware of averages.** When unexpected weather conditions occur, practitioners should take care to ensure that the use of averages does not mask important indicators. For example, April and May of 2021 in Montana were colder than average and preceded the second warmest June on record. The unusually cool April and May suppressed green-up across Montana, while the unusually hot June caused plants to move into dormancy prematurely. The combination of these two temperature-driven events greatly increased the severity of the drought across Montana that summer. However, despite the large swing in temperature, the *average* temperature over those three months appeared unremarkable.

Precipitation in Context

When evaluating precipitation, it's easy to focus on the question of "how much." However, this number may provide an incomplete or even misleading picture if not coupled with informed answers to "where" and "when." This is because drought indices can misrepresent the effect of seasonal timing of precipitation in the aggregation of data.[12] For example, east of the Continental Divide in Montana, June is a critical month for precipitation. If June precipitation is lacking, a summer drought is more likely in that region. While a June precipitation deficit will be apparent in precipitation metrics, an out-of-season heavy rain event in mid- or late-July or August could appear to erase that deficit in the SPI, SPEI, or precipitation percentiles. So, even as higher temperatures and minimal precipitation in June create drought conditions that trigger plant dormancy and other impacts, precipitation indices may suddenly indicate near normal or even above normal conditions. Understanding the seasonality and context (including timescales) of drought metrics is vital to understanding drought in Montana (Box 3).

BOX 3. *THE IMPORTANCE OF SEASONAL CONTEXT IN UNDERSTANDING DROUGHT*

The maps shown here illustrate the effect of a rare August storm on the Standardized Precipitation Evapotranspiration Index (SPEI) during the summer of 2021. That year was hot and dry, and drought conditions had enveloped all of the state by early July. However, an unusual 3-day rain event during the third week of August released between 1.5 and 4 inches of precipitation across much of Montana, more than twice the normal amount usually received during the entire month!

The first map shows the longer-term drying effect of a springtime moisture deficit on much of the state using the 90-day SPEI, from mid-May to mid-August (Figure 3). The second map, showing 90-day SPEI from June to August, shows the response of SPEI to the unusual rain event in mid-August (Figure 4). Without understanding the context of typical summer precipitation patterns in Montana, we might assume that the rain event had abated the drought. However, as we know from the benefit of hindsight, severe to exceptional drought conditions persisted across the state throughout the fall and early winter of 2021.

This example illustrates the pitfalls of assessing drought conditions without knowledge and consideration of broader seasonal weather patterns and how they influence soil moisture status. It also demonstrates the importance of using a convergence of evidence approach in drought assessment. Integrating multiple metrics with drought impacts and knowledge of local conditions is a crucial part of assessing drought intensity.

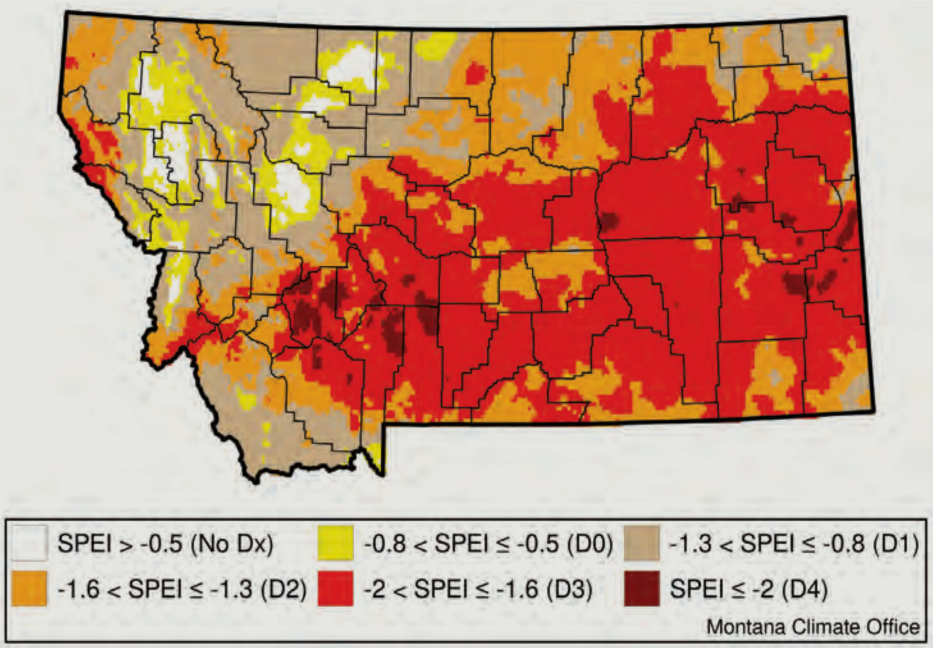


FIGURE 3: Standardized Precipitation Evapotranspiration Index – May 15, 2021 thru August 15, 2021

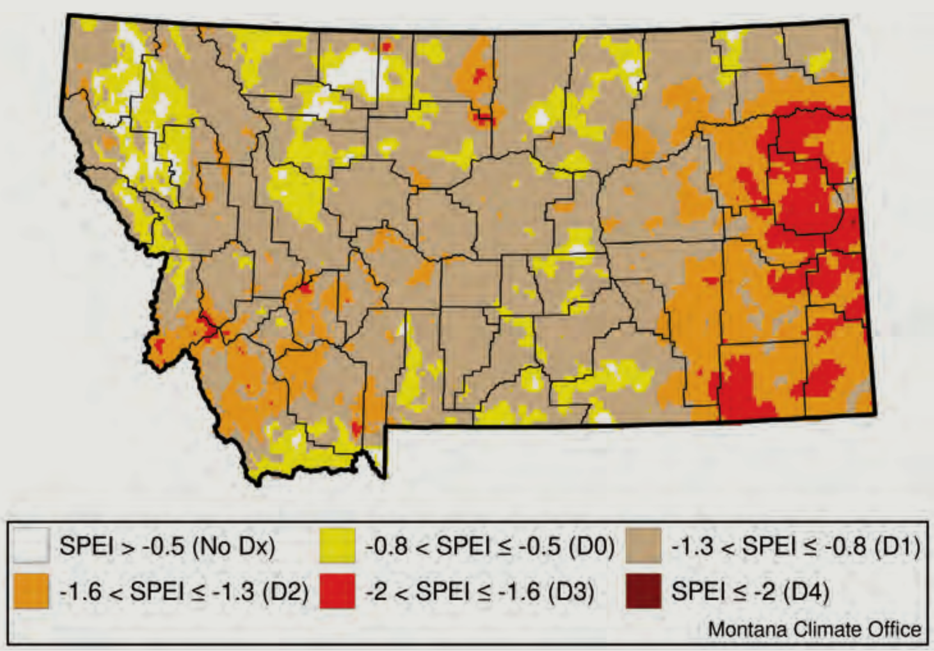


FIGURE 4: Standardized Precipitation Evapotranspiration Index – June 1, 2021 Thru August 31, 2021

Multi-year Events

Drought conditions in Montana can persist for several years. During multi-year drought events, short-term (e.g., 30- to 180-day) metrics may not fully describe conditions on the ground, especially in spring, summer, and fall. This is because long periods (1+ year) of below normal precipitation can have significant impacts on groundwater and surface water availability, with associated impacts on streamflows, lake systems, stock water ponds, wetlands, and vegetation. These long periods of abnormal dryness also result in extremely dry soils that hinder moisture infiltration, which would normally provide beneficial recharge. During these situations, it is important to consider short-term metrics within the context of multi-year dryness.

Local Drought Monitoring

While USDM classifications offer a good representation of regional drought conditions, the drought maps provided there often lack enough detail to accurately show local conditions, so a more targeted local monitoring effort within watersheds is often needed. As Montana's weather and water monitoring networks have improved, this task has become much easier. We now have a large volume of data, drought metrics, and other information that provide a good starting place for local drought monitoring. These include:

The Upper Missouri River Basin (UMRB) Drought Indicators Dashboard

The Dashboard is an interactive tool developed by the Montana Climate Office and is the primary source for drought monitoring data in Montana. This site computes and displays a multitude of common drought indices and indicators daily and at various timescales (Table 1). The drought dashboard also provides easy access to data collected by the Montana Mesonet and offers convenient "quick plotting" functions to evaluate recent (last 3 months) soil moisture responses to recent weather.

Montana Drought Impacts Reporter & Viewer

This website serves as a portal for people to report observations, post photographs, and view data about local drought impacts across Montana.

High Plains Regional Climate Center

The center offers monthly climate summaries, maps of temperature and precipitation data, and a portal to view historical NWS station data and other tools.

National Weather Service Weather and Hazards Data Viewer

On this site, users can view precipitation totals from multiple weather stations at one time.

USDA – Natural Resources Conservation Service National Water and Climate Center Precipitation Portal

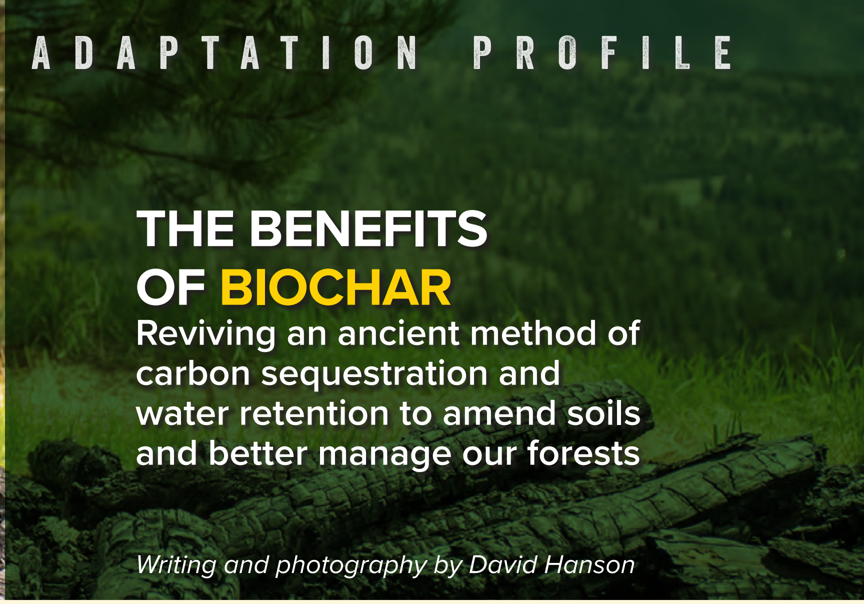
This portal offers site-specific and basin-scale information on snowpack, precipitation, streamflow projections, and other data.

DNRC Stream and Gage Explorer (StAGE)

This site provides interactive links to DNRC and USGS real-time stream gage networks.

USGS Water Watch

This is the portal to the agency's real-time stream gage network and provides other water resource tools and data.



THE BENEFITS OF BIOCHAR

Reviving an ancient method of carbon sequestration and water retention to amend soils and better manage our forests

Writing and photography by David Hanson

It's a perfect day for burning. The wet, cool spring of 2022 continues in the Blackfoot Valley with a high of 50 degrees, overcast skies, and a promise of evening rain. Yesterday, Dave Atkins, a retired Forest Ecologist with the U.S. Forest Service, and a few volunteers strung cable around thinned pines and firs and winched the small logs down steep slopes covered in young grasses, Indian paintbrush, larkspur and balsam. Today the slash pile sits beside a double-ringed metal circle that looks and acts like an oversized campfire ring. The wood will be methodically burned in the ring and then extinguished to create "biochar," a new term for a simple, ancient practice that could be another tool to enhance water retention in soils and sequester carbon.

Biochar is the charcoal-like product created from pyrolysis—burning organic matter in the absence of oxygen. A typical open fire of organic matter burns down to ash, an oxidative process in which almost all the carbon in the organic material volatizes as carbon dioxide released into the atmosphere. Burning without oxygen sequesters most of the carbon in the char and creates a porous material with a complex, convoluted structure ideal for water and nutrient retention when spread on gardens, crop fields or forests.

The amount of carbon stored in the soil far exceeds the carbon found above the earth's surface, so the idea of utilizing soil to sequester carbon offers a promising adaptation to climate change. But in typical fuel reduction efforts in U.S. forests, the thinned timber is burned to ash in large piles. It's an easy and inexpensive way to eliminate the debris, but one that releases the wood's stored carbon into the atmosphere.

"Pile burning is a total waste of that material so if you can use it one way or another, let's use it," says Dr. Tom DeLuca, Dean of Forestry Ecosystems & Society at Oregon State University, and one of the leading researchers on biochar's implications for soils.

"Our prairies used to burn every 1-5 years so that char was incorporated into the soils frequently for thousands of years," DeLuca explains. "Biochar is a natural part of soil ecosystems that we've eliminated so there's no reason to not apply it if it's available and not too expensive to access."

> **"Biochar is a natural part of soil ecosystems** that we've eliminated, so there's no reason to not apply it if it's available and not too expensive to access."
>
> — TOM DELUCA

Barry Dutton, a retired soil scientist, has been consulting with the Blackfoot Challenge for 13 years. The Challenge is an organization seeking to coordinate efforts to conserve and enhance the natural resources of the Blackfoot watershed, of which Atkins' land is a part. Dutton is working with The Nature Conservancy (TNC), Bureau of Land Management, U.S. Forest Service, and the University of Montana on a study of applied biochar on Blackfoot Valley soils.

"I am interested in biochar for three main reasons," Dutton says. "As a soil amendment to increase water and nutrient holding capacity, as a way to reduce air pollution from slash burning, and as a way to sequester carbon. In terms of drought concerns for irrigated agriculture, increasing soil water holding capacity can let us put on more water more quickly. This can increase the time between irrigations and reduce the number of irrigations per season."

For Atkins, the biochar process is simple. The oversized fire ring, or kiln, is five stakes and two sets of five metal panels screwed together with a five-inch gap between the walls. He seals the metal ring's base with dirt so oxygen isn't drawn in from the bottom. He loads the ring with wood, ideally larger pieces at the bottom in a horizontal matrix, and adds wood as the fire burns down. The goal is an evenly packed bed of fuel that burns mostly in the lower half of the four-foot-high kiln. Once the flames have dissipated and the fire burns in an evenly distributed red-hot blaze, Atkins methodically extinguishes the fire, thus capturing the carbon in the charcoal wood before its released into the atmosphere

As Atkins extinguishes the last of the slash pile in a steamy haze, a light rain starts to fall on the Blackfoot Valley. Atkins unscrews the metal panels and the jet-black logs spread on the ground, charred time capsules of carbon. There's nothing new to pyrogenic organic burning, but Atkins and others hope to revitalize the ancient practice and let biochar become an engine of carbon sequestration in forestry and a tool for drought resiliency in agriculture. For now, Atkins will continue preaching the benefits of biochar using his forest to store carbon for the next thousand years. ■

Photo by Michael Downey

SECTION 2: DROUGHT VULNERABILITY AND ADAPTATION

Robust drought management starts with monitoring and assessment and goes beyond short-term response. A holistic management approach requires long term preparation by identifying and implementing proactive programs, policies, and strategies that will reduce future drought impacts. This preparedness, also known as drought adaptation, is key to building resilience at local, regional, and state levels.

Effective drought adaptation first requires a thorough understanding of how human and natural systems are negatively impacted by drought. Most drought impacts can be linked to underlying vulnerabilities in ecological and socioeconomic systems. These vulnerabilities can be driven by climate. For example, some parts of the state experience drought more frequently than others. But drought vulnerability also has an inherent human dimension – variables designed and controlled by people, like proximity to stored water or the presence of a local drought management plan – play a role in determining a given community's susceptibility to drought impacts. Once these underlying vulnerabilities are identified, they can illuminate the most appropriate adaptation strategies, and when and where to implement them (see Appendices C, Montana Drought Vulnerability Assessment and Appendix D, Adaptation Strategies).

Just as drought impacts and vulnerabilities differ across Montana's ecosystems and communities, so do drought adaptation strategies. The right strategy for one community may not be right for another. Community resources and capacity, local leadership, primary water uses, and many other variables determine which adaptation strategies are appropriate at the local level to address local needs.

Adaptation strategies also differ by scale. State-level drought adaptation involves identifying and enacting policies, programs, funding, and other large-scale, administrative or governance pathways to assist local communities in coping with drought. Local (county, watershed, municipal, individual) strategies are more focused and specific, and they often involve on-the-ground projects or behaviors, such as irrigation or municipal water infrastructure repair, floodplain restoration, fish habitat improvement, or livestock grazing rotation. Drought planning or at least incorporation of drought into other local plans or policies (such as county growth policies, municipal capital improvement plans, building codes, landscape ordinances, watershed restoration plans) is also a key adaptation strategy communities can pursue under local government authorities or voluntary initiatives.

The vulnerability assessment that follows examines Montana's drought vulnerabilities using existing data and stakeholder narratives. The insights gained from it informed the development of adaptation strategies, which, in the Plan, are compiled under the Management Recommendations Section (see page 56).

Photo by Donnie Sexton

This section is a summary of the Montana Drought Vulnerability Assessment prepared during the planning process. For full methodology, primary and secondary data, survey response tables, and analysis, refer to the Assessment.

Montana Drought Vulnerability Assessment

We assessed Montana's drought vulnerability using an integrative, statewide process wherein data-based vulnerability scores were paired with descriptive narratives collected directly from stakeholders (Appendix C). The assessment focused on five main water-use sectors: agriculture; conservation and land management; energy and industry; recreation and tourism; and planning and community development, which included municipal water supply.

Vulnerability is typically measured as some combination of three components: exposure, sensitivity, and adaptive capacity. The vulnerability score for each sector below represents an integration of all three of these components (see Methods I), while descriptive stakeholder narratives, generated through one-on-one interviews and an online survey, add complementary, supporting details and information on sensitivity and adaptive capacity (see Methods II).

Exposure is the presence of people, livelihoods, ecosystems, infrastructure, or other assets in places that could be negatively affected by drought.

Sensitivity is the susceptibility of water users to drought.

Adaptive capacity is the ability to manage or reduce drought impacts through actions taken before or during drought.

Methods I – Quantifying Vulnerability

The vulnerability assessment generated county-level vulnerability scores for each water-use sector using datasets that represented each of the three components of vulnerability:

Exposure

Calculating exposure relied on U.S. Drought Monitor (USDM) drought classifications – both frequency of drought and change in classification over time. Drought frequency was defined as the number of weeks each county experienced a severe (D2) or greater drought from 2000 – 2022 (Figure 5). The change in drought classification was reflected by a trend line based on USDM drought classes (integers from 0 to 4) for each county. A line that sloped downward represented decreasing drought severity, while an upward-trending slope signaled increasing drought severity (Figure 6).

USDM classifications were ideal for estimating drought exposure because they integrate a variety of drought metrics with professional judgment to determine the classification (see Drought Monitoring and Assessment) – instead of picking and choosing certain monitoring indicators or indices. The change analysis of "changes in conditions over time" variable uses historical trends to predict future conditions, while the drought frequency variable provides direct information about drought's reoccurrence. Although the USDM data is limited by its relatively short time span, it accounts for changes at a smaller spatial scale (i.e., county level) than most global climate models. Thus, this approach provides more opportunities for on-the-ground, adaptive management.

Sensitivity and adaptive capacity

Sensitivity and adaptive capacity were computed by compiling various publicly available datasets that represent the different water-use sectors, such as annual water withdrawals, employment data, or ecological indicators (Appendix C). Since many of these datasets could be reasonably interpreted to characterize both components, the two were combined for the purpose of this analysis. The resulting values serve as indicators of human susceptibility to drought impacts.

Vulnerability scores

Data for all three components was compiled and then combined mathematically to produce a vulnerability score for each county within each water-user sector (more detail is provided in Appendix C). Scores were categorized as low, medium-low, medium-high, and high to create maps of drought vulnerability for the state. Scores were computed such that a county's vulnerability within a sector is relative to all other counties within that sector; therefore, comparisons can be made only among the counties within a given water-use sector. Also, a low vulnerability score does not imply no vulnerability or a lack of importance: **all of Montana is vulnerable to drought, and individuals will experience impacts differently.** The scores simply provide us with a tool to compare the relative amount of vulnerability to drought impacts based on the data we have.

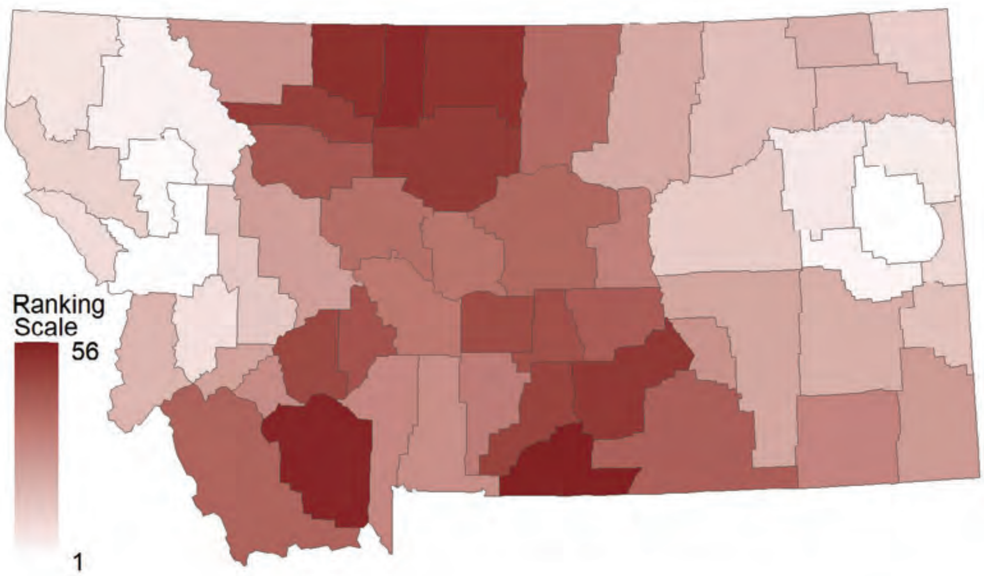


FIGURE 5. Relative drought frequency in Montana, 2000-2022. The number of weeks each county experienced a D2 (severe drought) or greater drought according to the U.S. Drought Monitor. Frequency values were scaled and relativized to each other to facilitate comparisons among counties.

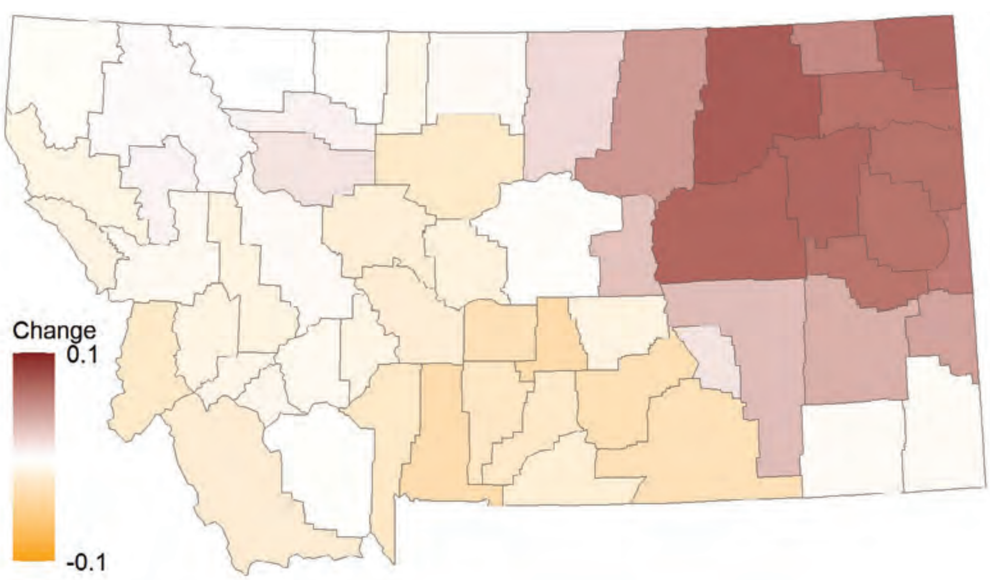


FIGURE 6. Relative change in drought conditions over time, 2000-2022. Change in drought conditions over time was calculated by graphically depicting drought severity for each county using the U.S. Drought Monitor classifications (integers from 0 to 4) for each week of measurement. A line was drawn to represent the trend over time, and the slope of this line was used to estimate the relative change in drought conditions. Downward-trending slopes represented decreasing drought severity while upward-trending slopes signaled increasing drought severity. Change over time values were scaled and relativized to facilitate comparisons among counties.

Methods II – Compiling vulnerability narratives

In addition to the vulnerability scores, information about sensitivity and adaptive capacity was solicited from water users around the state through one-on-one interviews and an online survey. This approach was used because drought has unique human elements that can be difficult to ascertain from data alone. Specifically, the degree to which a given water-use sector will be impacted by drought, as well as its ability to adapt, are both influenced by the people experiencing the water shortfalls. Therefore, hearing directly from water users about their experiences with drought and how they have learned to adapt was a logical complement to the data-derived vulnerability scores. Although most participants identified with more than one water-use sector, they were asked to select their primary water-use sector for the assessment – this helped categorize and synthesize the narratives.

One-on-one interviews

All stakeholders from the regional groups (about 150 people) were invited to participate in an interview using the method of their choice (in person, virtual, or by phone). Additional participants were recruited by asking interviewees to recommend other possible participants and by further direct outreach. The goal was to hear from stakeholders representing all five water-use sectors, across the state. All willing stakeholders (63 total) were interviewed about their experiences with drought, including impacts and monitoring, as well as their perspective on available resources and programs to prepare, respond, and adapt to drought events. Although not a statistically representative sample, the interviewees provided a broad range of water user perspectives from all regions of the state. Interviews were recorded and transcribed, and specialized software was used to identify common topics and themes within and across water-use sectors to develop vulnerability narratives.

Online survey

An online survey was also deployed with the goal of reaching a wider range of stakeholders, many of whom may not have time for an interview. A total of 245 people, representing a variety of water-use sectors from across the state, completed the survey. The survey questions were a mix of multiple-choice and open-ended questions about drought conditions, impacts, and resources for adaptation. Survey data was similarly coded for common themes and integrated into the vulnerability narratives.

Drought vulnerability in Montana

The results of the vulnerability assessment are presented on the following pages for each of the water-use sectors. Each section begins with an overview of stakeholder participation and a map depicting vulnerability scores for the given water-use sector. Major impacts and sector-specific considerations are described next, followed by a summary of drought response and adaptation strategies. Notable quotes from participants are highlighted.

AGRICULTURE

Photo by Sean R. Heavey

The agriculture water-use sector had the largest proportion of stakeholders represented: 21 interview participants (33%) and 96 survey respondents (39%). This sector includes many types of producers: ranchers, irrigated and dryland crop growers, and specialized operations. Areas with high vulnerability scores are concentrated in the east side of the state, in particular the northeast and north-central regions, as well as Beaverhead County in the southwest (Figure 7).

Impacts and sector-specific considerations

The impacts of drought on farmers and ranchers are undeniable: producers described the deep financial, physical, and mental toll drought takes on them just to maintain their operations. Drought can cause production losses, increased production costs to buy and transport supplemental hay, and additional time and labor needed to haul water. In addition, it is more difficult to maintain pasture and crop quality because of reduced water supply, greater competition from weeds, and grasshopper outbreaks.

Flooding and wildfire are prominent secondary drought impacts that can destroy crops and agricultural infrastructure. Dry soils have poor water infiltration, so sudden precipitation events more readily cause flooding and soil erosion. Producers also stay vigilant for lightning-caused wildfires that can destroy pastures and crops. Finally, producers described the abject mental toll of drought – it is both heartbreaking and demotivating for those who are so intimately tied to the land and so reliant on moisture, and the resulting stress persists throughout the year.

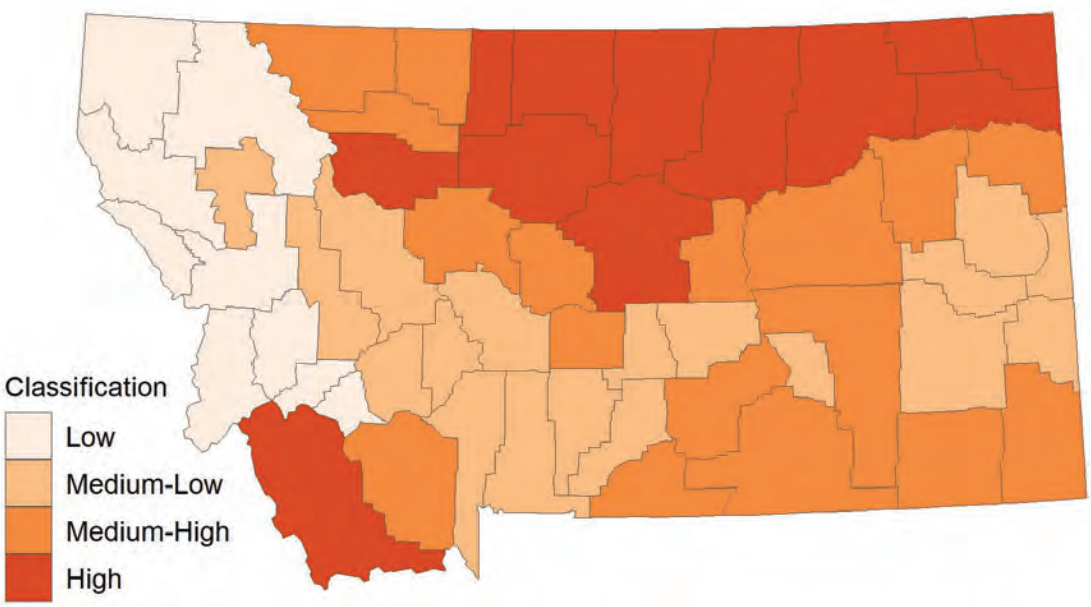


FIGURE 7. Drought vulnerability scores for the agriculture water-use sector. Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

MONTANA VOICES

VULNERABILITIES

STRESS: Drought is one of those things … [it's] always there … hovering in the background, and no matter how good the years are, you know that it's coming back … You're always worrying about it.

– Rancher, South Central Region

EXPENSES: Because hay had to come from so far away, there was a lot more spent on freight and gas prices went up. We normally don't spend anything on hay, and for the 2021-'22 winter, we spent $126,000.

– Rancher, Central Region

MENTAL HEALTH: When you go outside and every step you take, a hundred grasshoppers fly up … And it hasn't rained all year and it's over a hundred degrees … 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 wears on you. I struggled last year just to get the motivation to go out and do anything.

– Farmer, North Central Region

STRESS: It can be a terrible, heartbreaking thing. One of the worst things about drought is its insidious nature; that it creeps on you incrementally and things get worse … It's always there, even in the good years.

– Rancher, Southeastern Region

Note: the comments summarized here reflect the views expressed by interview participants and not necessarily the water use sector as a whole. They are included to provide context to themes identified.

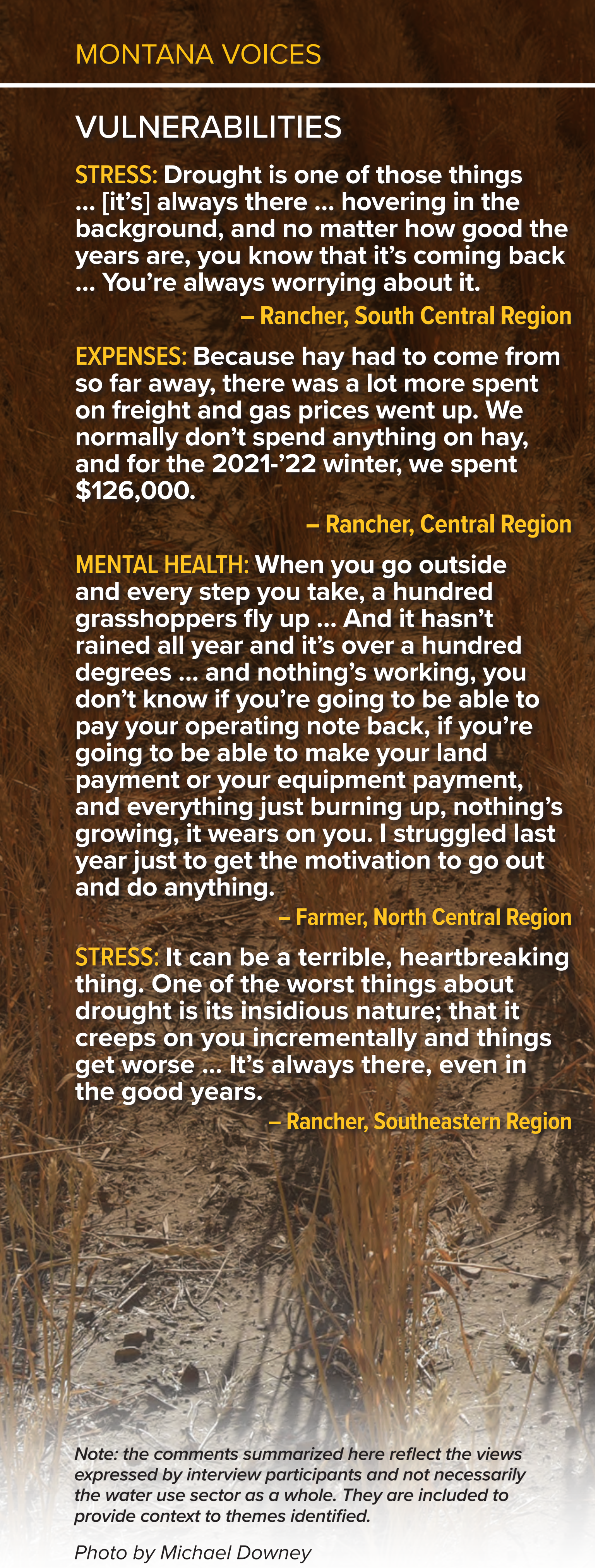


Photo by Michael Downey

Water distribution and communication with other users are important tools to mitigate conflict and alleviate tensions during drought. Many producers expressed gratitude for water commissioners and ditch riders whose knowledge of the rivers and irrigations systems ensures water use is maximized to the greatest possible extent. They also noted cooperation and communication with other users as a key part of effective water management.

Many producers emphasized the importance of their lived experiences in planning and monitoring drought conditions. This longer-term perspective often offers practical insight and experience that can be more valuable than sifting through the many online monitoring resources, which many producers find overwhelming, difficult to interpret, and lacking in fine-scale spatial resolution to accurately reflect what they see happening on the ground.

Responding and adapting

Producers expressed disappointment in the existing financial relief and incentives programs tied to drought. Federal programs are tied to USDM classifications, which do not always match what producers observe at their farms and ranches because of the sparse weather station network in many parts of Montana. Many producers would like to implement more practices that build drought resilience, such as cover crops and grazing management. But federal incentives often reward conventional practices at the expense of adaptation and experimentation.

Producers identified that state government could fill in financial gaps by creating programs that provide immediate relief, as well as offering incentives or credits that enhance financial flexibility to help producers through drought cycles. Participants also supported expanding drought monitoring networks to better capture conditions on the ground, and they cited the need for more weather stations (to monitor soil moisture and precipitation) in eastern Montana. Improved systems for collecting and sharing individual measurements (e.g., Community Collaborative Rain, Hail & Snow Network, CoCoRaHS) would also benefit producers.

Many producers described the stress and isolation of coping with drought in their day-to-day operations. Talking with others who were experiencing the same challenges alleviates some of the burden and validates their feelings. Creating more networking opportunities, such as events and workshops, where producers can hear from other producers about adaptive strategies and learn from each other, can encourage others to adopt adaptive strategies and strengthen social connections.

Communication, education, and outreach were frequently mentioned strategies for helping producers cope with and adapt to drought. Diverse messaging approaches, such as mail and various social media, would reach more Montana producers. Outreach about drought conditions and available resources, especially before conditions get severe, would help producers prepare. In addition, workshops and other educational opportunities can help both new and seasoned producers. In particular, storytelling is an effective strategy for teaching and sharing innovative practices. Facilitating dialogue and creating a shared sense of purpose across water-use sectors can unite people and mitigate local tensions.

The producers we spoke with shared a sense of pride and commitment to their land and operations. Adapting to drought conditions by implementing best management practices and water conservation strategies will build local resilience and sustain agricultural production as a viable sector in Montana. In addition, supporting local organizations, like watershed groups and conservation districts, helps unite landowners.

MONTANA VOICES

ADAPTATIONS

COORDINATION: Communication is big. Just get the word out of what people are finding and how other people are doing. … Maybe there's better ways to do stuff.
– Rancher, Southeastern Region

MONITORING: 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.
– Rancher, North Central Region

MONITORING: What we really need now is soil moisture monitoring.
– Rancher, Southeastern Region

STORAGE: I'd like to see exploration of projects where we could store high runoff in the spring.
– Farmer, Southwestern Region

Photo by Donnie Sexton

CONSERVATION AND LAND MANAGEMENT

Fifteen interviewees (24%) and 37 survey respondents (15%) identified conservation and land management as their primary water-use sector. Participants included professionals from nonprofit organizations and state agencies, as well as university researchers, environmental consultants, and water quality specialists. The highest vulnerability scores were concentrated in the southwestern corner of the state, where high drought exposure overlaps with significant ecological values (e.g., wetlands or native trout) and a high proportion of impaired lakes and streams (Figure 8).

Impacts and sector-specific considerations

Participants described the multiple ecological and environmental impacts associated with drought. Persistent low flow conditions are associated with a range of water quality impairments, including high water temperatures, harmful algal blooms, and concentration of pollutants, all of which affect the local ecology and fisheries. Diminished flows and altered run-off timing can make river ecosystems more homogenous by limiting the recruitment of woody debris and reducing peak flows that scour out sediment and maintain dynamic hydrology. Similar to the threats that drought poses to riparian ecosystems, participants described an increase in overall vulnerability of forest ecosystem health due to interrelated and compounding impacts caused by drought. Prolonged drought conditions can result in increased susceptibility to pest and disease outbreaks and higher intensity wildfires, which can further compound issues since fire response efforts reduce agency capacity to implement forest management projects across the landscape.

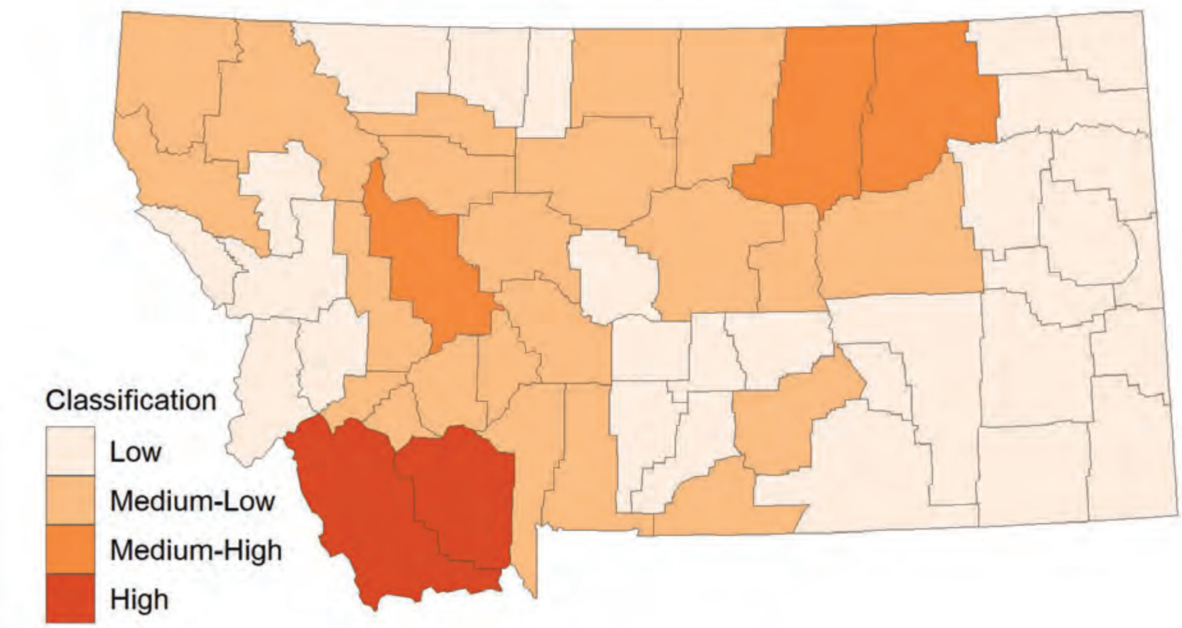


FIGURE 8. Drought vulnerability scores for the conservation and land management water-use sector. Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

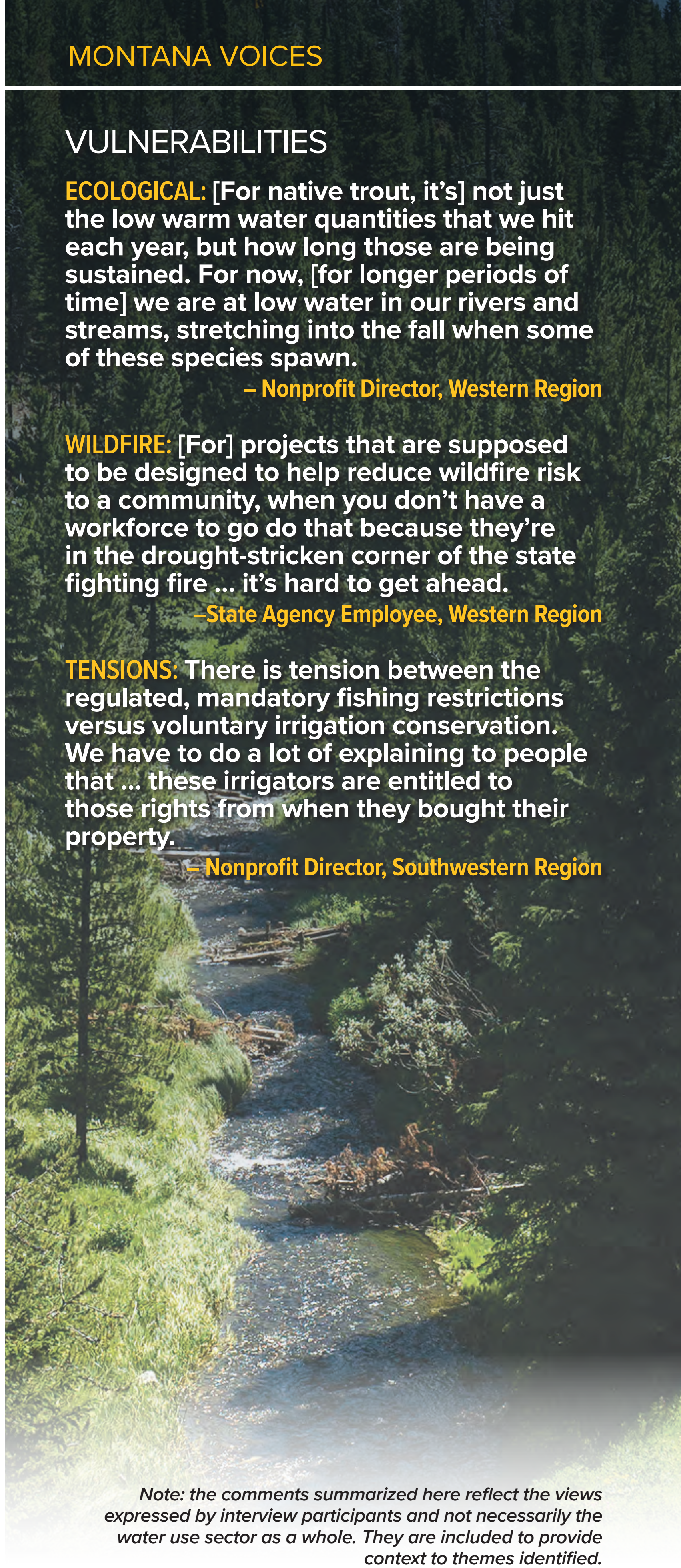
Participants also noted that tension among water-use sectors creates conflict and impedes the ability to work collaboratively toward solutions. In addition, limitations on staff capacity and project funding at federal, state, and local levels were often cited as barriers to implementing collaborative, landscape-scale projects.

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.

Responding and adapting to drought

Participants repeatedly emphasized the value of drought monitoring networks, particularly stream gage networks, in both responding and adapting to drought. Stream gage networks are critical infrastructure in preparing for drought, especially because measured streamflow is a simple and easy to understand metric for local drought management plans. Other monitoring networks, such as Montana Mesonet and the Natural Resources Conservation Service's SNOTEL (Snow Telemetry), were often mentioned as important to monitoring water supplies and informing local decision-making.

Education, outreach, and communication were often mentioned as key strategies for drought response and adaptation. Participants reiterated a common sentiment – that water resources belong to all of us – so providing the public with opportunities to learn, understand, and act are essential components of building local resilience and promoting collaborative dialogue.



MONTANA VOICES

VULNERABILITIES

ECOLOGICAL: [For native trout, it's] not just the low warm water quantities that we hit each year, but how long those are being sustained. For now, [for longer periods of time] we are at low water in our rivers and streams, stretching into the fall when some of these species spawn.

– Nonprofit Director, Western Region

WILDFIRE: [For] projects that are supposed to be designed to help reduce wildfire risk to a community, when 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 hard to get ahead.

–State Agency Employee, Western Region

TENSIONS: There is tension between the regulated, mandatory fishing restrictions versus voluntary irrigation conservation. We have to do a lot of explaining to people that ... these irrigators are entitled to those rights from when they bought their property.

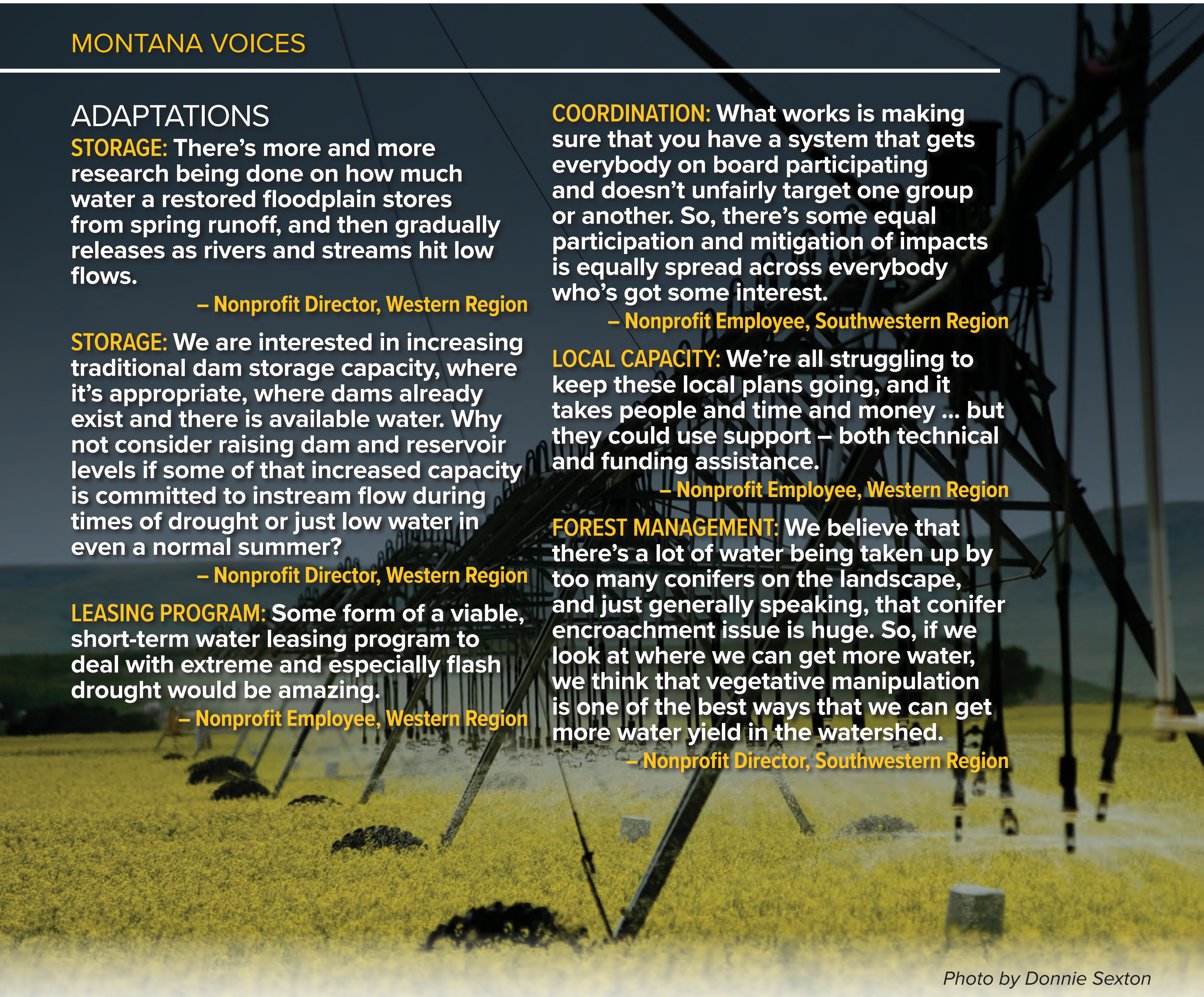
– Nonprofit Director, Southwestern Region

Note: the comments summarized here reflect the views expressed by interview participants and not necessarily the water use sector as a whole. They are included to provide context to themes identified.

Photo by Donnie Sexton

Participants expressed support for changes in procedures or policy to enhance flexibility and provide for more certainty in the water rights system. Specifically, facilitation of short-term water use changes to instream flow would empower more water users and conservation groups to effectively respond to changing water supply conditions. Many participants also noted that agency-enforcement of water rights and greater oversight of land development would both help ensure that this shared resource is indeed being used as the law intends. Finally, most participants focused on enhancing storage – both natural and built – as a key adaptation strategy to build more flexibility into water management.

Most participants acknowledged that building statewide drought resilience requires local capacity, coordination, and engagement. Supporting watershed groups was the most commonly-cited adaptation strategy in this sector – mainly because these organizations can connect local residents to resources and funding to effect on-the-ground change. Collaborative, voluntary approaches to drought management are most likely to be successful, so ensuring trusted local organizations can facilitate planning and adaptation is critical. The state can play an essential role by providing tools and resources for planning, outreach, and project implementation.



MONTANA VOICES

ADAPTATIONS

STORAGE: There's more and more research being done on how much water a restored floodplain stores from spring runoff, and then gradually releases as rivers and streams hit low flows.

– Nonprofit Director, Western Region

STORAGE: We are interested in increasing traditional dam storage capacity, where it's appropriate, where dams already exist and there is available water. Why not consider raising dam and reservoir levels if 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

LEASING PROGRAM: Some form of a viable, short-term water leasing program to deal with extreme and especially flash drought would be amazing.

– Nonprofit Employee, Western Region

COORDINATION: 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

LOCAL CAPACITY: We're all struggling to keep these local plans going, and it takes people and time and money … but they could use support – both technical and funding assistance.

– Nonprofit Employee, Western Region

FOREST MANAGEMENT: 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

Photo by Donnie Sexton

ENERGY AND INDUSTRY

This sector comprised a smaller proportion of overall participation with three interviews (5%) and two surveys (<1%). Most participants represented the hydropower industry, although one managed a private timber company. Areas of the state with higher vulnerability scores often coincided with high water withdrawals for mining and industry or the presence of hydropower operations (Figure 9).

Impacts and sector-specific considerations

Participants who work in the hydropower industry described the potential for drought to impact their electricity-generating capacity, especially for run-of-river operations which have limited storage. Even higher volume storage reservoirs are impacted because warmer air temperatures associated with drought cause higher evaporation losses. Lower streamflow can also make it difficult to meet the licensing requirements issued by the Federal Energy Regulatory Commission, which typically include flow and temperature requirements for fisheries habitat.

Participants from other industries, such as timber, described drought as reducing the survival rate of planted seedlings, as well as threatening the overall health and composition of forests. Drought increases the susceptibility of trees to pests and disease and slows growth rates.

All participants in this sector mentioned wildfire as a top concern associated with drought. Fires pose direct threats to power infrastructure and timber stands, and participants said fires can also impact contract labor. Forest restrictions or closures due to fire risk limit the amount of outdoor work that can be done. And, when contract crews are fighting fires, they are not available to work in other industries.

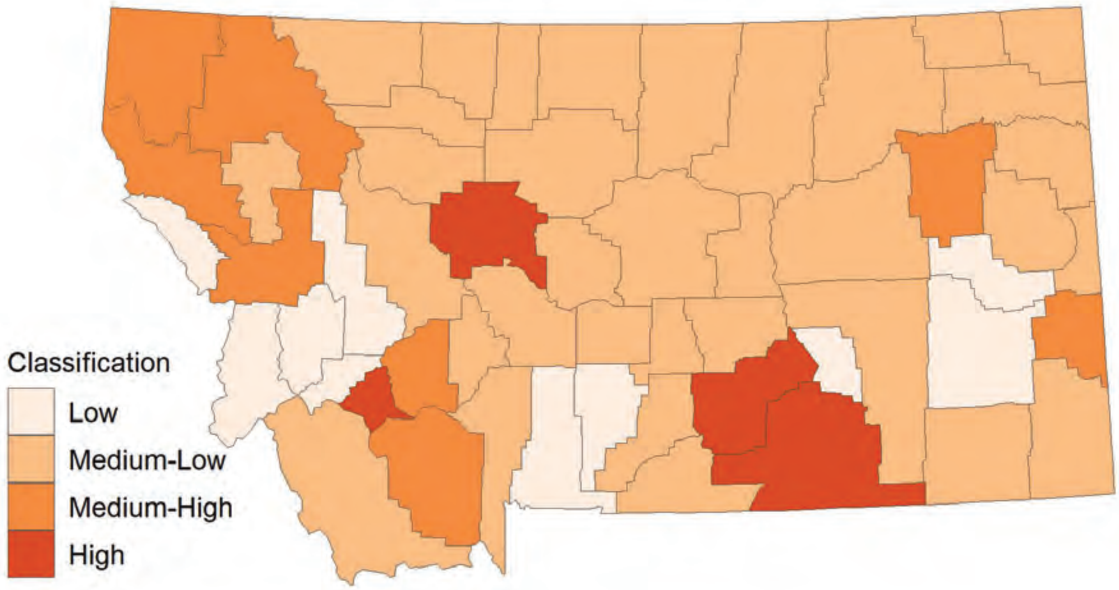


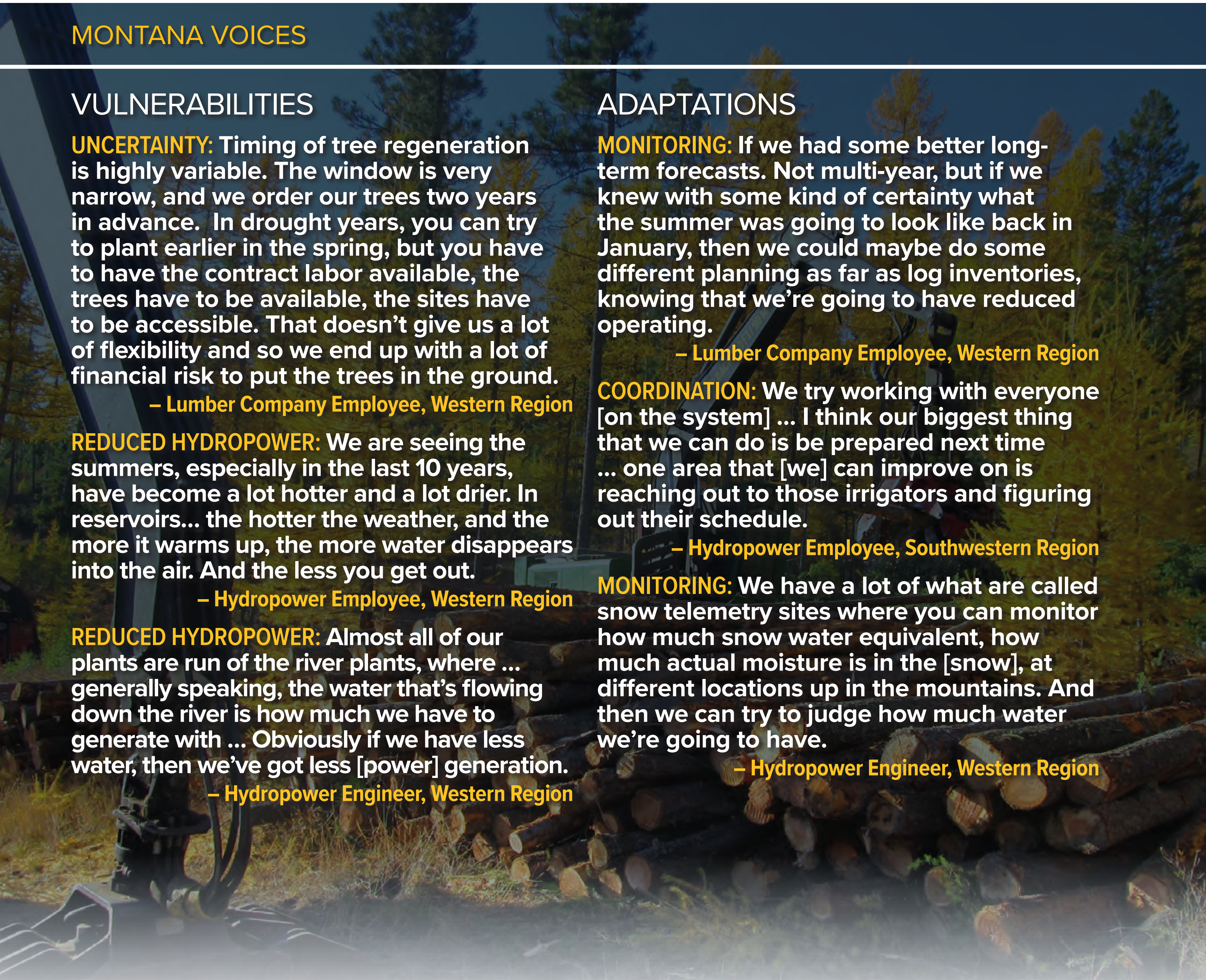
FIGURE 9. Drought vulnerability scores for the energy and industry water-use sector Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

Responding and adapting to drought

Participants in the energy and industry sector noted that they are limited in the actions they can take to respond to drought, but they closely monitor water supply to better anticipate near-term conditions. They expressed support for better long-term forecasting (> 10 days) and monitoring networks, especially SNOTEL and stream gages.

Participants highlighted collaboration with other water users as key to effective drought adaptation. Hydropower personnel described their communications with downstream irrigators as key to ensuring water releases are timed to maximize water use. Coordinating with state and federal agencies is also important for effective management of land and water resources. Developing and maintaining communication networks with local, state, and national organizations and stakeholders is foundational to adapting and sustaining these industries in the future.

MONTANA VOICES



VULNERABILITIES

UNCERTAINTY: Timing of tree regeneration is highly variable. The window is very narrow, and we order our trees two years in advance. In drought 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. 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.

– Lumber Company Employee, Western Region

REDUCED HYDROPOWER: We are seeing the summers, especially in the last 10 years, have become a lot hotter and a lot drier. In reservoirs… 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

REDUCED HYDROPOWER: Almost all of our plants are run of the river plants, where … generally speaking, the water that's flowing down the river is how much we have to generate with … Obviously if we have less water, then we've got less [power] generation.

– Hydropower Engineer, Western Region

ADAPTATIONS

MONITORING: If we had some better long-term forecasts. Not multi-year, but if we knew with some kind of certainty what the summer was going to look like back in January, 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

COORDINATION: We try working with everyone [on the system] … I think our biggest thing that we can do is be prepared next time … one area that [we] can improve on is reaching out to those irrigators and figuring out their schedule.

– Hydropower Employee, Southwestern Region

MONITORING: We have a lot of what are called snow telemetry sites where you can monitor how much snow water equivalent, how much actual moisture is in the [snow], at different locations up in the mountains. And then we can try to judge how much water we're going to have.

– Hydropower Engineer, Western Region

Note: the comments summarized here reflect the views expressed by interview participants and not necessarily the water use sector as a whole. They are included to provide context to themes identified.

Photo by Anna Lau

PLANNING AND COMMUNITY DEVELOPMENT AND MUNICIPAL WATER

Photo by Thomas Lee

Nineteen interviewees (30%) and 63 survey respondents (26%) identified planning and community development or municipal water supply as their primary water-use sector. Most participants work for municipalities and counties in planning, municipal water supply, or elected leadership roles. Higher vulnerability scores generally corresponded to areas with large populations, high rates of growth, and municipal dependence on surface water. The sectors were combined for interview analysis as there was considerable overlap across participants, geography, and drought-related concerns. However, it was useful to generate separate vulnerability maps because the planning and community development sector represents a larger picture of county-wide growth and overall water use, incorporating domestic wells and small, rural public water supplies, while municipal water captures data more specific to municipalities and public water supplies (Figures 10 and 11).

Impacts and sector-specific considerations

Participants from this sector described the ongoing challenge of meeting future water demand for a growing population while simultaneously preparing for the impacts of future drought. They emphasized their focus on long-range planning and a desire to implement proactive adaptive strategies well in advance of worsening drought conditions. Drought is often associated with other hazards, such as flooding and wildfires, that pose threats to human health, public safety, and community infrastructure, and all three hazards can harm local economies.

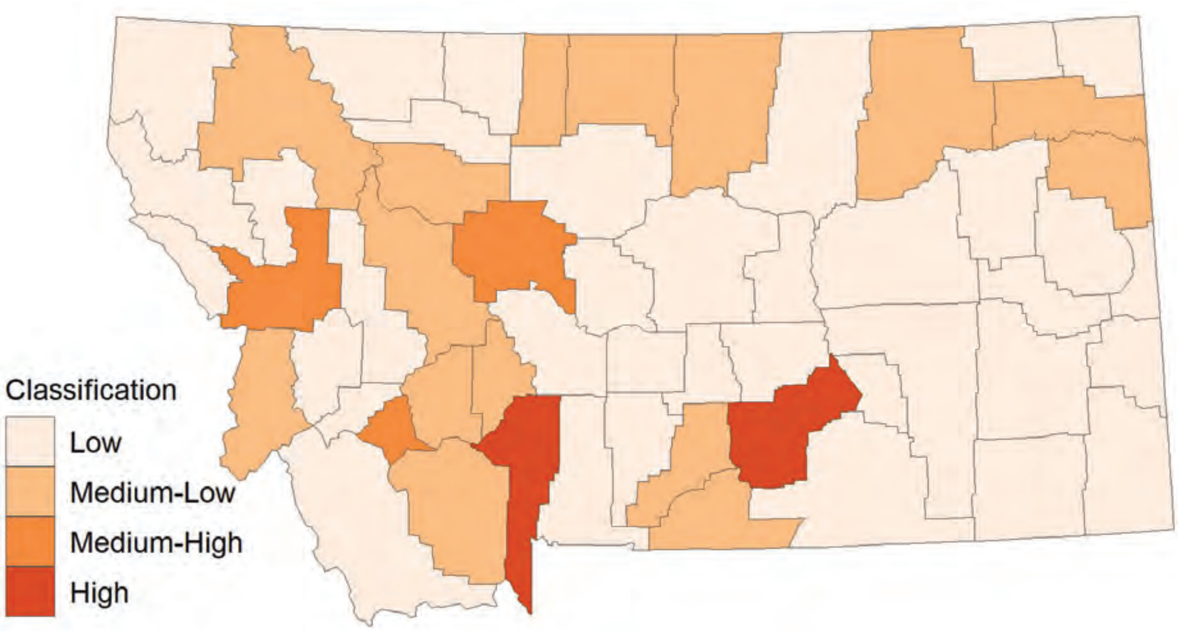


FIGURE 10. Drought vulnerability scores for the planning and community development water-use sector. Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

Participants found access to groundwater makes a big difference in how communities plan. Communities dependent on surface water have a greater sense of urgency in their public communications and water conservation planning. However, even communities with wells are looking ahead to the potential impacts of persistent drought on groundwater resources. Planners repeatedly emphasized the importance of monitoring water supplies as part of preparing for the future.

Responding and adapting to drought

Local government drought contingency planning is often nested into larger planning efforts, such as local hazard mitigation plans, emergency response plans, or growth policies. Even in more rural areas without water or sewer infrastructure, drought is still a major part of planning because of its potential to impact local agricultural producers.

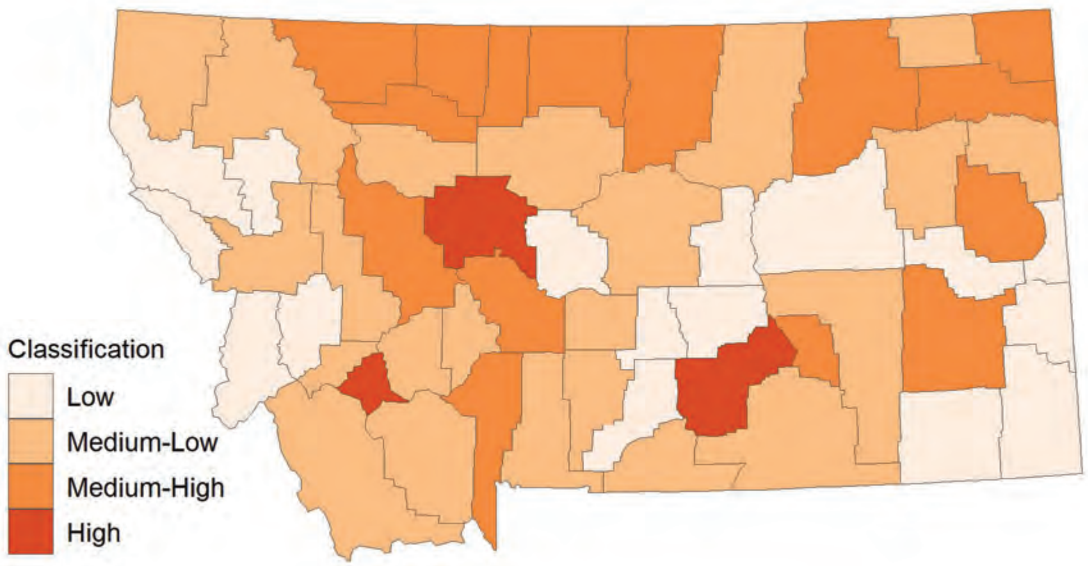


FIGURE 11. Drought vulnerability scores for the municipal water supply water-use sector. Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

MONTANA VOICES

VULNERABILITIES

ECOLOGICAL AND ECONOMIC IMPACTS: My mind goes to those instances where the water temperature and flows have been so high, flows so low, that we have a stressed fish population that closes our major rivers to recreational or even guided fishing. It definitely has an impact on our local economy and our business industry.

– Municipal Water Employee, Western Region

MUNICIPAL SUPPLY: Last summer our demands in June hit just about 13 million gallons a day. And for context, [the city's] winter demands are four and a half [million gallons a day] ... It was higher than we've ever seen in July or August when you expect to see those peak demands.

– Municipal Water Employee, Southwestern Region

WATER QUALITY AND MUNICIPAL TREATMENT: If there's a heavy drought and the discharge [in the] stream goes down and we're discharging a given quantity [of treated sewage] 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 no sewer plant, no city.

– County Planner, Southwestern Region

CONFLICT: 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 a more holistic approach.

– Hydrogeologist, Western Region

Note: the comments summarized here reflect the views expressed by interview participants and not necessarily the water use sector as a whole. They are included to provide context to themes identified.

Photo by Thomas Lee

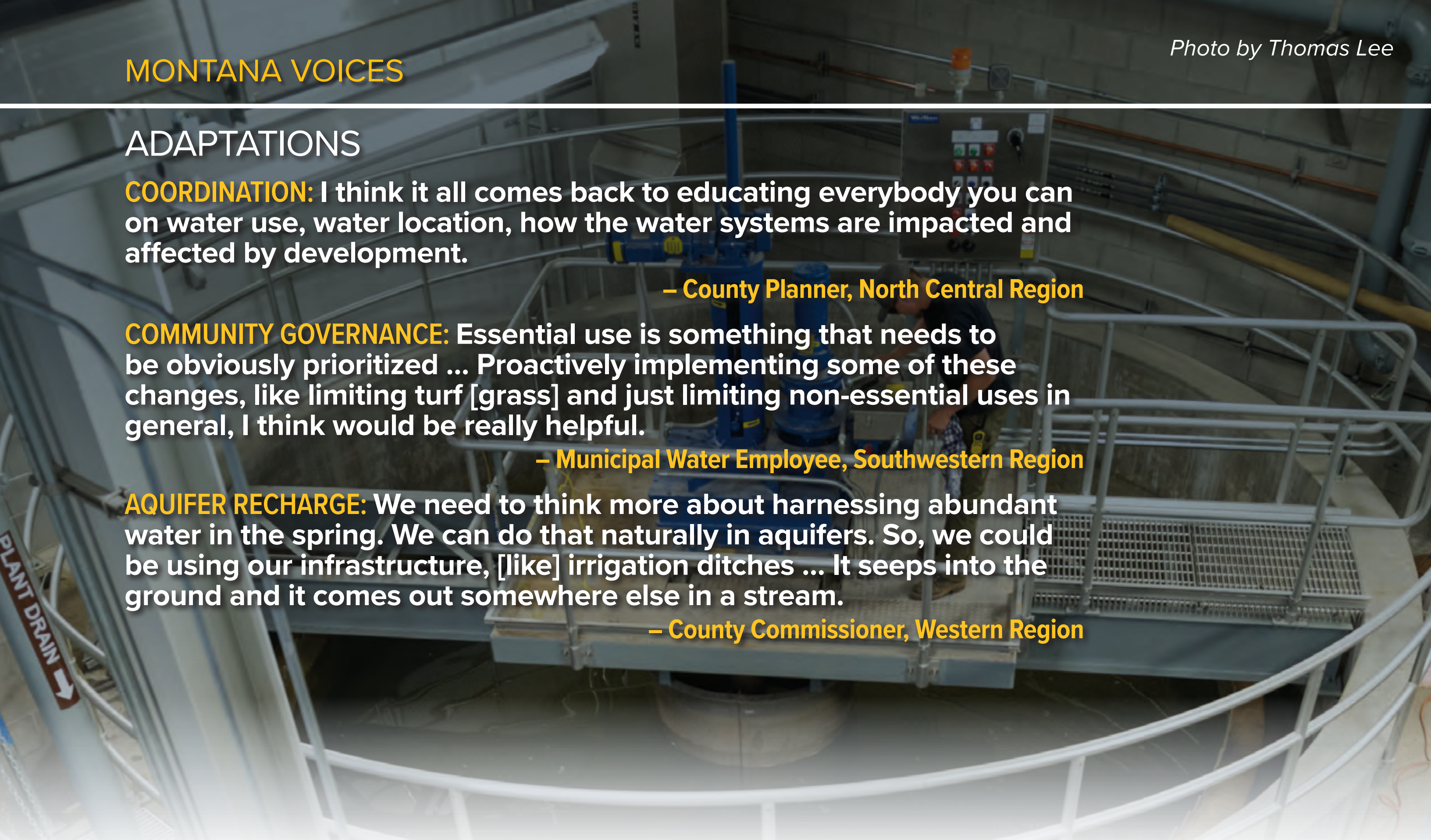


Photo by Thomas Lee

ADAPTATIONS

COORDINATION: I think it all comes back to educating everybody you can on water use, water location, how the water systems are impacted and affected by development.

– County Planner, North Central Region

COMMUNITY GOVERNANCE: Essential use is something that needs to be obviously prioritized ... Proactively implementing some of these changes, like limiting turf [grass] and just limiting non-essential uses in general, I think would be really helpful.

– Municipal Water Employee, Southwestern Region

AQUIFER RECHARGE: We need to think more about harnessing abundant water in the spring. We can do that naturally in aquifers. So, we could be using our infrastructure, [like] irrigation ditches ... It seeps into the ground and it comes out somewhere else in a stream.

– County Commissioner, Western Region

Most participants felt it was critical to conduct ongoing education and outreach programs, even if the direct impacts of drought are not felt by all constituents. They perceived community outreach as one of their key roles. Secondary impacts, such as wildfire risk and smoke, tend to resonate more in their communities than simply dry weather conditions.

Participants identified that community-based, voluntary adaptation efforts can prime communities for drought management planning because they educate the public on water supply issues and conservation. The ability to access reliable water supply data is important because projections for both population growth and water supply figure prominently in preparation and adaptation. Many small communities lack the resources and capacity to develop local water conservation and drought plans, so providing examples and accessible resources could promote more active local planning.

Local leadership from rural parts of the state echoed similar sentiments as participants from the agriculture water-use sector. Drought relief for producers, especially ways to alleviate the high costs of hay, are key to sustaining local communities. Many rural economies depend on local agricultural production for their vitality, so helping producers through difficult drought periods is key to maintaining the health of these regions.

Education and outreach are important, but many participants expressed a desire for the state to go beyond voluntary efforts by offering more technical and regulatory support for managing water supplies during drought. Increasing flexibility and options for municipal water restrictions and evaluating strategies to increase conservation through incentives or regulations would help local governments implement programs and strategies more effectively.

Participants expressed support for water supply monitoring, especially groundwater, as an important part of community planning and management. Most local governments do not have the funding or capacity to conduct extensive groundwater monitoring without state or federal support. Long-range projections and predictive tools would better inform local planning and public education efforts.

Many participants suggested that consistent, coordinated messaging around drought using a variety of platforms and strategies could highlight the importance of planning and conservation. Providing supporting information, such as best practices and priorities for conservation, would be invaluable to supporting these communications.

Photo by Donnie Sexton

Representatives from the recreation and tourism sector included five interviewees (8%) and nine survey respondents (4%). Most of them, including fishing guides, outfitters, and lodge owners, were involved in river-based recreation and tourism. Central and southern Montana reflected high drought vulnerability, especially where communities are dependent on lodging tax revenue and where more fishing access sites and state parks are located (Figure 12).

Impacts and sector-specific considerations

Participants described a wide range of drought impacts to the recreation and tourism sector. The uncertainty in late season (i.e., August) streamflow has led many outfitters to adjust their trip bookings for earlier in the summer; however, in recent years, July has also been characterized by unreliable flows in certain rivers. Despite these schedule adjustments, participants described significant revenue losses due to low and less-predictable flows in the summer months.

Participants expressed increasing concerns over the health of fisheries because of drought impacts to rivers, including warmer water temperatures and reduced or dewatered tributaries. Fisheries health concerns are compounded by the recent rise in recreational fishing, which tends to concentrate use in certain places during drought as people avoid areas of low flow.

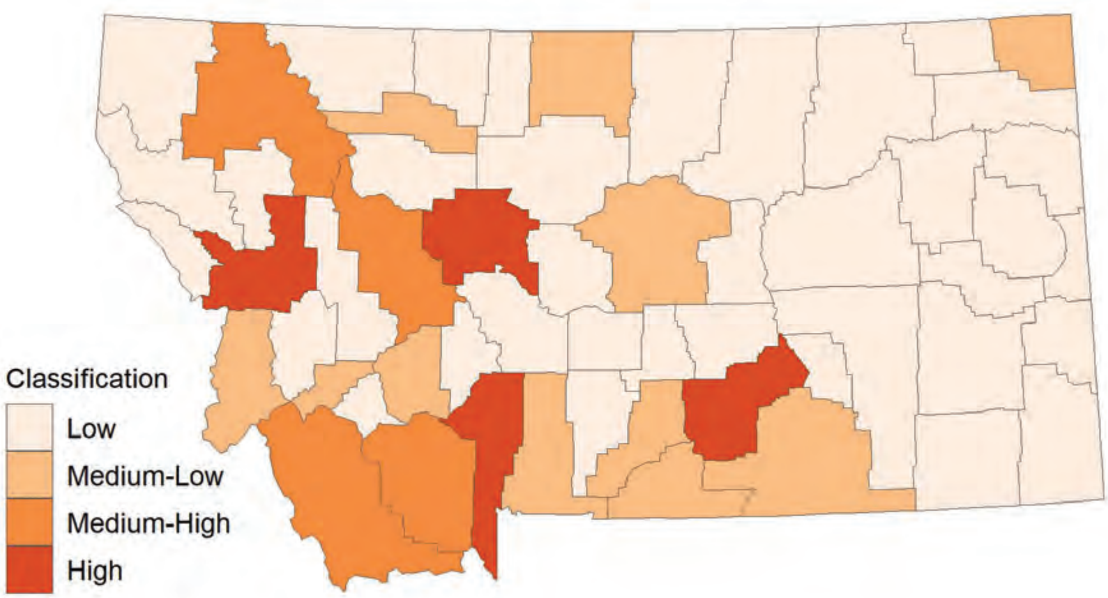


FIGURE 12. Drought vulnerability scores for the recreation and tourism water-use sector. Scores were computed using datasets representative of the three components of vulnerability: exposure, sensitivity, and adaptive capacity.

Participants noted that working on the river every day and watching streamflow decline in real time has a wearing impact on the mental wellbeing of guides and outfitters. Most participants said they could weather one or two seasons of drought, but persistent, multi-year drought has consequences for the long-term viability of their businesses and the potential to impact the tourism sector of Montana's economy.

Responding and adapting to drought

Participants in this sector have been adapting to drought and frequent hoot owl restrictions by scheduling trips earlier in the summer and meeting clients in the early morning for day trips. They also educate their clients about drought impacts to aquatic and riparian ecosystems to instill wider understanding of best practices for recreation.

Participants expressed support for more monitoring and measurement of water. Stream gage networks and, to a lesser extent, SNOTEL sites, are critical to informing daily operations. Many also support more active measurement of water use, especially in closed basins, and enforcement, when appropriate.

MONTANA VOICES

VULNERABILITIES

ECONOMIC IMPACTS: Our fishing business is obviously super dependent on water quality and temperatures. Two things that really suffer when you have a lot of drought.

– Fishing Outfitter, South Central Region

ECONOMICS IMPACTS: 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. There's been a significant decline.

– Fishing Outfitter, South Central Region

ECONOMIC IMPACTS: Last year (2021) 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, and in southwest Montana, we have closings that also impact our business.

– Fishing Outfitter, Western Region

ECOLOGICAL: 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. There's not enough water in the spawning season; if there's low water it's stressful . . . Do you want to have a healthy mainstem? Have a healthy tributary.

– Fishing Outfitter, Southwestern Region

ECONOMIC IMPACTS: No water, no work.

– Fishing Outfitter, Western Region

RECREATIONAL EXPERIENCE: During an excessive drought we have fewer options of where we can take people fishing ... We don't want to catch [fish] when the water is too warm, because it puts stress on them. So, we have less places to take fishermen. Other folks are going to those same places, so those areas tend to get crowded.

– Fishing Outfitter, Southwestern Region

Note: the comments summarized here reflect the views expressed by interview participants and not necessarily the water use sector as a whole. They are included to provide context to themes identified.

Photo by Donnie Sexton

Supporting local entities, like conservation districts and watershed groups, and promoting collaboration and cooperation among water users were both commonly mentioned as ways to facilitate local drought planning and alleviate conflict. Watershed groups are trusted local entities that can help coordinate awareness about the impacts of warm water temperatures and overcrowding on the river.

Participants also suggested exploring changes to policy that could promote streamflow and alleviate crowding. Specifically, they were interested in ways to increase flexibility (and flow) within the existing water rights system.

Participants in this sector emphasized the importance and value of tourism to Montana's economy, as well as their willingness to collaborate with other users toward the common goal of maintaining viable local economies.

MONTANA VOICES

ADAPTATION

TIMING: Dealing with the hoot owl situation that happens almost every year now, usually starting in August, sometimes a bit earlier. We've adjusted the schedule, running a lot of morning, half-day trips, and also meeting clients at dark... Most of the people understand the situation we're dealing with and are more than willing to accommodate it.

– Fishing Outfitter, Western Region

MEASUREMENT: I am advocating [for] 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.

– Fishing Outfitter, Southwestern Region

LOCAL CAPACITY/COORDINATION: The only way to mitigate in a drought in a positive manner is to work within your local watershed group ... Having local watershed groups is the most effective way to manage water.

– Fishing Outfitter, Southwestern Region

POLICY: [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.

– Survey Respondent, Southwestern Region

Photo by Donnie Sexton

Cross-Sector Themes

Many common themes emerged from our conversations with stakeholders. The themes underscore existing vulnerabilities to drought, and they offer insights into the most essential tools and strategies to support all water users as we adapt to drought conditions and build long-term resilience.

- **Expanding drought monitoring networks and streamlining information.** Monitoring data is essential to informing USDM designations, and it is also a key part of preparing for drought. Understanding year-round hydrologic patterns, especially snowpack, soil moisture, and streamflow, can inform local drought planning. Securing long-term, reliable funding sources for monitoring infrastructure was one of the most common recommendations from stakeholders. In addition, improving longer-term forecasting and predictive tools would provide better support for on-the-ground decision-making.
- **Supporting watershed groups.** Watershed groups were described by stakeholders in all water-use sectors as invaluable for community engagement and collaboration. Many stakeholders noted that drought resilience will be most effective if strategies and planning are done at the local level, and watershed groups are uniquely positioned to disseminate information and lead proactive planning efforts. They also provide a means for networking and peer-learning, which offers social support during hard times and ongoing educational opportunities.
- **Land stewardship education and communications.** Landowners can implement a wide range of water conservation and drought resilience practices, and public education programs were a commonly recommended strategy for implementing voluntary practices. Best practices can range from improving soil health and optimizing irrigation infrastructure on agricultural land to drought resilient landscaping in urban areas. Ongoing public educational programs can inform citizens about practices and funding resources for implementing them. Importantly, many stakeholders said that storytelling was an effective way to share experiences and encourage the adoption of adaptive strategies.
- **Funding for drought relief and building resilience.** Stakeholders from all sectors frequently mentioned funding for programs to provide both drought relief and implementation of proactive strategies at the state level. Participants valued the relief and incentives offered by federal programs but also noted gaps and shortcomings that influence agricultural operations and local economies.
- **Optimizing water storage, both natural and built.** Water storage was a predominant theme for building drought resilience. Participants from each of the five sectors brought forth expanded access to water storage as a benefit that would help mitigate the impacts of drought.
- **Streamlining information.** Monitoring data and local planning resources need to be timely, accessible, and useful. Stakeholders expressed feeling overwhelmed by the numerous online resources and would prefer consolidation of the most relevant and useful tools.
- **Addressing climate change.** Climate change, including extreme weather events and warmer temperatures, is already impacting Montana's use and management of water resources. Stakeholders from all sectors expressed support for integrating climate change adaptation strategies into state policies and planning.

SEEDING THE FUTURE

In northern Hill County, an ambitious farm wants to demonstrate that organic dryland practices can be successfully scaled across Montana.

Writing and photography by David Hanson

Doug Crabtree hit the snooze button this morning and he wishes he hadn't. It's Wednesday in mid-May and there's still roughly 3,200 acres to seed. The sun, in a cloudless sky, is already well above the distant horizon. There's an urgency as Doug and Jack, a long-haired Jack Russell settle into the air seeder cab. 30 acres of barley seeds remain in the tank, enough for one mile-long strip of dirt. Few things in the world make the air crackle with hope like a farmer dropping seed into bone-dry soil with a 75% chance of rain.

The scale here, even for Montana, is disorienting. The tower of an abandoned border-patrol radio base looms like a lighthouse 15 miles east. You can see a few neighbors, their tree-lined houses and grain bins make patches on the rolling tan carpet of mostly conventional wheat. At night you can hear a mouse breathe.

Crabtree and his wife Anna Jones-Crabtree own Vilicus Farms, an organic dryland crop farm in Hill County, about three miles from Canada. They started the farm in 2009 with the belief that dryland, rotational, organic farming can be viable on a large-scale.

"We're an island of biodiversity in an ocean of earth," Anna likes to say.

"My dad farmed about 4,000 acres in Ohio," Doug says. "He supported our project out here but he never understood the diversity of it—the idea of living with weeds. I'm not sure he understood what we were doing, but he knew why we were doing it. Organic farming is something you first have to believe in as a better way. It's certainly not easier."

Tilling and rotation are the secret to Vilicus' ambitious large-scale organic operation, but the tilling practice is fraught with controversy. Tilling too much or too deep can result in vital topsoil being blown away and exposes more soil to drying and ultimately compaction. At Vilicus, they take tilling very seriously with the intention of mimicking the historical impacts of large ungulates like elk, deer, antelope and bison on the soil. Tilling is also the only way they can control weeds without using herbicides. If successful, they've created a competitive advantage for seeds versus weeds, while avoiding chemical inputs.

"At the root of organic farming is the belief that we must feed the soil, not the plant," Doug says as the seeder locks into its GPS track. "To do that, you have to learn the art of tillage."

Of Montana's 59 million acres of agriculture, less than 1% (351,000) is in organic production. Doug and Anna want to change that. It's a daunting task. Even adding another 1% is a scale well beyond their capacity, but they hope to act as a proof point in how organic can be done. To them, re-learning how to grow food and seed by replicating, in a controlled way, natural processes is a critical adaptation as the climate changes. Most synthetic fertilizers and herbicides are derived from petrochemical products that contribute to global warming and can be an unpredictable cost for the farm (not to mention the health concerns over their use on food). Doug and Anna farm organically because they believe in it, but also as a way to establish proven methods for food and seed production and offer real-world experience to young farmers wanting to create their own organic farms.

"You're not going to go flip a switch and suddenly have all organic agriculture," Anna says. "So what's our transition? What are the steps we can take right now that set us up for success and faster progress later?"

"My hope is that we can identify new opportunities or plant some seeds that will help shift the whole system toward organic because that's the thing that'll help us respond, adapt and be flexible to whatever happens with the climate. And, yeah, I hope it actually rains tomorrow."

For now, Doug needs to get this seed in the ground. As the rumbling seeder drops barley specs into the dusty soil, he admits that they sometimes wonder if annual dryland farming is viable. The alternative out here would be a return to perennial grazing with cattle or bison. That would mark a massive loss for large-scale food and seed production needed to feed the world's population.

"We're always observing, learning, incorporating or eliminating," he says. "We started with five-crop rotations, which I thought was radical, and now we're at seven-crop rotations. Almost everything we do is experimental and the elephant in the room is the climate changing beneath our feet, or above our head, as it were." ■

"My hope is that we can identify new opportunities or plant some seeds that will help shift the whole system. **And, yeah, I hope it actually rains tomorrow."**

—Anna Jones-Crabtree

SECTION 3: OPERATIONAL AND ADMINISTRATIVE FRAMEWORK FOR DROUGHT MANAGEMENT

The Operational and Administrative Framework identifies the key players involved in state-level drought management and shows the pathway from drought monitoring and assessment to state-level (emergency) and federal-level (disaster) declarations that trigger state and federal action (Figure 13). Clearly documenting drought management roles, responsibilities, and processes makes a complex system accessible to the public and provides a foundation for working toward greater coordination and efficiency moving forward.

Key State Partners

Drought and Water Supply Advisory Committee

Montana's drought response is led by the statutorily defined Drought and Water Supply Advisory Committee (Drought Committee), which serves as the integration point for state, federal, tribal, and local entities that are responsible for managing natural resources and supporting constituents affected by drought. The Montana Legislature established this interagency drought advisory committee (§ 2-15-3308, MCA) in 1991, following an extended period of drought in the 1980s, to improve drought monitoring and coordination of state resources to reduce impacts.

The Drought Committee is chaired by a representative of the Governor's Office and comprises seven additional voting members representing state agencies with direct roles in drought management, including the Montana Departments of: Agriculture (DOA); Commerce; Environmental Quality (DEQ); Fish, Wildlife and Parks (FWP); Livestock (DOL); Military Affairs – Disaster and Emergency Services (DES); and Natural Resources and Conservation (DNRC). These agencies aid in assessing, responding to, and preparing for drought, primarily through existing programs. They also provide knowledge, expertise, and technical assistance and coordinate support with federal partners. DNRC provides administrative support to the Drought Committee and its Monitoring Subcommittee.

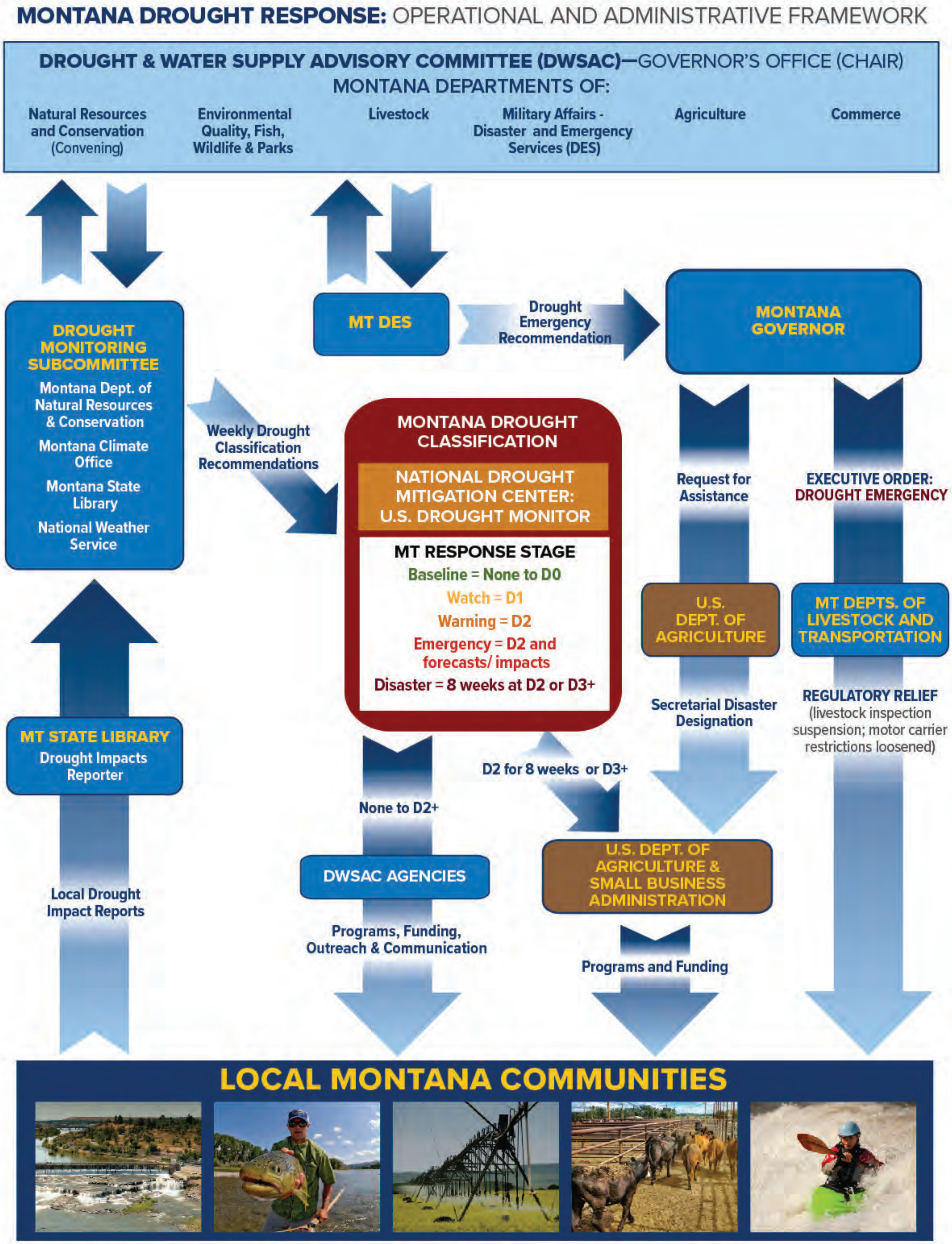
Drought Monitoring Subcommittee

The Monitoring Subcommittee is made up of representatives from DNRC, Montana State Library (MSL), Montana Climate Office (MCO), and the National Weather Service (NWS). Additionally, several Drought Committee agencies monitor and assess drought as part of their regular duties and provide this information to the Monitoring Subcommittee. Other partners, such as the U.S. Geological Survey (USGS) and the U.S. Forest Service (USFS), regularly support the Monitoring Subcommittee with current streamflow, groundwater, and soil moisture information.

Federal, State, Tribal, and Local Entities

The Drought Committee is supported by federal, state, tribal, and local partners that help assess conditions and coordinate resources. Federal partners support the Drought Committee by providing meteorological and hydrologic data, as well as drought relief through financial assistance and planning programs. Federal partners include NWS, USGS, USFS, the U.S. Bureau of Reclamation (USBR), the U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA), the National Agricultural Statistics Service, and the U.S. Small Business Administration (SBA). Tribal governments and local partners, including county and city governments, local planning organizations, non-governmental organizations, and other state partners, such as the Montana Bureau of Mines and Geology (MBMG), Montana Tech's Ground Water Information Center (GWIC), and Montana State University Extension Service, not only report conditions and impacts, but also help to identify community needs and implement science-based solutions to address drought and water security.

FIGURE 13. Operational framework for drought monitoring and assessment, emergency declaration process, and delivery of agency resources to local communities.



For a larger version of the Montana Drought Response Framework please visit drought.mt.gov/response-actions

TRADITIONAL KNOWLEDGE INFORMS CLIMATE SCIENCE AND ADAPTATION

A cultural relationship with landscape infuses climate strategy for the Blackfeet.

Writing by Al Kesselheim

When Blackfeet people say they are of the land, it is not hyperbole. It is a statement of cultural reality. The landscape, the animals, the water, the soil, the weather, the people . . . all one.

"We've had this relationship for generations," says Latrice Tatsey, Cultural Ecologist with the Piikani Lodge Health Institute, when we meet with a team working on the Blackfeet Climate Change Adaptation Plan on a snowy December morning in the Blackfeet Environmental Office in Browning.

"Western thinking is very linear," adds Helen Augare-Carlson, Blackfeet Community College Institutional Development Title III Director. "Our thinking is cyclical and holistic."

Everything about the climate plan speaks to this connection between landscape and culture, and to the interwoven nature of the effort: referencing ceremonies and the wisdom of elders, incorporating education about climate change in school curriculum, dove-tailing with other conservation efforts on the reservation, and listening to and observing the people and the land before taking action.

Using beaver mimicry on local streams is a case in point. Beaver dam analogs have become a key strategy in the effort to conserve water, build soils, recharge groundwater, and retain streamflows in watersheds that have suffered from the impact of climate change.

"This is not a new concept," says Gerald Wagner, Director of the Blackfeet Environmental Office. "We pay attention to animals. We observe them and communicate with them and learn."

What the Blackfeet have learned from observing beavers has led to the construction of small dams on streams, built from local materials – pine posts, willow branches, sod – to strategically contain water in ponds that help mitigate the impacts of drought and retain flows in dewatered streams.

Local school students are helping build and monitor the projects, plugging leaks, photographing from monitoring points, wrapping trees, sampling and measuring water and soils. Early results are promising – streams flow longer, ground water storage has increased, and wetland habitat is rebounding.

Photo by Thomas Lee

> **"We use citizen scientists and local landowners to create the plan for their property."**
>
> **—HELEN AUGARE-CARLSON**
> **Blackfeet Community College Institutional Development Title III Director.**

K-12 students are exposed to climate issues through field trips, partnerships with landowners, camps, and language immersion sessions that connect them to ancient wisdom while priming them to become stewards of the land going forward.

The 800-acre Blackfeet Community College campus and the local high school grounds provide valuable laboratory testing sites for climate change projects, including a greenhouse, solar panels, snow-fencing and stream restoration. In the process, young people learn about climate related challenges and take part in implementing measures to address them.

In a field next to a high school parking lot, a set of snow fences are being tested to capture snowdrifts in selected spots that will collect meltwater and recharge aquifers, add moisture to the soil, and increase forage. A variety of fencing materials, from orange plastic to woven willow, are being used to assess effectiveness. From the looks of it, the woven willow is proving to be the most efficient material with the largest drift behind it. Cameras in set locations document the seasonal record of these snowdrifts and soil moisture is carefully measured.

The same principle applies on the larger landscape. “We use citizen scientists and local landowners to create the plan for their property,” says Edmo. Who better to rely on than the stewards who have lived on the landscape, observing seasons and the evolution of changes for decades and in some cases, for many generations? They know where the winds come from, where the streams dry up, how the vegetation and wildlife has adapted over time.

Intensive regenerative grazing practices, for example, are an outgrowth of the traditional grazing regimes of herds of bison that once migrated across this same landscape by the millions. “That is how this land developed and evolved,” says Augare-Carlson.

For the Blackfeet, the relationship with landscape extends back to a time before international boundaries, to a time when bison thundered across the prairie in teeming herds, to a culture with intimate ties and ceremonies to honor every aspect of the environment. Over centuries, they have watched their territory shrink, their people become entangled with western values and habits, and their cultural bond with the land grow more tenuous.

“People throw around the word ‘resilience’,” says Tatsey. “That resilience starts with sustaining your own community, sustaining your culture.”

“We were privileged to grow up in this culture,” says Edmo. “Now it’s our job to keep translating that forward for future generations through our traditional history and through science.” ■

Photo by Tyrel Fenner

Photo by Sean R. Heavey

SECTION 4: DROUGHT RESPONSE

State Emergency Declaration

At the state level, the Governor may declare a drought emergency for individual counties or the whole state. The process is as follows: the Monitoring Subcommittee reports drought conditions to Montana's Drought and Water Supply Advisory Committee (Drought Committee). The report includes an overview of counties experiencing emergency drought conditions based on the status determined collaboratively with U.S. Drought Monitor (USDM) and any additional observed and/or modeled data, local impact reports posted on the Montana Drought Impacts Reporter & Viewer, and other information. Drought Committee members also contribute their observations of conditions on the ground based on resource assessments conducted by their respective agencies and feedback from their constituents. Based on a convergence of evidence, the Montana Departments of Natural Resources and Conservation (DNRC) and Military Affairs – Disaster and Emergency Services (DES), in conjunction with the Drought Committee, discuss and prepare an emergency declaration request for the Governor's Office. The Governor's Office, in consultation with DES, issues an executive order that authorizes state agencies to initiate response actions to address drought.

Federal Disaster Designation

The U.S. Department of Agriculture (USDA) Secretarial disaster designation process for severe drought is streamlined to reduce paperwork and documentation requirements at the local Farm Service Agency (FSA) level, making the process more efficient and timelier for agricultural producers. The expedited "Fast Track" process provides a given county an automatic disaster designation when USDM reports that any portion of that county meets the severe drought intensity value (D2) for eight consecutive weeks or a higher drought intensity value (D3-D4) for any length of time during the growing season. Counties that do not meet the Fast Track criteria can also request a USDA Secretarial disaster designation through the general process by demonstrating a 30 percent production loss of at least one crop or a through a determination made by surveying producers that other lending institutions will not be able to provide emergency financing.

For the general USDA Secretarial disaster designation process, a written request must be made on behalf of the affected county by the Governor, Indian Tribal Council leader, or FSA State Executive Director to the Secretary of Agriculture within three months of the ending date of the disaster. Local FSA offices compile the required agricultural loss information into a Loss Assessment Report, which is then reviewed by the County Emergency Board to determine if a 30 percent production loss of at least one crop occurred. The County Emergency Board's recommendation to approve, defer, or reject the request is submitted to and reviewed by the State Emergency Board, which submits its final recommendation to FSA's national headquarters. FSA national headquarters reviews the loss information on the Loss Assessment Report, determines eligibility, and prepares a package, including the letter of approval or disapproval, to be signed by the Secretary of Agriculture. The Secretary then notifies the Governor of this determination, and the Governor notifies the affected counties of the process outcome.

Response Actions

Response actions can alleviate drought impacts in the short term. To clarify "who does what when," the Drought Committee and Monitoring Subcommittee have identified triggers and corresponding actions for each drought stage (Table 3).

Drought Stages, Triggers, and Corresponding Response

USDM uses five classifications: abnormally dry (D0) are areas that may be going into or coming out of drought, and four levels of drought status, including moderate (D1), severe (D2), extreme (D3) and exceptional (D4). Montana's drought classifications are established weekly by Montana experts using a convergence of evidence, including reports from water users across the state.

Montana has five stages to guide drought management and response activities (Table 3). The "baseline" stage reflects normal to abnormally dry conditions and describes ongoing state actions, regardless of the presence of drought. Three drought response stages (watch, warning, and disaster) are triggered by USDM drought classifications, and each initiates a set of response actions. The "disaster" stage is linked to the federal disaster designation process and aligns with the USDA Fast Track for disaster designation. The "emergency" stage, declared by the Governor, triggers a separate set of state-level response actions.

BASELINE (NONE TO D0): Characterized by normal conditions (USDM category "none") through the development of abnormally dry conditions (D0).

- Baseline monitoring of natural resource conditions (e.g., streamflow, reservoirs, groundwater, water quality, forest and rangeland health, fish and wildlife populations, invasive species, harmful algal blooms) is conducted by Drought Committee member agencies and other agencies as part of their regular duties. Conditions are used to develop the weekly recommendation to the USDM.
- Monitoring information is shared in the Monitoring Subcommittee's weekly communications, Drought Committee's meetings, and through April and July Water Supply and Moisture Condition Reports.

WATCH (D1): Moderate drought in any part of the state.

- During the "watch" stage, baseline monitoring and communications continue, and Drought Committee agencies and partners begin to increase outreach efforts to convey drought conditions and resources to the public.

WARNING (D2): Severe drought in any part of the state, regardless of duration or extent.

- This stage provides a mechanism for the Drought Committee and partner agencies to direct communications and resources to constituents in these areas before emergency conditions develop.
  - Worsening conditions are assessed as part of each agency's regular duties and are reported to coordinating agencies during regular Drought Committee meetings and to the public through agency outreach. Land and water use, fishing, and hunting restrictions may be triggered at this stage based on agency protocols.
  - Some agency actions are triggered by conditions revealed through baseline monitoring, not USDM categories. For example, reduced streamflow and increased water temperature are often a consequence of drought. These conditions can trigger execution of Montana Fish, Wildlife & Parks (FWP)'s instream flow (Murphy) rights and fishing (hoot owl) restrictions.
  - Though not officially triggered by D2 drought, the Montana Departments of Agriculture (DOA) and Livestock (DOL) may begin to coordinate USDA counseling services.
- State-level emergency and environmental contingency grants and loans become available at this stage.

EMERGENCY: The Governor may declare an official drought emergency based on reported conditions, impacts, forecasting information during times of severe (D2) drought, and/or a recommendation by the Drought Committee. The "emergency" stage begins once the Governor makes an official emergency declaration.

- When a drought emergency is declared, the Governor's Office issues a press release to alert affected constituents and communicate the state's response and resources available to alleviate immediate impacts.
- The emergency declaration gives the state the ability to lift restrictions, such as motor vehicle weight limits and livestock inspections, to allow for the streamlined transport of animals, stock water, and feed.

DISASTER: The drought disaster is automatically triggered by the Fast Track USDA Secretarial disaster designation process, when a county experiences eight consecutive weeks of severe (D2) drought, or the development of extreme (D3) or exceptional (D4) drought conditions for any length of time. If a Fast Track designation has not been triggered by drought conditions, but production losses meet the eligibility requirement, the Governor, Indian Tribal Council leader, or FSA State Executive Director may request the Secretarial disaster designation by making a written request to the Secretary of Agriculture.

- The Governor's Office issues a press release to communicate the disaster extent and available resources.
- Montana Department of Commerce, DOA, and DOL work with federal agencies to coordinate relief for their constituents.
- Counties are eligible for USDA drought relief programs.


Photo by David Hanson

TABLE 3. Montana drought response actions. Montana has five stages to guide drought management and response. Each stage maps to a USDM classification except the "Warning" and "Emergency" stages, which can both occur during the USDM D2 (Severe) classification and are differentiated from each other assessments by and reports, impacts and/or recommendations produced by the Drought Committee (DWSAC). Response Actions are grouped by action type (e.g., communication, monitoring, assessment, regulatory), and the responsible party is identified for each.

Stage and Trigger	Response Actions	Responsible Party
BASELINE None to D0 (Abnormally Dry) in one or more counties	**Communications & Coordination**	
	Weekly recommendations to U.S. Drought Monitor	Monitoring Subcommittee
	Drought and Water Supply Advisory Committee Meetings (March - October, as warranted)	DWSAC
	April and July Water Supply and Drought Forecast Reports	DNRC, DWSAC
	Local water supply outreach and communications	Local watershed groups
	Monitoring & Assessment	
	Drought monitoring	Monitoring Subcommittee
	– Calculate metrics and maintain drought indicators dashboard	MCO
	– Develop Montana Mesonet (meteorological and soil moisture monitoring network)	MCO
	– Maintain Montana Drought Impacts Reporter	MSL
	Conditions monitoring	DWSAC & Partners
	– Statewide streamflows and temperatures	USGS, DNRC, FWP
	– Reservoir levels and water supplies	USACE, USBR, DNRC
	– Forests and rangelands	DNRC
	– Chronically dewatered/ high priority streams for instream flow leasing	FWP
	– Fish populations, water body fishing use, and harvest	FWP
	– Aquatic invasive species (AIS)	FWP
	– Game populations and WMA conditions	FWP
	– Crop Progress and Condition Reports, monthly Dec-Mar, then weekly Apr-Nov	DOA, NRCS, USDA
	– Groundwater levels in aquifers	MBMG, DNRC
	– Groundwater quality	MBMG, DEQ, DOA
	– Surface water quality based on designated beneficial use	DEQ
	– Public water supply systems	DEQ
	– Harmful Algal Blooms (HABs)	DEQ, DPHHS, FWP
WATCH D1 (Moderate Drought) in one or more counties	**Communications & Coordination**	
	Communicate worsening conditions to affected stakeholders, including federal agencies, Montana Office of Tourism, Board of Outfitters, and citizens	DWSAC, local watershed groups
	Issue press release on fire conditions, prevention, mitigation, and education	DNRC
	Meet with local groups to discuss flow conditions and response	FWP, DNRC
	Communicate best practices to reduce fish loss (proper handling, irrigation diversions)	FWP, DNRC
	Issue drought newsletter for public water suppliers	DEQ
	Conditions Assessment & Reporting	
	Identify streams subject to fishing regulation changes and/or instream flow water rights call if conditions worsen	FWP
	Assess potential for economic damage to agricultural sector if conditions continue or worsen	DOA, DOL

Level	Rule or Protocol	Action	Agency
WARNING D2 (Severe Drought) in one or more counties + convergence of evidence	**Regulatory Restrictions or Relief**		
	Rule or Protocol		
	Hunting Regulations	Evaluate game populations and implement hunting regulation changes and/or access restrictions (where warranted)	FWP
	Angling Restrictions	Implement hoot owl restrictions (where warranted)	FWP
	FWP Water Right Call Protocol	Implement instream flow call protocol (where warranted)	FWP
	Fire Restrictions	Coordinate fire and travel restrictions on state lands; and state land closures (where warranted)	FWP, DNRC, counties
		Support and communicate any county level fire restrictions	DNRC
	Drinking Water Rules	Issue health advisories, boil orders (if warranted)	DEQ
	HAB Guidance	Beach closures for harmful algal blooms (if/where warranted)	DEQ, DPHHS, FWP
	Funding or Resource Support		
	Administer Emergency Grant/Loan Program		DNRC
	Authorize environmental contingency funding (if warranted)		Governor's Office
	Coordinate counseling services (USDA)		DOL, DOA
EMERGENCY D2 + conditions, impacts, and/or DWSAC recommendation	**Initiate State Emergency Declaration Process**		
	Prepare declaration for Governor & Review		DES & DWSAC
	Issue MT Emergency Declaration		Governor's Office
	Communications & Coordination		DES & DWSAC
	Issue press release		Governor's Office
	Regulatory Relief		
	Ease motor vehicle restrictions		DOT
	Relaxation of cattle inspection requirements		DOL
	Consider emergency haying or grazing on selected WMAs, following associated environmental review and selection process and evaluate Trust Lands available for leasing for emergency grazing		FWP
DISASTER D2 for 8 consecutive weeks or D3+ (Extreme or Exceptional Drought) in one or more counties	**Disaster Designation**		
	Seek USDA Secretarial disaster designation (Fast Track or Request)		USDA - FSA
	Communications & Coordination		
	Issue press release		Governor's Office
	Funding or Resource Support		
	Conduct damage assessments, coordinate relief with federal agencies (USDA, SBA)		DOL, DOA
	Assess tourism impacts, coordinate relief with federal agencies (SBA small business loans)		Commerce

Abbreviations: MT Department of Agriculture (**DOA**), MT Department of Natural Resources & Conservation (**DNRC**), MT Department of Environmental Quality (**DEQ**), MT Department of Transportation (**DOT**), MT Department of Commerce (**Commerce**), MT Department of Military Affairs – Disaster and Emergency Services (**DES**), MT Department of Fish, Wildlife & Parks (**FWP**), MT Department of Livestock (**DOL**), MT Department of Public Health and Emergency Services (**DPHHS**), U.S. Department of Interior – Bureau of Reclamation (**USBR**), U.S. Department of Interior – U.S. Geological Survey (**USGS**), U.S. Army Corps of Engineers (**USACE**), U.S. Department of Agriculture – Farm Services Agency (**FSA**), Drought and Water Supply Advisory Committee (**DWSAC**), Small Business Administration (**SBA**), MT Climate Office (**MCO**), MT State Library (**MSL**), MT Bureau of Mines and Geology (**MBMG**), Wildlife Management Area (**WMA**)

RISING TROUT HELP TO RAISE AWARENESS

As a warming climate forces recreational fishing closures, a few veteran Montana guides are educating younger guides on the complexities of water challenges.

Writing and photography by David Hanson

"The spinners are floating down that wrinkle," Brant Oswald says aloud, either to himself, me, or just the river, in general. He deftly lifts his line from the water, casually back-casts then drops it onto the dark surface. His hand-tied spinner fly lands above the wrinkle and twirls, just before the smooth, blunt jaw of an 18-inch brown trout shatters the surface.

Oswald has seen a lot on the water. He began as a guide and instructor with Orvis (then Mel Krieger) before establishing his own guiding service based in Livingston in the early 90s. He's published articles on fly fishing and served on the board of the Fishing Outfitter's Association of Montana (FOAM) and on the Governor's Upper Yellowstone Task Force. Montana fly fishing has been good to him, but Brant's been around long enough to read the wrinkles.

For Oswald and other guides, leading people to fish in Montana has always involved more than knowing the honey holes and landing trophies. State regulations, private land access, and mitigating for over-crowding make up a matrix of considerations. The ongoing drought and increasing temperatures have added another layer of complexity: "Hoot Owl Closures."

The hoot owl restrictions, an early 1900s moniker that refers to the early morning hours when loggers would hear owls hooting, are meant to limit stresses on fish by restricting fishing to the coolest hours of midnight to 2pm. Guides and their clients have had to adjust as these closures have become more frequent, widespread and enduring.

The fixed dates clients have been long accustomed to aren't practical or effective considering earlier snowpack melt, warmer summer temperatures, and droughts. Earlier snowpack runoff might mean certain rivers fish better in the spring, but there's always the chance for a late-spring flood event like the Yellowstone experienced in 2022. Mike Bias, Executive Director of FOAM and an outfitter himself, says there are almost no guides pushing August trips on the Big Hole River. They now aim for April, despite the risk of foul weather.

A socioeconomic resilience study projects that drought and warming waters could result in a spending decline in recreational activity of 64% in southwestern Montana rivers such as the Yellowstone, Madison, Big Hole, and Bitterroot by 2040 (Cline et al., 2022). This change is due to the fishing industry abandoning the area as waters warm and the trout migrate or disappear. Adaptation for the recreation industry starts with client messaging about how those impacts translate into lower stream flows, higher

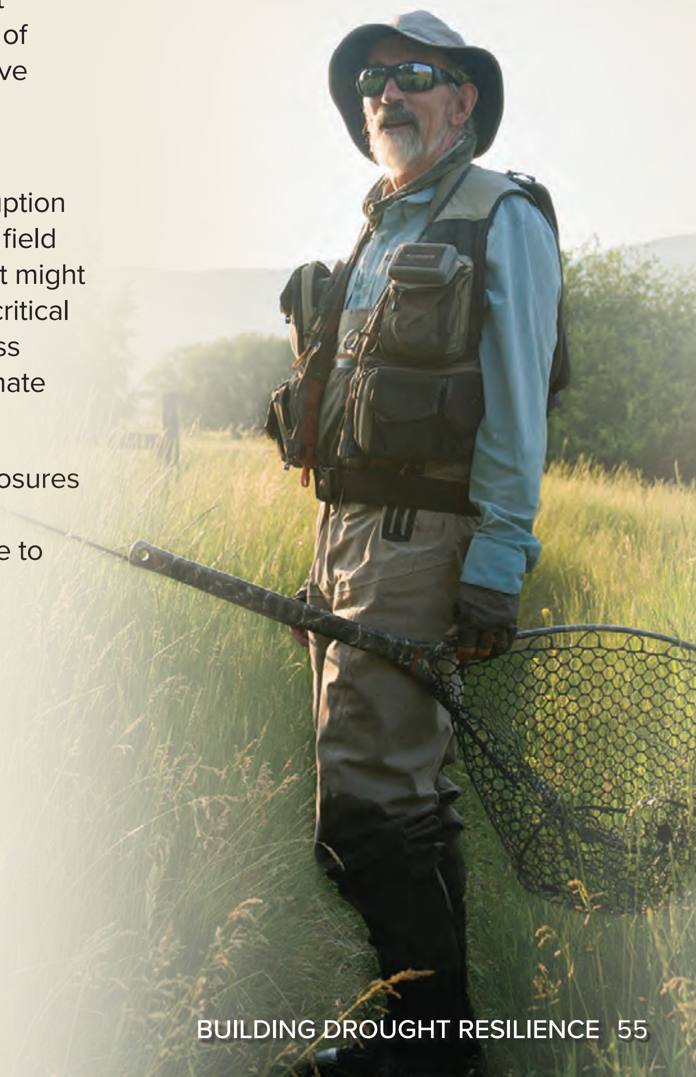
water temperatures, and other impacts that kill fish and ultimately change their vacations.

A few years ago Oswald read an article in Trout Unlimited that challenged guides to step up and be better educators around river stewardship. Clients from around the world come to Montana and they look up to guides for river knowledge. Oswald realized he and fellow guides have an obligation and an opportunity to be as informed as possible, especially in light of the threats posed by droughts, climate change, and the accompanying regulations. He and other veteran guides including Bias and the FOAM organization created a program—Guiding for the Future (G4F)—that would help educate guides on hydrological, ecological, agricultural, and social issues that impact Montana fisheries.

"As a guide you have two people in your boat for 8 hours," says Bias. "That's 20-30 people per week for 30 weeks. There's a lot of misinformation out there. If the guides know the background of conservation and physiology, that's a lot of influence we can have with the general public."

Oswald and G4F had their first training course in 2019 with 25 guides. COVID halted their progress for two years, but the disruption motivated the G4F team to create a hybrid model of online and field classes. Now G4F can reach a larger audience at a lower cost. It might seem like a small thing, but as any fisherman knows, access is critical to success and the client-guide relationship offers its own access point for sharing perspectives and raising awareness about climate issues.

"There's an urgency now," says Bias. "We had more hoot owl closures last year than any other year before. It's awareness. It's shared sacrifice. The water supply issue affects all of us and we all have to apply those concepts of conservation to the rivers." ■



"There's an urgency now. The water supply issue affects all of us and we all have to apply those concepts of conservation to the rivers."

—BRANT OSWALD

SECTION 5: DROUGHT MANAGEMENT RECOMMENDATIONS

Developing Recommendations

The goal of the Montana Drought Management Plan (Plan) is to make the state of Montana more drought resilient. Building resilience may require implementing a broad range of proactive adaptative strategies to help water users prepare for future droughts. The strategies collected here originated from public meetings, survey responses, interviews, and conversations by stakeholders including tribal members and representatives of water-use sectors – agriculture, business, conservation, culture, energy, fish and wildlife, forestry, local governance and planning, recreation, tourism, and wildland fire. In addition, the Montana Drought and Water Supply Committee (Drought Committee; convened for this planning effort as the Montana Drought Task Force) provided input, leadership, and insight on behalf of the Montana Departments of Agriculture (DOA); Commerce; Environmental Quality (DEQ); Fish, Wildlife & Parks (FWP); Livestock (DOL); Military Affairs – Disaster and Emergency Services (DES); and Natural Resources and Conservation (DNRC).

Altogether, the 36 recommendations are a synthesis of the numerous ideas, concerns, and solutions brought forward by hundreds of Montanans from across the state to better prepare Montana for future drought.

Summary

The stakeholder-generated recommendations are organized into seven broad categories that span many aspects of water use and management, including policy, funding, programs, technical assistance, coordination, and communications. Many recommendations offer proposed changes to specific state programs and policies that would remove barriers to, or better support, local-level action. While most recommendations focus on state-level action and complement existing state plans, some propose actions at community or federal levels.

DNRC wants to emphasize that these recommendations are not driven by the Department but are instead a reflection and compilation of stakeholder feedback. They reflect a wide-ranging menu of ideas and options to build drought resilience. Where appropriate, DNRC has identified the agencies with primary authority over each recommendation's subject matter. If unidentified, the recommendation is intended to be considered by the many private, local, state, federal, and tribal entities involved in water management in Montana. All recommendations contained in the Plan are subject to the existing institutional and legal framework for water use in Montana as provided for by the Montana Constitution, prior appropriation doctrine, and the Montana Water Use Act, as well as budgetary constraints. Implementation of some recommendations may require the Montana Legislature to amend the Montana Water Use Act.

From Planning to Implementation

These stakeholder-derived recommendations represent a suite of tools that may be used to create a more drought resilient Montana. Implementation will require further development of important issues like funding sources and availability, as well as coordination to ensure a cohesive and consistent statewide policy direction.

DNRC will lead the implementation effort by analyzing each recommendation based on its potential beneficial impact, the funding required, the level of complexity and coordination required, implementation timeframe, and availability of stakeholder and partner support. These factors, along with the feedback of the Drought Committee, executive and legislative branches, and stakeholders, will guide the DNRC in developing an implementation work plan for the biennium and beyond. Two near-term priorities have already emerged due to their potential benefits and widespread appeal:

- The recommendations under the Agency Coordination and Partnerships category require minimal investment and policy reform to achieve, and they are therefore being pursued immediately.

- The recommendations under the Water Supply, Storage, and Delivery received broad and enthusiastic support at every level: vulnerability assessment interviewees from every sector cited storage as an adaptation that would increase resilience; public commenters consistently cited storage as a priority; and the Legislature directed the Water Policy Interim Committee to complete a study of water storage during the 2023-24 biennium. While full implementation of the recommendations in this category will require long-term investment, pressing ahead with the initial steps is a clear near-term priority.

1 WATER SUPPLY, STORAGE, AND DELIVERY Maximize water supply, storage, and delivery by enhancing existing built storage, expanding natural storage, and assessing infrastructure

Water storage is one of the earliest drought adaptation strategies and continues to play a critical role in meeting current and future water demands. Montana's federally owned reservoirs were constructed between 1900 and 1950, and state-owned water projects were mostly built in the 1930s. Consequently, Montana's dams and reservoirs require significant and ongoing investment (private, state, and federal) for maintenance, repair, and rehabilitation.

The Montana State Water Plan (2015) recognized that large, traditional (built) water storage projects are "expensive to plan, construct, operate, and maintain" and are further "limited by the availability of suitable locations, cost, public support, the need to mitigate environmental impacts, and the limited legal and physical availability of water." The State Water Plan endorsed ways to maximize built storage capacity through rehabilitation and modifying reservoir operation policies, as well as integrating natural storage to benefit water supplies and ecosystems.

Identify future stable funding for rehabilitation and maintenance of state and private water projects

Maintenance of Montana's state water projects is largely supported by the coal severance tax and the sale of hydropower from state-owned Toston Dam, which currently generates $5 to $6 million annually. The state's agreement to sell power generated by Toston at a fixed rate expires in 2024, and future revenue streams to fill this gap are uncertain. **Montana, led by DNRC, should explore potential alternative funding sources to ensure Montana's state water projects continue to meet the needs of the many water users across Montana who rely on them.** Although much of the water stored by state-owned projects is marketed to local water users' associations for irrigation, some projects, such as Painted Rocks, also store water to augment late-season instream flows for fisheries.

Similarly, more than 75% of Montana's dams are owned by private or semi-public (e.g., water user associations) entities[13], and, although their typical purpose is to store water for irrigation or livestock, many of them provide broader public benefits, such as flood control, recreation, and late-season streamflow. The operation and maintenance costs, as well as liability, are the responsibility of the dam owner(s), and no existing federal programs fund operation and maintenance of privately owned dams. Thus, dam owners bear the full costs of these expenses. Dam maintenance is a public safety issue, as well as a key to better management of water during drought and flood conditions. **Montana should explore whether adequate funding is available in existing grant and loan programs to support ongoing operation and maintenance of privately owned and semi-publicly owned dams.**

Assess opportunities to expand surface water storage projects

Building new surface water storage projects in Montana is unlikely, but there may be opportunities to enhance and expand the storage capacity of the more than 64,000 existing projects, many of which are located in the headwaters of major river systems. Many are nearly (or already exceed) 100 years in age and would require varying levels of rehabilitation to restore or increase their historical volumes. In addition, the patchwork of dam ownership (private, local governments, state government, tribal governments, public utilities, and federal government) throughout the state adds complexity because of differing regulations and operating plans.

A statewide feasibility and cost-benefit analysis of surface water storage projects in Montana would provide much-needed guidance as to which projects make the most sense to pursue as opportunities to increase surface water storage. This would be a significant undertaking, but such a project would not need to start from scratch. Feasibility analyses have already been conducted for most state-owned water projects. The potential gains from analyzing the remainder and aggregating the findings make it a worthy endeavor. The feasibility studies would vary depending on the project but would need to address: administration (ownership and feasibility of transferring to the state, if appropriate; options for contracting water; and evaluation of operation plan); water assessment (volume, timing, use, and availability); engineering assessment (operations and maintenance, current conditions, modifications for irrigation, options to increase storage, and hydropower options); and possible funding strategies. **Montana, led by DNRC, should look to maximize the use of already-built reservoir storage across ownership categories as a tool for supplementing late-season streamflow and meeting water demand by assessing the statewide feasibility of expanding surface water storage.**

Evaluate managed aquifer recharge as an adaptation strategy

Managed aquifer recharge can build drought resilience by temporarily storing water underground. This process can offset groundwater depletions from pumping, and, for aquifers that can potentially hold more water, it can even increase the total stored volume. By building on localized aquifer recharge projects required for mitigation, Montana could consider regional aquifer recharge in the context of a state-run program, like Idaho, though this approach would likely require substantial feasibility analysis. Potential next steps to pursue include assessing examples from other states' programs; convening a technical meeting with water managers from other states; assessing Montana's hydrogeology/geology to identify areas where aquifer recharge projects might be successful; locating potential source waters; identifying potential policy barriers and options for modification; and combining all available information into a framework for advancing future field and modeling projects and funding opportunities. **DNRC, in close collaboration with the Montana Bureau of Mines and Geology and other stakeholders, should lead an evaluation of managed aquifer recharge sites in Montana.**

Complete a feasibility analysis and prepare a preliminary project design for a cloud seeding pilot project in Montana

Cloud seeding programs for generating snowpack, increasing summer precipitation, and suppressing hail have been in practice since the late 1950s. Currently, eight western states and several Canadian provinces have active programs in place. The programs in Wyoming and Idaho are aimed toward boosting snowpack in areas where reduced winter snowfall and earlier snowmelt have diminished summer and late season streamflows, affecting agricultural production, recreation, hydropower production, and other uses. While cloud seeding is not a panacea for diminished water supplies, it may offer a tool for enhancing water supplies in some Montana watershed basins. In recognition of this potential, the 2023 Montana Legislature appropriated funding to study cloud seeding in the state. **The utility, cost and benefits of cloud seeding should be evaluated through a robust science-based evaluation of Montana's climatology, geography, and other variables affecting the feasibility of cloud seeding in Montana.**

Use and incentivize nature-based solutions to maximize water capture and retention

Watershed practitioners, researchers, landowners, and funders are increasingly looking to nature-based solutions to increase water capture and retention. Nature-based solutions include a wide range of practices that capitalize on natural processes to preserve or restore function of natural systems, including the storage of water in riparian areas, wetlands, and floodplains. These systems act like a sponge by temporarily holding runoff water. Eventually, water either returns to the surface or recharges groundwater.

Preserving intact floodplains and wetlands is the most cost-effective way of enhancing natural water storage. However, where activities like development, overgrazing, and/or artificial channelization have already impaired stream function, process-based restoration methods can restore river and floodplain connectivity to improve riparian function and bolster drought (and flood) resilience. For example, some practitioners in Montana have achieved this by installing networks of deformable grade structures, or "beaver dam analogs," to slow water and restore stream function. This integration of beaver habitat into stream restoration projects is a key goal of the Montana Beaver Action Plan (2021) because it facilitates self-sustaining natural processes that promote landscape-wide drought and wildfire resilience. Existing models can be used to identify areas of historical beaver presence and/or wetlands (e.g., Beaver Restoration Assessment Tool or floodplain storability models), which can help prioritize the implementation of natural storage projects.

Project funders could evaluate whether current grant and loan programs adequately support and facilitate nature-based solutions, especially where required cost-benefit analyses or other program requirements tend to prioritize built infrastructure (i.e., Federal Emergency Management Agency programs). Practitioners and researchers could monitor natural storage projects to better determine their efficacy at watershed and larger landscape scales.

Explore a new paradigm of integrated floodplain management

Disturbances to riparian ecosystems, such as road building, vegetation clearing, or erosion, can cause channelization, which is a progressive deepening of the streambed such that the stream can no longer access its floodplain. In contrast, when riparian areas are left intact, floodplains can absorb high flows and provide both drought resilience and flood attenuation benefits. Floodplain management and policy are complex and require local, county, state, and federal coordination. Several states have sought to better integrate floodplain management frameworks, including policies, funding, and projects, that can meet local land-use priorities while encouraging and restoring natural river function and floodplain connectivity.

Washington's Floodplains by Design program is a successful, public-private partnership and funding program that uses a landscape-scale, multi-partner approach to integrated floodplain management. Oregon's multi-county Floodplains for the Future program is conservation district led and relies on integrated floodplain management to encourage thoughtful floodplain use while also limiting flood risk, restoring fish and wildlife habitat, and increasing natural water storage capacity, which attenuates flooding and drought. While neither model may be appropriate for Montana, there is already a channel migration easement program through Montana Freshwater Partners. **DNRC, working with local governments and federal agencies, could explore approaches to better integrate floodplain management for drought and flood resilience through policy change, novel partnerships, and targeted financial investment.**

In addition, DNRC's Floodplain Management Program can continue and expand its public outreach and communication activities on the benefits of open space in floodplain areas, no adverse impact development practices, and sound mitigation projects (including acquisitions in high-risk flood areas), as well as provide education and training on best development practices in and around floodplains. The Floodplain Management Program can also explore the development of a targeted, strategic outreach and education program for riparian property owners that emphasizes the importance of riparian vegetation in building resilience to both droughts and floods.

Update studies of public and private irrigation infrastructure condition and needs

Irrigation is a critical hedge against drought for many of the state's agricultural producers, but much of Montana's public and private irrigation infrastructure (including storage, conveyance, and on-farm systems) is aging. DNRC is increasing investments in its grant programs that support irrigation, but neither state nor federal funding programs can adequately address all outstanding infrastructure needs. **DNRC should explore funding an updated statewide study of irrigation infrastructure conditions with an analysis of possible funding sources, to help prioritize future state and federal investments in irrigation in Montana.**

2 WATER POLICY Modify or create state policies to enable voluntary water-use flexibility and clarify water management roles

Changing conditions require changing responses, but Montana's extensive statutory and regulatory water-use framework can impose barriers to quick adaptation. Fortunately, policy adjustments are available that could increase responsiveness and resilience in the face of drought while still protecting existing uses from adverse effect. The common theme of the policy recommendations is that they promote flexibility and creativity within the prior appropriation system to allow Montanans to quickly adapt when drought occurs.

Offer legal protection for water users who voluntarily conserve water

"Use it or lose it" is common shorthand for one of the cornerstones of prior appropriation doctrine: water must be put to beneficial use or the user risks forfeiting their water right. In Montana, like many other western states, this clause is known as abandonment (§ 85-2-404, MCA). Abandonment can serve as a powerful disincentive for a water user to voluntarily conserve water through curtailment of their use (e.g., by participating in a watershed drought plan). **Voluntary water conservation is an important tool for building drought resilience, so Montana should explore ways to provide assurance to water users that they will not be subject to abandonment for temporarily reducing their water use during periods of drought.**

Streamline administrative review for short-term water management actions

The water right change process through DNRC requires public comment and objection periods, an analysis of historical diverted volume and consumptive use, and a determination of whether the change will adversely affect other water users. The change process is intentionally thorough to protect existing water users. However, some short-term drought management actions that involve temporary changes to the purpose or place of use or point of diversion may not require such intensive analysis. For example, an irrigator might temporarily switch from a low-water tributary to a mainstem source for a few weeks or might leave some water instream rather than use the entire volume for irrigation. **DNRC should use its Comprehensive Water Review process to consider a shorter, simplified review process for temporary water right changes to allow for greater management flexibility during drought while still protecting other water users.**

Establish flexible, short-term water leasing

Establishing a simple, streamlined path to short-term (i.e., up to one year or as little as an irrigation season) water leasing is a key policy strategy Montana should explore to build multi-sector drought resilience. Although we often think of temporary leases as ways to boost instream flow (§ 85-2-408, MCA), they can be applied to other beneficial uses as well, such as municipal water suppliers, which often bear a disproportionate burden to provide critical services (e.g., drinking water and fire suppression) for rapidly growing and urbanized populations. Creating more flexibility in short-term leases would allow water users to be nimbler in how they respond to drought.

Instream flow is a recognized beneficial use (§ 85-2-102(5)(d), MCA), and water rights that list instream flow as a purpose are held to the same statutory criteria as other existing rights with different beneficial uses. In 2013, the Montana Legislature provided a mechanism for temporary water right leases that were not subject to the more rigorous change criteria. However, that provision expired in 2019. § 85-2-427, MCA (2013) (Terminated July 1, 2019--sec. 4, Ch. 236, L. 2013). Current law allows for short-term leases of water volumes (§ 85-2-410, MCA) for dust abatement or road construction, and this concept could be extended to instream flows during periods of drought. Oregon currently relies on short-term instream flow leases (with a <45-day review period) as the bedrock of that state's drought response program. If Montana re-established such a program, it could provide a highly effective approach to maintaining streamflow during drought, especially when combined with dedicated funding for instream flow leasing (discussed below in the Funding category).

Short-term leasing programs are only as effective as they are flexible: This approach hinges on a short review period and a relatively simple administrative procedure (outside of DNRC's well-established water right change process). **Montana, led by DNRC, should consider reestablishing a short-term water leasing program as a key drought response policy tool.**

Assess feasibility of water banking and water marketing for mitigation

Water supply banks are physical (reservoirs or aquifers) or institutional (administrative/market-based) mechanisms that facilitate the exchange of water that is already accounted for by existing and new water rights through purchase or lease. Several western states, including Idaho, Washington, and Nevada, have established water supply banks in various physical and institutional forms. Water supply banks offer flexibility during drought in various ways, especially in river basins that are considered overallocated and closed to new water uses. Water supply banks may also be created through voluntary formal agreements among users that are managed and enforced by the parties involved.

Marketing for mitigation and water supply banks could simplify permit analysis and have the potential to reduce the number of permit exemptions (i.e., exempt wells) needed to accommodate new development and accomplish other new uses. **DNRC should use its Comprehensive Water Review process to consider further build-out of mitigation for marketing or other forms of water banking, including improving statewide measurement to ensure a workable water accounting foundation for such solutions.**

Consider hydrologic and legal mechanisms to facilitate aquifer recharge with existing irrigation infrastructure

Under certain hydrogeologic conditions, surface water seeps to aquifers through unlined irrigation canals, ditches, and ponds. This seepage often benefits streams and rivers by augmenting streamflow or lowering stream temperature. The exact location and timing of such recharge depends on numerous variables, but in many places seepage from early-season irrigation practices reaches the stream in late summer when streamflow is low.

From a drought resilience perspective, aquifer recharge is an important process that already occurs and should be incentivized. Yet from a policy perspective, managed aquifer recharge (unaffiliated with a separate beneficial use) is not considered beneficial – or even legal outside of limited circumstances. The tension between physical (drought resilience) and administrative (water rights) perspectives of aquifer recharge and its benefits warrants reform.

Definition of beneficial use: Currently, aquifer recharge is not considered a beneficial use in Montana's water right system outside of the context of offset of adverse effects resulting from net depletion of surface water. Yet incidental recharge can create

Photo by Michael Downey

landscape-scale drought resilience benefits for people and ecosystems that could be amplified if accomplished in an intentional manner. For example, diverting water into canals and onto fields in the weeks preceding the start of irrigation season – when the water is not used for the beneficial use of irrigation – could have significant benefits for drought resilience by storing water in soils and aquifers that would otherwise run downstream. **DNRC should use its Comprehensive Water Review process to explore broadening the definition of "aquifer recharge" (§ 85-2-102(3), MCA) to clearly authorize recharge as a standalone use, outside of mitigation or marketing for mitigation.**

Incentivize voluntary retention of flood irrigation infrastructure: In addition to aquifer recharge from ditches and canals, the practice of flood irrigation itself can also recharge shallow aquifers and provide late-season return flow that can benefit downstream water users and aquatic ecosystems. However, flood irrigation is labor and time intensive, and, as a result, many irrigators are converting operations to sprinkler systems because of labor and time savings, among other benefits. The timing and volume of return flows from flood irrigation depends on site-specific conditions, but, in general, irrigators who want to remain in flood irrigation should be incentivized to retain the practice when downstream benefits are clear. Existing state grant and loan programs could help defray the costs of upgrading flood irrigation infrastructure (e.g., headgates instead of tarps) to make it easier, and program criteria could be structured to promote this type of infrastructure in locations where downstream benefits occur. **DNRC and the U.S. Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS) should evaluate their irrigation funding programs to determine whether the programs adequately support voluntary retention of flood irrigation.**

Clarify future water right enforcement roles and responsibilities

As Montana nears the completion of its statewide adjudication of pre-1973 water rights, there is some uncertainty about which entity will assume what responsibilities for administering and enforcing water rights. Confusion about the appropriate process and forum for water rights matters should be avoided. If policies that promote drought adaptation through flexible use of water rights, including those discussed in this section, are to fulfill their purpose, it is imperative that management and enforcement processes be simple and straightforward for users to navigate. DNRC initiated discussions to explore the future roles of the judiciary, water commissioners, and DNRC in 2021 as part of its Comprehensive Water Review process. **DNRC is revisiting the discussion with a stakeholder working group in preparation for the 2025 session. DNRC should leverage the Comprehensive Water Review process to recommend appropriate policy changes in support of clear water right administration and enforcement roles and responsibilities.**

Photo by Donnie Sexton

3 FUNDING Establish dedicated, flexible, and stable state funding for multi-sector drought preparedness and response

Montana has made significant investments in drought adaptation (preparedness) through various state agency funding programs. Short-term drought emergency funding at the state level includes DNRC's emergency grant and loan program and Montana Coal Endowment Program (MCEP) emergency grants (for drinking water and wastewater infrastructure). The majority of drought response funding available to Montanans comes from federal sources such as USDA – Farm Service Agency (FSA) grants and loans and Small Business Administration (SBA) disaster loans. These federal programs are inherently reactive because funding eligibility most often is contingent on a county drought classification of severe (D2) for eight weeks or extreme (D3) for any duration.

Establishing a flexible, stable source of drought response funding is a critical investment the state can make to protect drought-impacted Montanans who either don't qualify for, or don't have the capacity to apply for, federal funding – or who need funding sooner than federal timelines allow (a reality in many cases). **The state could modify existing grant programs to be more responsive to drought and/or create new, dedicated source(s) of flexible and responsive drought emergency funding to address needs in key sectors.**

Establish flexible "bridge funding" to support agricultural producers

In practice, farmers and ranchers must make management decisions well before severe or extreme drought sets in – whether that's reducing livestock herd size, planting or not planting certain crops or fields based on seasonal water supply projections, reducing stocking rates, planning for supplemental feed, and other timely decisions.

In recent years, neighboring states have set examples of different forms of flexible funding programs. Oregon's Agricultural Disaster Relief Fund (2021) offers forgivable loans (up to $150,000 per operation) to farmers and ranchers impacted by drought. Colorado administers a flexible, streamlined Flood and Drought Response Fund that has no timelines, no application, and sparse guidelines – it starts with a simple phone call to the Colorado Water Conservation Board. **Montana could establish a flexible, time-sensitive, state "bridge funding" program to address gaps in federal programs and better support agricultural producers during and after drought.**

Support Montana's drought-impacted businesses, especially those reliant on natural resource-based tourism and recreation

Many of Montana's communities depend on natural resource-based tourism and recreation to sustain them. Community livelihood in these cases is closely linked to the condition and accessibility of nearby water bodies. When rivers like the Yellowstone, Madison, or Big Hole close due to drought (or flooding), local businesses are often directly and immediately impacted by customer cancellations and negative media coverage, which lead to reduced revenue, staff layoffs, and other stressors. **The Montana Department of Commerce could consider establishing a business relief funding program to help stabilize businesses with grants or low-interest loans as soon as drought impacts occur.**

Establish a funding program to support instream flow leases

Non-governmental organizations (NGOs), such as Trout Unlimited and the Clark Fork Coalition, and FWP often collaborate with water right holders to mitigate stream dewatering using instream flow leasing. The water right holder, usually an irrigator with a senior right, leases some or all of their right. The leased portion is left instream, and the water right holder receives a pre-negotiated compensation as stipulated in the lease agreement. Agreements are tailored to individual situations, and lessees cannot make call unless the right has been formally changed to reflect instream flow as the beneficial use. Currently, funding to support these leases comes from a variety of local, state, and/or federal sources; FWP's instream flow program receives its funding from license dollars. Few of these funding sources are specifically dedicated for instream flow, and all of them are increasingly competitive to procure. However, the benefits of such funding extend to the lessor, lessee, and beyond – to fisheries and aquatic ecosystems. **The state should evaluate whether current funding for FWP's instream flow program is sufficient, and DNRC could expand an existing program or establish a new one to provide dedicated funds for instream flow leases to promote more of these opportunities.**

Create a voluntary state incentive program to promote drought resilient agriculture

The Saving Tomorrow's Agriculture Resources (STAR) program is a free, voluntary, point-based framework focused on soil health and land stewardship. STAR originated as a conservation district project in Illinois but is now administered by several states, each of which has tailored the program to address local resource concerns. In Colorado, for example, STAR is the bedrock of the state's soil health improvement program, and production systems are evaluated based on practices known to improve soil health, water quality, and water availability. The adoption of STAR or a similar program in Montana could build drought resilience in both dryland and irrigated operations by incentivizing voluntary practices that boost water infiltration and retention in soil. **Montana should consider administering STAR or a comparable homegrown incentives program to promote further adoption of voluntary sustainable agricultural practices**.

Create dedicated, sustainable funding to build local watershed management capacity

A large network of watershed groups, conservation districts, land trusts, and other nonprofit organizations are recognized as invaluable leaders for restoring and conserving water resources across Montana. These organizations are primarily supported through private donations and state and federal project grants. Few grant opportunities exist that support watershed capacity building (i.e., staff time unaffiliated with a specific project) and planning, and those that do are limited, competitive, and often require a disproportionate amount of time to apply for and manage, compared to the return.

Relevant state agencies (such as DNRC and DEQ), NGOs like Montana Watershed Coordination Council, and federal funders should evaluate their funding programs for how well they meet watershed capacity-building needs. Potential changes might include establishing new programs, adjusting existing programs, such as DNRC's Watershed Management Grant, in response to stakeholder needs; and increasing funding duration, amount of funding per group, and amount of overall funding. This would provide reliable baseline support that is critical in sustaining community-level groups that work on the ground. Capacity funding would also promote better cross-watershed knowledge exchange by supporting watershed coordinators and conservation district affiliates for the time they spend engaging their communities and building trust, attending trainings, and sharing their stories at conferences and meetings – time that they are rarely compensated for under the current structure.

Photo by Michael Downey

4 DROUGHT AND WATER SUPPLY MONITORING Stabilize support for and expand existing networks; support the Montana Climate Office; assess mechanisms to expand water measurement; and invest in hydrologic modeling

Accurate drought forecasting, monitoring, and assessment rely on a sophisticated network of weather stations, stream gages, groundwater monitoring, and snow telemetry (SNOTEL) sites that measure streamflow, groundwater, snowpack, precipitation, temperature, soil moisture, and other essential indicators. This state and federal network is bedrock to Montana's ability to accurately monitor, respond, and adapt to drought and flooding in a changing climate. The ongoing investment in and maintenance of this network is critical for accurate weather forecasts, flood prediction, and drought assessment in support of the state's agriculture and tourism economies and to protect lives and property. Also, accurate monitoring helps secure millions of dollars in federal disaster relief for Montanans during severe drought years.

The data from Montana's monitoring networks is valuable for understanding drought conditions and making assessments, but it is also essential to the development of predictive models for future droughts. Therefore, a comprehensive evaluation of the existing gaps in these networks is an essential first step in guiding future network investments and ensuring the data collected is as useful as possible over the coming years.

The ability to effectively monitor, prepare for, and respond to future drought requires a more complete picture of the overall water balance within specific geographies. In addition to advancing drought monitoring and assessment, DNRC is also exploring water-use measurement and hydrologic modeling to further understand how drought influences various water supply inputs (i.e., groundwater and precipitation) and outputs (i.e., all types of water use) across a watershed or river basin.

Fund the long-term operation and maintenance of Montana's weather and soil moisture monitoring network (Mesonet)

Between 2023 and 2028, the U.S. Army Corps of Engineers (USACE) is funding the installation of more than 200 new weather stations (one station every 25 miles) across central and eastern Montana at a cost of more than $21 million. This network will provide important and accurate weather, soil moisture, and climate information in an area that has long been underserved. This network will greatly enhance monitoring efforts for drought and flood forecasting, prediction, and early warning. Although the initial federal appropriation includes funding for near-term operation and maintenance, an eventual shortfall between federal funding and actual costs is anticipated. One Mesonet station requires approximately $13,000 annually in operation and maintenance costs, including staff time, travel, and equipment. **Montana should assess funding the eventual gap in operation and maintenance costs and participating in the long-term governance of the multi-state Mesonet network.**

Increase funding in support of the state's U.S. Geological Survey (USGS) real-time stream gage network

The USGS stream gage network in Montana currently comprises 218 real-time stream gages on Montana's mainstem rivers and their large tributaries. The annual operation and maintenance costs are shared among USGS and a variety of federal, state, tribal, local, and private sources. A combination of increasing costs and flat federal funding over the last 10 years has resulted in USGS congressional appropriations covering only about 39% of gage network costs in Montana, meaning that a growing financial burden is being passed on to funding partners. DNRC and FWP are the primary cost-share partners for the state of Montana. In 2022, DNRC and FWP collectively provided a cost share of $598,985 to support streamflow and/or water temperature monitoring, and Montana's contributions increased by another 15% over the following two fiscal years. The Legislature created the Stream Gage Oversight Work Group, a temporary subcommittee of the Drought Committee, to conduct a review of the USGS gage network and funding challenges. The group provided specific recommendations for federal and state investment in gage network infrastructure in its summary report to the Water Policy Interim Committee in 2022. **In accordance with the report's findings, the state should consider providing a minimum of $700,000 baseline funding, plus an annual increase for inflation, to DNRC and FWP to maintain the USGS stream gage network in Montana.**

Complete the build-out of the DNRC real-time stream gage network

The DNRC real-time stream gage program measures flows on smaller streams and tributaries that complement the larger rivers and tributaries monitored by the USGS. Streamflow information collected by DNRC serves state-specific water administration, distribution, and management objectives and supports local water planning and management. The 2015 State Water Plan recommended that a network of 100 state-operated, permanent, year-round stream gages be installed. To date, existing resources have allowed the DNRC program to install, operate, and maintain 36 real-time gages. All streamflow information collected through the network is available to the public on DNRC's web-based Stream and Gage Explorer (StAGE). DNRC received one-time only funding of $1.461 million from the Montana Legislature for the 2024–2025 biennium, which will fund personnel, equipment, and operations for 30 additional gages in an effort to continue expanding the network to the recommended 100 gages. **The state should consider permanent funding for the ongoing operations and maintenance of the state gage network**.

Increase groundwater monitoring through real-time measurement

Drought tends to have near-immediate impacts on surface water, but its effects on groundwater can be more difficult to evaluate because responses often appear weeks or months after the events that caused them, like recharge from canal seepage or depletion from a shortfall in precipitation. However, persistent drought can reduce aquifer storage due to less recharge and more water use. Accordingly, monitoring groundwater response to drought can inform proactive water supply management. Monitoring can be used to assess the efficacy of managed aquifer recharge projects and evaluate the sustainable yield of aquifers. In addition, it can help predict groundwater discharge to spring-fed streams, as well as potential flood events, because rising water tables can signal imminent inundation above ground.

In Montana, the USGS operates a network of six real-time monitoring wells to assess the effects of climate variability on groundwater, while the Montana Bureau of Mines and Geology (MBMG) uses a network of about 900 wells located in principal aquifers across the state to monitor groundwater. Long-term hydrographs from these wells document groundwater responses to wet and dry periods over annual and decadal scales. Water-level data is measured about four times per year (minimum; some wells are equipped to provide continuous measurements that are downloaded later). The quarterly schedule means that data can be out of date by a few months when they are posted to MBMG's website. This delay can be inconsequential when groundwater levels are relatively static and predictable, but for aquifers that are more dynamic, the delay precludes planning and preparing for changes in groundwater supply. However, recent advances in sensor and telemetry technologies allow real-time groundwater data acquisition, which eliminates the delay.

To assess the feasibility, benefits, and costs of real-time groundwater monitoring, DNRC is collaborating with MBMG to install real-time equipment on a subset of the well network (10 to 15 wells) over the next few years. Candidate wells are being selected based on existing knowledge of groundwater response. The highest priority wells are those that have an established long-term record (>20 years) and that exhibit sensitivity to a variety of signals (e.g., withdrawals from pumping or recharge from inputs like irrigation, precipitation, and surface water). This pilot project will inform future efforts to expand real-time groundwater monitoring across the state. It will also evaluate how stakeholders use near real-time groundwater data accessible through StAGE and the MBMG Ground Water Information Center (GWIC) database to enhance community-based watershed planning. **DNRC and MBMG should use the information gained from this pilot study to guide the expansion of real-time groundwater monitoring throughout the state**.

Support the Montana Climate Office and the Upper Missouri River Basin Drought Dashboard

The State Climatologist position has been in place since the 1990s, and the Montana Climate Office (MCO) has been recognized by the Governor's Office as an independent body that provides Montanans and partners nationwide with critical scientific information on climate and drought. MCO, under the leadership of the State Climatologist, delivers targeted water, weather, and climate information to Montanans for specific sectors of interest across Montana's distinct geographical, resource, and water-use sectors. Importantly, MCO also develops new drought monitoring products and tools designed specifically to meet the monitoring challenges posed by Montana's diverse climate and landscape.

MCO serves a critical role in providing valuable technical support and expertise to the state's Drought Monitoring Subcommittee and Drought Committee. It developed and maintains the Upper Missouri Drought Dashboard (Drought Dashboard), which provides essential weather and drought information to resource managers, producers, and the public across a seven-state region of the Northern Great Plains, Northern Rocky Mountains, and North Cascades. It also manages the state Mesonet database, including station cellular data subscriptions and technical assistance, station data feeds to National Oceanic and Atmospheric Administration (NOAA) and other federal databases, and coordination among multi-partner station maintenance and land access. This real-time Mesonet data is an essential tool within the Drought Dashboard. **The state could consider investing in the work of MCO by funding a position to maintain and further develop the Drought Dashboard – a critical resource that facilitates the state drought monitoring and assessment process, which underpins millions of dollars of federal drought relief for Montanans annually.**

Assess mechanisms to expand statewide measurement of water use

Water-use measurement is the foundation of enforceable water administration. A lack of consistent, accurate measurement is a current barrier to management strategies like mitigation for junior depletions and guarding against unauthorized expansion of use. Improving water measurement will unlock greater flexibility and certainty in adequately meeting current and future water demand. In 2021, DNRC identified water-use measurement as a key challenge during its Comprehensive Water Review process. Approaches such as direct incentives, cost shares, and establishing tie-ins to infrastructure funding could help encourage water-use measurement alongside strengthened regulatory and statutory requirements. **DNRC should continue to prioritize water-use measurement as an area for intensive stakeholder engagement and development of policy recommendations.**

Invest in statewide hydrologic modeling

Hydrologic models are frequently used to study and quantify water supply and use but are rarely used operationally (i.e., in real time) to inform management decisions. **DNRC should develop a framework to incorporate operational hydrologic models into regional and statewide water management.** After this developmental phase, the state should continue to invest in this modeling framework through hiring additional technical staff and improving, maintaining, and expanding the model as a statewide resource. Significant planning, outreach, and collaboration with stakeholders and partners will also be necessary to ensure that modeling products are tailored to specific watershed needs.

5 HUMAN HEALTH
Address human health impacts from drought

The 2021 Climate Change and Human Health in Montana report, a follow-up to the 2017 Montana Climate Assessment, details the myriad impacts of drought on human health. While extreme heat can directly impact human physiology, drought is associated with many other indirect health impacts, such as inhalation of wildfire smoke or dust particles, exposure to diseases transmitted by ticks and mosquitoes, and impairment of water quality from harmful algal blooms. Given its relation to physical health, community livability, and individual livelihoods, drought is a known driver of increased rates of stress, anxiety, depression, substance abuse, and other conditions. Both short- and long-term drought can have cumulative negative impacts on mental health across Montana, and especially among rural Montanans whose livelihoods depend on natural resources (e.g., agriculture, forestry, and fishing sectors) and those who rely on hunting, fishing, and wild plants to meet nutritional and cultural needs.[14]

The Montana Department of Public Health and Human Services (DPHHS) currently maintains a statewide network of local and tribal public health officials who monitor public health impacts, including those related to drought. **In the event of widespread or newly emerging drought-related public health issues, DPHHS will enhance its surveillance of impacts and communicate the best evidence-based strategies to clinicians and communities via the existing network.**

Support communities in implementing recommendations identified in the Climate Change and Human Health in Montana report

The report provides accessible recommendations for communities to address impacts from heat, poor air quality, water-related illness, food insecurity, vector-borne and zoonotic diseases, and declining mental health. For example, communities can establish cooling centers, plant shade trees to reduce urban heat, update codes to incentivize sustainable building practices, and fund air filtration systems. **Communities should look to this report as a key, actionable resource for addressing community-level drought impacts, while agencies and other organizations should review and enhance their support for community actions addressing drought and human health.**

Increase public awareness of, and funding for, resources related to suicide, substance abuse, and mental health, especially among rural populations

While some mental health resources exist for drought-impacted communities, **increasing public awareness of — and expanding funding for — new and existing mental health programs is critical to ensuring their efficacy.**

Photo by Michael Downey

6 COMMUNITY GOVERNANCE
Help communities build drought resilience

State and federal policies and rules related to water quantity, water quality, land use, and infrastructure create an overarching regulatory framework within which counties and municipalities operate. The state currently supports community-level drought resilience through existing grant programs that fund water and wastewater infrastructure and planning, for instance. But given the challenges posed by multiple levels of governance — and the fact that each community retains unique resources with which to address its natural resource issues – it is difficult to direct state support in an overarching way.

Several recommendations provide pathways for the state to offer greater support, including those that facilitate short-term water leasing (see the Water Policy category), support drought monitoring networks (see the Drought and Water Supply Monitoring category), and promote the integration of drought resilience into existing state programs (e.g., programs that fund water and wastewater infrastructure; see Agency Coordination and Partnerships category). Other measures to build drought resilience at the local level will rely on individual governments defining community priorities, generating political will, securing funding and capacity, and addressing other factors that vary widely across Montana's diverse communities.

Modify state policy to promote drought-resilient building

The state building code must balance several competing interests. It establishes reasonably uniform baseline standards that achieve a variety of goals, including modernization, energy efficiencies, and reduced building costs. (§ 50-60-201, MCA). The Montana Department of Labor and Industry (DLI) has adopted numerous building codes, including plumbing and Wildland Urban Interface (WUI) codes – both of which have implications for local drought resilience.

Local governments, such as counties, incorporated cities, and towns, may only adopt building codes that have been adopted by DLI and may not adopt more stringent codes. (§ 50-60-301, MCA). However, local governments may adopt voluntary energy conservation standards for new construction and provide incentives to encourage voluntary energy conservation (§ 50-60-301(2)(b), MCA). **State and local governments should continue to explore opportunities to promote voluntary water efficiency standards.**

The review and adoption of building codes by DLI is an ongoing process. DLI often incorporates national and international building code provisions into the state building code. DLI engages in stakeholder outreach and input when revising building codes. **Local governments should actively engage in the rulemaking process to encourage adoption by DLI of building code provisions that facilitate greater water efficiency at the local level and encourage owners, design professionals, and builders to voluntarily implement greater levels of energy efficiency in building design and construction than those required by law.** See, for example, ARM 24.301.161 which incorporates portions of the International Energy Conservation Code and expressly encourages voluntary incorporation of energy efficiencies in design and construction that exceed minimum requirements.

Similarly, **DLI could amend Montana's version of the International Wildland-Urban Interface code** (ARM 24.301.181) **to encourage voluntary implementation of greater levels of fire protection in building design and construction.** A recent Headwaters Economics report notes that hundreds of thousands of Montanans currently live in areas with moderate to high wildfire risk, with more high-risk homes being added every year.

Although DLI has authority to adopt rules regulating new construction, repairs, and remodels, it is the responsibility of local governments to enforce post-construction compliance for residences. Local governments also have authority to regulate in areas outside of new construction, repairs, and remodels, such as adopting ordinances governing location of plants near structures and how firewood can be stored. **Local governments should ensure that they are adequately enforcing building codes after completion of residential construction projects and adopting fire-wise regulations for plantings, wood storage, and other post-construction matters over which they exercise jurisdiction.**

Increase state assistance for municipal water and land-use planning and management

Montana currently supports local government drought resilience efforts through broadly applicable grant and loan programs, but technical and planning assistance at the municipal level is highly specialized and is largely the purview of independent consultants and engineers, non-governmental organizations like Montana Rural Water Systems, and even – in some cases – federal entities like the Environmental Protection Agency. Many of Montana's smaller communities lack resources and capacity to effectively monitor and assess drought, plan for growth, or implement water conservation and efficiency strategies. These under-resourced communities would benefit from increased public-sector support.

DNRC should explore ways to help local governments through better coordination of planning resources, technical assistance, and funding opportunities. For instance, planning staff could lead the coordination and submission of multi-jurisdictional grant applications to fund infrastructure upgrades or to establish local water conservation incentive programs. In addition, state agencies who retain experts in hydrology and engineering should consider offering more programmatic support – through direct staff time – to assist municipal and county governments with key components of integrated water and land-use planning. Primary planning steps include assessing current and projected water supply, characterizing and projecting water demand, addressing aging infrastructure, conducting water loss studies, examining water rate structures, developing water master plans, and planning for drought. DNRC developed an introductory guide to municipal integrated water and land-use planning that can help communities outline the planning process and get started.

Convene and support an interdisciplinary community water task force to develop drought resilience resources for Montana communities

Local governments can pursue many actions to build drought resilience. Examples include investing in planning, establishing or updating ordinances, developing incentive programs, enhancing community outreach, and more. Yet communities often identify a lack of guidance and model resources as an obstacle in building drought resilience. For instance: what are best practices for establishing a rebate program for water-efficient plumbing fixtures? How should a city swap out non-functional turfgrass in boulevards? What water rate structure best incentivizes water conservation? What is in a municipal drought plan?

Developing model resources for different-sized communities that address the above questions will require significant research, expertise, and capacity that exceeds state agencies' current purview. A potential way to develop Montana-specific guidance and model resources is for the state to invest in a community water task force. **The state could consider convening and supporting a community water task force consisting of local water providers, public works directors, engineers, and other experts to identify and develop model resources local communities can use to build drought resilience.**

Key model resources a municipal water task force might develop include:

- Growth policy guidance
- Water supply
- Homeowners' association (HOA) covenants
- Zoning regulations
- Irrigation and landscaping ordinances
- Public outreach and education
- Building codes
- Rebate and other incentive programs
- Water rate structures
- Drought and water conservation planning guidance
- Leak repair and infrastructure upgrades
- Stormwater capture and storage
- Water metering
- Wastewater management

7 AGENCY COORDINATION AND PARTNERSHIPS Better coordinate drought management across state and federal agencies; build diverse partnerships

Drought is complex to assess, monitor, and manage and, thus, it requires a multi-agency approach. Multiple state agencies currently address drought in their plans, policies, programs, communications, and stakeholder engagement efforts. But better coordination and integration of efforts would improve drought management. Montana should communicate with federal agencies about incorporating drought resilience into federal programs, and it should periodically assess whether existing federal funding and technical assistance programs adequately address diverse state needs.

Expand Montana's Drought and Water Supply Advisory Committee

In view of potential health impacts of drought, **Montana's Drought Committee should include a representative from DPHHS.** This would improve interagency coordination and better integrate existing and new drought and human health programs at the state level.

DNRC should additionally explore the potential for appointing further Drought Committee members representing a wider variety of interests, including, for example, tribal nations, the MCO, and other state and federal partners.

Better align state and federal funding opportunities

State grant timelines, limitations, and even objectives are sometimes misaligned with related federal funding opportunities. For instance, if federal and state agency programs have disparate funding timeframes, applicants may not be able to secure adequate local match or services. Agricultural producers have noted the difficulty of trying to access federal drought relief funds when process or timeline bottlenecks arise. If a federal grant program maintains that only a federal agency can conduct planning, engineering, and design for local drought relief projects (e.g., pipeline or well installation), the project may not be completed within required time constraints due to agency staff capacity limitations. A conservation district in north-central Montana recently missed out on the FSA's Emergency Conservation Program funding for drought relief because of a local shortage of qualified well drillers and contractors. Similarly, some federal grant programs may be so broad that they miss local nuances (e.g., eastern Montana soil that is naturally high in salinity) that render the programs ineffective. These disparities can lead to frustration and missed opportunities for applicants.

The Natural Resource Grants Working Group (Working Group) convened by the Montana Watershed Coordination Council (MWCC) and made up of state, federal, NGO, and private funders, is working to provide more coordination and continuity among conservation funders in Montana. MWCC was created in 1992 by an interagency memorandum of understanding, "to create a more efficient system of cooperation and coordination among natural resource governmental agencies and organizations in Montana." In 2013, it organized as a 501(c)(3) non-profit corporation.

The Working Group meets quarterly. Among its priorities are: 1) improving coordination among conservation funders in Montana; 2) reducing barriers to applying for and managing federal conservation funding, including match funding; and 3) providing better access to conservation grants, including updating the Montana Conservation Menu, which lists natural resource funding opportunities by category, eligibility, funder, and other criteria. **State and federal funding agencies should continue to support the Working Group by participating in meetings and on subcommittees, funding the group's priority activities, and modifying existing (or new) grant programs and offerings to be more responsive to the needs of Montanans – especially in building drought resilience.**

Continue emphasizing cross-boundary forest management and promoting drought-resilient forests through the Montana Forest Action Plan and its associated programs

Drought and forest health are intricately linked in Montana, with nearly one-quarter of the state covered by forested lands. Overstocked forests, characterized by a higher tree density than natural conditions can support, are particularly susceptible to drought.

The implementation of active forest management and restoration has proven effective at addressing this issue. These practices include commercial harvest, thinning, hazardous fuels reduction, prescribed fire, and controlled wildfire managed for resource benefit

BOX 4. *INCORPORATING DROUGHT RESILIENCE INTO EXISTING STATE PROGRAMS*

There are numerous ways that drought resilience measures can be incorporated into existing state programs. The following list, while not exhaustive, includes specific strategies that were identified during the planning process.

Department of Environmental Quality

- Identify drought-related impacts to water quality into Total Maximum Daily Load (TMDL) documents.
- Incorporate projects and activities that build drought resilience into watershed restoration plans.
- Consider requiring certain regulations be adopted, or practices be implemented (e.g., drought contingency plan, water metering), to qualify for water-infrastructure grants and loans through the State Revolving Fund (SRF).

Department of Fish, Wildlife and Parks

- FWP stewards aquatic resources and wildlife habitat in fulfillment of its mission, so integrating drought resilience is already an implicit part of its programs and management activities. FWP should continue managing Montana's fisheries and wildlife resources for present and future benefits, and management should incorporate drought adaptation strategies when possible. Grant programs (Future Fisheries Improvement and Wildlife Habitat Improvement) should continue to encourage projects that promote drought resilience.
- Public education programs should include information about drought impacts to fish and wildlife and promote best practices when fishing, hunting, and recreating during times of drought.

Department of Natural Resources and Conservation

- Continue including drought mitigation (projects and planning) as a crucial state need within the Reclamation and Development Grants program.
- Continue emphasizing cross-boundary forest management and promoting drought resilient forests through the Montana Forest Action Plan and its associated programs.
- Continue using the chronically dewatered streams list in decision making and planning, including reviews of water right changes and beneficial use permit applications. Work with FWP to keep the list updated and current.
- Expand and support the purview of the Montana Stream Restoration Committee (a group led by DNRC and the Lewis and Clark Conservation District with various agency partners) to focus on projects that preserve and/or restore the functioning of natural ecosystems.
- Support the expansion of interagency, collaborative programs, such as Silver Jackets, to encourage nonstructural floodplain projects that can reduce flood risk and enhance natural water storage.

Department of Military Affairs – Disaster and Emergency Services

- Encourage inclusion of projects that build drought resilience in county-level pre-disaster mitigation plans.
- Continue to support acquisition projects that remove pre-existing structures from areas vulnerable to flooding and create open space areas in critical floodplains, which allow additional water storge while reducing future flood risks.
- Continue developing public-private partnerships to expand breadth of projects. For example, government collaboration with non-profit organizations can facilitate the implementation of larger projects than could otherwise be achieved by one entity working alone.

Department of Commerce

- Condition grant criteria to favor drought resilience-building activities, such as planning or economic diversification projects, and promote drought resilience projects through community technical assistance programs.
- Consider requiring certain regulations be adopted, or practices be implemented (e.g., drought contingency plan, water metering), to qualify for water-infrastructure grants and loans, including the MT Coal Endowment Program (MCEP, formerly TSEP) and Community Development Block Grants.
- Assist Montana communities in the integration of water and land use planning by incorporating water supply and drought resilience planning into existing programs, such as the Community Technical Assistance Program.

particularly in overstocked stands and places where conifers have encroached on historically unforested areas. These actions offer dual benefits by improving forest health and benefiting drought management efforts.

State and federal land managers should continue to collaborate with each other, as well as private landowners, to promote drought resilient forests through implementation of these and other strategies set forth in the Montana Forest Action Plan.

Incorporate drought resilience measures into existing state programs

To better integrate drought management at the state level, agencies should examine overlap among their drought-related efforts and seek opportunities for partnership. Agencies should also incorporate new drought resilience measures, or expand existing drought resilience measures, in their programs and activities (Box 4). Finally, all state agencies should strive to integrate water management and drought information into existing education and outreach programs, where applicable.

Develop a state drought communications strategy to improve information exchange at state and local levels

Official drought assessment and monitoring at the state level is systematic and well-structured, but there is not an associated, systematic process for delivering this timely information to communities. Currently the Drought Committee uses public meetings during the spring and summer and occasional earned media coverage as its main avenue for information exchange. **The Drought Committee should define a deliberate process for better communicating drought information with interested local communities.**

Improve drought coordination and communication across Montana

Building a drought-resilient Montana requires a strong and active network of stakeholders, government agencies, tribal nations, and many other partners to ensure effective communication and collaboration. At the local level, communities can be empowered to take an active role in drought management through programs that facilitate workshops, training, and/or meetings. For example, the Confederated Salish & Kootenai Tribes, in collaboration with the Montana Climate Office and The Wilderness Society, is currently leading a pilot project, the Native Drought Resilience Project, that can provide a model for other communities to train local climate leaders and develop drought-ready communities. Similarly, the Montana State University Extension's Wildfire and Drought Task Force provides a wide range of research-based educational programs and resources about drought adaptation throughout the state. Ensuring that outreach and communication efforts are both coordinated and collaborative will help empower local communities to plan and prepare for droughts.

DNRC and the Drought Committee should bolster statewide drought coordination by exploring the formation of new regional coordinating entities; compiling multi-entity drought management resources on a single web platform; and providing dedicated state support for existing statewide coordinating entities, such as the Montana Association of Conservation Districts and MWCC, that offer training, resources, support, and coordination for Montana's watershed communities.

SIMPLE STRUCTURES LEAD TO HEALTHIER STREAMS

Low-tech methods of stream restoration provide an effective and efficient way to improve habitat and increase drought resilience.

Writing and photography by David Hanson

In a dry prairie stream bed, halfway between Winnett and Grass Range and 55 miles due east of the nearest stoplight in Lewistown, Joshua Powell lies on his stomach to patch sod into a gap of an imitation beaver dam also known as a beaver dam analog (BDA). This BDA is only 20 feet across, made of willow and conifer boughs woven between vertical wooden posts pounded into the dry, ephemeral stream bed. Chunks of dirt and sod are added to seal the base, a simple but crucial step to ensure that when water does flow in the channel it doesn't scour underneath the dam. Beaver dam analogs don't impound water like typical dams, but instead slow water just long enough to spread it out, allowing it to soak into the surrounding meadows, creating habitat and supporting plant growth.

Powell, a 25-year-old from Memphis, TN, is the leader of the Montana Conservation Corps' Mesic Strike Team, a crew of four summer employees tasked with building low-tech stream restoration structures on the north-central Montana prairie. Based out of a camp in Winnett, the team will build 20-30 low-tech structures in two stream channels as part of a public-private partnership between the Bureau of Land Management (BLM) and the King Ranch. Then they'll move to another site on the prairie for more of what is called low-tech restoration: practical, affordable, easily built structures that can help waterways and riparian zones regain natural form and function after years, decades, or centuries of disruption.

Ecologists and hydrologists have recently learned a lot from beavers. Before their populations were decimated in the early 19th Century, the ubiquitous beaver and their dams created a massive water retention system, slowing stream flows and forcing water to spread into braided channels and shallow floodplains that cultivated habitat for animals and fostered diverse plant growth. Beaver dams and woody vegetation increase the connectivity between the stream, the floodplain, and shallow aquifers to create more diverse physical characteristics like pools, riffles, bars, etc. All of this structure leads to more diverse plant communities and animal habitat in the riverscape.

According to Alden Shallcross, a hydrologist with the Bureau of Reclamation, incompatible land use and other development have reduced natural wood accumulation and impacted beaver populations, thereby rendering streams and riverscapes more channelized and with less of the sponge-like capacity to hold the water in the landscape. Prolonged drought and increased temperatures have interrupted streams that once flowed perennially, and streams that were intermittent are now more ephemeral. Combine all these impacts with more intense flooding events and the riverscapes' ability to maintain healthy, complex variables are starting to unravel.

Beaver dam analogs slow water just long enough to spread it out, allowing it to soak into the surrounding meadows, creating habitat and supporting plant growth.

Stream and wetland restoration efforts have historically required expensive machinery and a long, costly permitting process. Traditional restoration efforts such as the Natural Channel Design method can cost $165,000/km, while low-tech approaches like BDAs cost around $11,000/km.[1] State and federal agencies are trying to minimize the costs and permitting hurdles, and BDAs are an attractive tool because of their relative simplicity. Plus, they are ideal for the kinds of public-private partnerships that support local interests and offer buy-in with state or federal resources.

State and federal agencies and their partners recognize the need to scale-up their restoration efforts. Isolated attempts to restore these natural processes will never have the watershed scale impacts necessary to increase long-term resilience across a landscape as large and diverse as Montana. But Shallcross and others believe in the benefits of low-tech solutions designed and planned by experts and implemented by small, trained crews that roam under the Big Sky. A BDA project is meant to kickstart the restoration process and is not a panacea for watershed scale restoration. Long-term solutions that build resilience and keep more water on the landscape will take time and a commitment to land management strategies that prioritize watershed health.

As another long, hot day on the prairie winds to a close, Joshua Powell and the Mesic Strike Team complete their final patches on the dam. Then they head up the stream channel about 100 yards to pound in poles and begin on another dam, busy as beavers. ■

[1] Silverman, N., Allred, B., Donelly, J., Chapman, T., Meastas, J., Wheaton, J., White, J., Naugle, D., Low-tech riparian and wet meadow restoration increases vegetation productivity and resilience across semiarid rangelands, March 2019, *Restoration Ecology Vol. 27*, No. 2, pp. 269–278. https://doi.org/10.1111/rec.12869

COORDINATING ADAPTATION STRATEGIES ACROSS STATE PLANNING RESOURCES

State agencies and other entities develop planning documents to guide their programs, and many of these include drought adaptation strategies, although they are not always specified as such. Aligning the recommendations from the Montana Drought Management Plan with other state plans offers further justification for them and bolsters support for organizations seeking to implement drought resilience projects. We identified common concepts, strategies, and other tools for building drought resilience from recent planning documents (Table 4), and we hope practitioners, decision-makers, and stakeholders will use this information to support ongoing efforts towards *building drought resilience*.

TABLE 4. Common concepts and strategies for building drought resilience in Montana, as documented in related planning and assessment documents. Each topic includes specific subtopics as follows:

- **Agriculture** Irrigation; water withdrawal; ditches and canals; soil health
- **Forest management** Forest landscapes; forest health; wildfire; prescribed fire
- **Funding** Funding ideas and/or agency information on funding
- **Human health** Drought and/or water quality impacts on physical and/or mental health
- **Monitoring and data** Water, snow, and soil monitoring; data management; data availability
- **Policy** Suggestions for policy
- **Storage, floodplains, and riparian health** Natural and developed water storage; side channels; bank stabilization; weed management
- **Water management and drought planning** Planning and management of water quantity, water quality, groundwater, and/or drought.

Plan or report	Sponsor	Agriculture	Community planning	Fisheries and instream flow	Forest management
Montana Drought Management Plan (2023)	DNRC	✔	✔	✔	
Montana Forest Action Plan (2020)	DNRC				✔
Montana State Water Plan (2015)	DNRC	✔	✔	✔	
Multi-Hazard Mitigation Plan & Statewide Hazard Assessment (2023)	MA -DES			✔	✔
State Wildlife Action Plan (2015)	FWP			✔	
Statewide Fisheries Management Program and Guide (2019-2027)	FWP			✔	
Nonpoint Source Management Plan (2017)	DEQ	✔		✔	✔
Priceless Resources - A Strategic Framework For Wetland And Riparian Area Conservation And Restoration In Montana 2013-2017	DEQ				
Montana Climate Assessment (2017)	IoE*	✔		✔	✔
Climate Change And Human Health (2021)	IoE*		✔		✔
Montana's Resilience Framework For Communities (2019)	Commerce		✔		
Montana Climate Solutions Plan (2020)	Montana Climate Solutions Council	✔	✔	✔	✔

**Montana Institute on Ecosystems*

Photo by Sean R. Heavey

Funding	Human health	Monitoring and data	Policy	Recreation and tourism	Storage, floodplains, and riparian health	Water management and drought planning
✔	✔	✔	✔	✔	✔	✔
✔		✔			✔	✔
✔		✔	✔	✔	✔	✔
✔			✔		✔	✔
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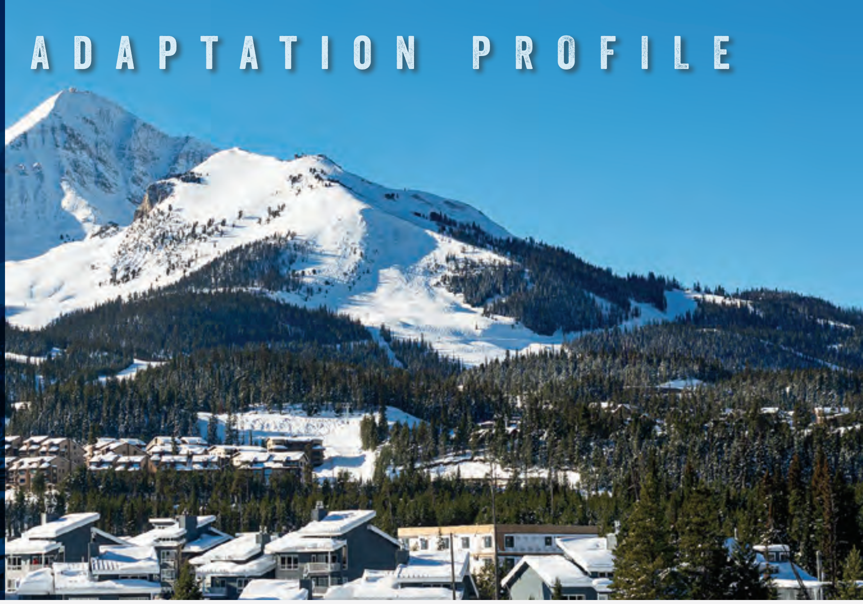

BIG SKY, BIG WATER

A growing resort community grapples with water efficiency adaptations

Writing by David Hanson and photography by Thomas Lee

Climate change and warmer, shorter winters pose an obvious threat to the ski industry of North America, and Montana is no different. While Big Sky Resort in the Gallatin River valley south of Bozeman has the advantage of being the highest elevation resort in Montana with consistent snowfall, there's no avoiding the shorter winters. Like other historically ski-oriented operations, Big Sky has been developing summer programs with mountain biking as the centerpiece to take advantage of longer summers and lift-access terrain.

But the pressures on Big Sky go beyond a diminished snowpack and fewer powder days. And the solutions to adapt a business and a community to the changing climate require more than a shift to summer sports. Big Sky, like many mountain towns in the west, has seen explosive growth since COVID and the ensuing Zoom economy sent urban professionals running to the hills. Increased water demands stemming from new development, a need for artificial snow making, and a growing population, also threaten the sustainability of the town. Steps being taken by Big Sky Resort and the surrounding community could offer insights into how ski towns can adapt to shorter winters and heightened pressure on water resources.

Reusing wastewater is a critical part of the water efficiency equation in Big Sky, both because of limited holding capacity for the cleaned wastewater, and as a way to minimize withdrawal demands on the aquifer. The current wastewater treatment facility was built in 2004, and town growth was outpacing the facility's capacity by the 2010s. A local non-profit, the Gallatin River Task Force, convened 35 stakeholders (state agencies, local developers, the water and sewer district, etc.) to collaborate on a planning document for community sustainability. One of the plan's core recommendations was to upgrade the wastewater treatment facility.

Big Sky is now in the process of a $48 million improvement project. The new plant would increase capacity and upgrade wastewater discharge from Class A to Class A-1 standards, meaning the reused water would be clean enough for snow making, industrial use, and aquifer recharge.

"At some point you could hit a crossroad where you can't provide more capacity for new development."

–Ron Edwards, Big Sky Water and Sewer District

Ron Edwards has been working with the Big Sky Water and Sewer District since 1995, back when there were no meters in the much quieter canyon community. Adapting to fast-paced growth and warmer, drier weather has been a multi-faceted effort.

“Even though our visitation numbers have gone up, we’ve seen our demand drop over the last five years in Mountain Village,” Edwards says. “I attribute that to a few things. We replaced old service lines and we improved our water metering, creating four tiers of rates – the more you use, the more you pay. There’s a correlation with rate setting and driving people to conserve water.”

The town’s economic engine and largest water user, Big Sky Resort, has been reusing its treated wastewater since the resort opened 45 years ago. All of its wastewater is reused for irrigation and golf course management, and the sludge produced from the wastewater treatment is mixed with sawdust and wood chips to create a compost that’s sold locally. Recently, the resort has implemented efficiency upgrades throughout its lodging and employee housing units. In their Golden Eagle employee housing unit water use declined 20% following the efficiency upgrades.

It’s tricky to find the balance between smart growth (more housing, more facilities, more revenue built to high-efficiency standards) and sustainable water use in a hydrologic setting dependent on groundwater supplied by snow. But drought conditions the last couple of years remind everyone of the realities facing a growing ski-mountain biking town.

“We’re not planners. We’re not zoners,” says Edwards. “At some point you could hit a crossroad where you can’t provide more capacity for new development.”

But for now, Edwards hopes to implement a rate program that increases water rates when the state agency declares drought, a practice that has seen success in California’s Cucamonga District.

Snow making is the next big hurdle for Big Sky Resort. Climate change means more snow making, and currently the resort taps into a surface water reservoir.

If the ski resort can eventually reuse the upgraded wastewater facility’s Class A-1 water it could pose an interesting scenario that might be a win-win.

“If we can reuse wastewater in the winter it would get us away from all this summer storage and open disposal options that run through winter months,” says Edwards. “That’s a game changer for my operation making it much easier to manage more water, and it creates a water recharge scenario— the snow making would essentially store water on the ski slopes as snow that would melt into recharge in the spring.” ■

POST-DROUGHT EVALUATION AND PLAN UPDATE PROCESS

The Montana Drought Management Plan (Plan) will be housed on the state's drought management website, which will provide an interagency, dynamic, and centralized platform to share planning resources and provide up-to-date drought information. The plan will be reviewed and updated on a regular schedule of annual, biennial, and ten-year intervals, and it will also be evaluated following major drought occurrences (Table 5). Staff from the Montana Department of Natural Resources and Conservation (DNRC) will work with the Montana Drought and Water Supply Advisory Committee (Drought Committee) to evaluate Plan effectiveness, track major accomplishments, and lead future updates.

TABLE 5. Overview of evaluation and update process for the Montana Drought Management Plan (Plan).

Review interval or trigger	Objectives
Annual review	Ensure that new response action and/or monitoring procedures are up to date. Address deficiencies and incorporate revisions and updates.
Biennial review – odd years	Track legislative changes ensure that new and revised drought-related policies are immediately integrated.
Ten-year review and update	In-depth review, evaluation, and update of the Plan, including stakeholder input. First update should occur in 2030 to ensure spacing with State Water Plan updates.
Post-drought evaluation	Review plan with a focus on successes and shortcomings. Identify and address deficiencies and incorporate updates.

RECOMMENDATIONS FOR FUTURE PLAN UPDATES

The Montana Drought Management Plan (Plan) contains all six elements of a modern drought plan, so future updates will have a solid foundation for expansion. Future Plan updates should strive to build on all the components; however, some specific ideas include:

Foster stronger, reciprocal collaborations with tribal nations. Several tribal nations in Montana have adopted climate adaptation plans and are actively implementing drought adaptation strategies; for example, members of the Blackfeet tribe are using strategically placed snow fences and beaver dam analogs to enhance water capture and storage as part of implementing the Blackfeet Climate Change Adaptation Plan (2018). On the Rocky Boy's Indian Reservation, members of the Chippewa Cree tribe are integrating traditional knowledge of culturally important plants, like sweetgrass, into wetland monitoring tools and developing an assisted migration program to provide longer-term protection for them. Information from these projects and others would be valuable for statewide planning and adaptation (see Appendix D). Planning staff should foster respectful, meaningful relationships with tribal partners that emphasize the mutual exchange of knowledge and resources.

Expand the vulnerability assessment by incorporating more data and adding water-use sectors. Additional qualitative (interviews and surveys) and quantitative (statewide indicators) data can be added to strengthen the existing work. Adding more water-use sectors (e.g., public health, wildlife, and wildfire) or dividing existing ones (e.g., separate Municipal Water Supply from Planning and Community Development) could also make the vulnerability assessment more comprehensive.

Develop an online application for assessing real-time drought vulnerability. The application could incorporate environmental, demographic, and water supply data to model real-time vulnerability for specific water-use sectors and locations. Additional functions, such as management or response actions, could be added to better inform adaptation. This would allow users to assess drought vulnerability over time, instead of relying on discrete data.

GLOSSARY

Acre-foot A unit of volume, mostly used in the United States, to describe large-scale water volumes. An acre-foot is the volume of one acre of surface area covered to the depth of one foot, which is equal to 43,560 cubic feet.

Adaptation The National Climate Assessment (2014) defines "adaptation" as an action to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities.

Adaptation Strategy A program, project, or approach that has been developed to respond to anticipated climate change impacts in a specific area of potential concern (as defined by the Environmental Resilience Institute at Indiana University).

Adaptive Capacity The U.S. Climate Resilience Toolkit defines adaptive capacity as the ability of a person, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change.

Administrative Rules of Montana (ARM) Agency regulations, standards, or statements of applicability that implement state law. An agency can adopt administrative rules that describe the organization, procedures, or practice requirements of the agency. Agencies are given rulemaking authority through the legislative process. Title 36, Chapter 12, ARM contains procedural rules pertinent to the DNRC's Water Rights Bureau.

Appropriate To divert, impound, or withdraw, including by stock for stock water, a quantity of water for a beneficial use.

Appropriation Right/Water Right The right to appropriate water pursuant to an existing water right, a permit, a certificate of water right, a state water reservation, or a compact (§ 85-2-102(2), MCA).

Aquatic Invasive Species Non-native plants, animals, or pathogens that cause environmental or economic harm.

Aquifer Recharge The United States Geological Survey defines aquifer recharge as water that moves from the land surface or unsaturated zone belowground to the saturated zone (aquifer). In § 85-2-102(3), MCA, aquifer recharge is defined as either the controlled subsurface addition of water directly to the aquifer or controlled application of water to the ground surface for the purpose of replenishing the aquifer to offset adverse effects resulting from net depletion of surface water.

Aquifer Storage and Recovery (ASR) A project involving the use of an aquifer to temporarily store water through various means, including but not limited to injection, surface spreading and infiltration, drain fields, or another department-approved method. The stored water may be either pumped from the injection well or other wells for beneficial use or allowed to naturally drain away for a beneficial use.

Artificial Channelization The process of straightening or redirecting natural streams into an artificially modified or constructed stream bed for reasons such as: flood control, development, or redirecting water flow.

Assessment (drought) An interpretation of drought metrics (data) to classify current drought intensity.

Beneficial Use Use of water for the benefit of the appropriator, other persons, or the public, including but not limited to agricultural (including stock water), domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, and recreational uses; use of water to maintain and enhance streamflow to benefit fisheries pursuant to conversion or lease of a consumptive use right (§ 85-2-102(5), MCA).

Beneficial Water Use Permit An authorization to use water, issued by DNRC, specifying conditions such as type, quantity, time, and location of use (§ 85-2-311, MCA, and ARM Title 36, Chapter 12, Subchapters 17 through 19).

Call The request by an appropriator for water which the person is entitled to under his/her water right; such a call will force those users with junior water rights to cease or diminish their diversions and pass the requested amount of water to the downstream senior water right holder making the call.

Classification (drought) A range of numbers preceded by the letter "D" for drought, used by the U.S. Drought Monitor and states to represent drought severity on a scale from D0 (abnormally dry) to D4 (exceptional drought). D0 is not an official drought category. It represents an area of drought concern.

Climate The average weather in a particular area over a period of time, typically taken as a 30-year period from a human perspective. Geologists and paleoclimatologists refer to the earth's climate over thousands to millions of years. The 2017 Montana Climate Assessment notes that the difference between weather and climate is a measure of time. Weather is the conditions of the atmosphere over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time (i.e., multiple decades).

Climate Change The 2017 Montana Climate Assessment defines climate change as changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changing risk of certain types of severe weather events, and changes to other features of the climate system.

Conservation District A unit of local government (closely aligned with county boundaries) that helps citizens conserve their soil, water, and other renewable natural resources. In Montana, conservation districts administer permits for activities that impact streambeds and banks under the Natural Streambed and Land Preservation Act ("310 law").

Consumptive Use Use of water that reduces supply, such as irrigation or household use (ARM 36.12.101(14)).

Cubic Feet Per Second A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge in a stream of a cross section one foot wide and one foot deep, flowing with an average velocity of one foot per second; equal to 448.8 gallons per minute.

Diversion/Means of Diversion Structures, facilities, or methods used to appropriate, impound, or collect water including but not limited to a dike, dam, ditch, headgate, infiltration gallery, pipeline, pump, pit, or well (ARM 36.12.101(35)); or, the transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.

Drought (1) Prolonged absence or marked deficiency of precipitation and/or high temperatures that reduce surface water groundwater or soil moisture availability. (2) Period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause adverse effects. Four types of drought, typically described by impacts, are described in Box 1.

Drought Monitoring Subcommittee (Monitoring Subcommittee) A five-person subcommittee consisting of representatives from DNRC, Montana State Library, Montana Climate Office, and the National Weather Service who assess drought conditions in Montana on a weekly, year-round basis.

Drought and Water Supply Advisory Committee (also Drought Committee) A multi-agency group coordinated by the DNRC. Its responsibilities include performing monthly water supply assessments, reporting on local impacts, identifying mitigation strategies, and directing financial, technical, and human resources to assist in regional and local drought management efforts (§ 2-15-3308, MCA).

Exposure The presence of people, livelihoods, ecosystems, infrastructure, or other assets in places that could be negatively affected by drought.

Flow Rate/Water Flow Rate A measurement of the rate at which water flows or is diverted, impounded, or withdrawn from the source of supply for beneficial use, and commonly measured in cubic feet per second (cfs) or gallons per minute (gpm) (ARM 36.12.101(27)).

Groundwater Any water beneath the land surface (§ 85-2-102(14), MCA).

Harmful Algal Blooms (HABs) An overgrowth of a type of algae, known as cyanobacteria, in water that can affect water quality and aquatic life. Some cyanobacteria can create toxins that may harm people and animals.

Indicators Variables or parameters used to describe drought conditions. Examples include measured precipitation, snowpack, temperature, soil moisture, groundwater, streamflow, and reservoir levels.

Indices Computed numerical representations of metrics used to evaluate drought conditions, assessed using climatic or hydrological inputs, including the indicators listed above. Examples of drought indices include the Standardized Precipitation Index (commonly referred to as the SPI) and the Evaporative Drought Demand Index (EDDI).

Instream Flow Water left in a stream for non-consumptive uses such as fishery resource maintenance or enhancement, recreation, navigation, or hydropower.

Irrigation Infrastructure Private and public physical structures needed for irrigation, including storage, conveyance such as ditches and canals, and on-farm irrigation systems.

Managed Aquifer Recharge (MAR) Commonly known as "water banking," MAR is defined by the American Geosciences Institute as water management methods that recharge an aquifer using either surface or underground recharge techniques. Common approaches are surface infiltration and deep injection methods.

Metric (drought) A variable (physical or computed) used to assess drought severity.

Mitigation (of drought impacts) The Integrated Drought Management Program defines "mitigation" as the lessening of potential adverse impacts of physical hazards through actions that reduce hazard, exposure, and vulnerability.

Mitigation (in water administration) The reallocation of surface water or ground water through a change in appropriation right or other means that does not result in surface water being introduced into an aquifer through aquifer recharge to offset adverse effects resulting from net depletion of surface water (§ 85-2-102(16), MCA).

Monitoring (drought) The process of documenting data and observations of drought conditions.

Montana Code Annotated (MCA) Laws of Montana classified by subject. Title 85, MCA, contains laws pertaining to water use.

Priority Date The clock time, day, month, and year assigned to a water right application or notice upon DNRC acceptance of the application or notice. The priority date determines the ranking among water rights (ARM 36.12.101(57)).

Response Actions that should be taken in response to emerging and ongoing drought.

Return Flow Part of a diverted flow that is applied to irrigated land use and is not consumed and returns underground to its original source or another source of water. Return flow results from use and not from water carried on the surface in ditches and returned to the stream. Other water users may be entitled to this water as part of their water right (ARM 36.12.101(62)).

Sensitivity The susceptibility of water users to drought.

Stream Gage A device that measures the flow of water at a specific point along a stream.

Total Maximum Daily Loads (TMDL) TMDL is defined by the EPA as the calculated maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant.

Vulnerability The degree to which a human or natural system is susceptible to, and unable to cope with adverse effects, such as drought. It is usually assessed as a function of exposure, sensitivity, and adaptive capacity. Vulnerability assessments are tools used to quantify and prioritize vulnerabilities and ensure appropriate adaptation strategies are employed.

Water Commissioner District court-appointed official who ensures that daily water allocations in the basin occur in accordance with the users' rights (Title 85 Chapter 5, MCA).

Water Lease An agreement with a water user to allow a person or organization, for a fee, to lease water from the user. Water leases are often used in Montana to maintain instream flow (§ 85-2-410 MCA).

Water Quality Chemical, physical, and biological characteristics of water that determine its suitability for a particular use.

Watershed The land area (or catchment) which captures precipitation and conveys it to a particular waterbody. It is bounded by ridges or divides. For example, a large watershed like that of the Bitterroot River is made up of the watersheds of all its tributaries, such as Mill, Blodgett, and Skalkaho Creeks.

Water Volume The amount of water in terms of gallons, acre-feet, or cubic feet.

Wildland-Urban Interface (WUI) The transition zone between human development and natural (undeveloped) landscapes and vegetation (fuels).

FIGURES & TABLES

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APPENDICES

Photo by David Hanson

ACKNOWLEDGMENTS

The development of the Montana Drought Management Plan was truly a collaborative, interdisciplinary, and statewide effort. The Plan integrates contributions and input from numerous state-level staff, contractors, technical experts, and representatives of local, state, tribal, and federal governments, universities, non-profits, and businesses. In addition, the Plan's broad depth and scope could not have been achieved without the support of stakeholder from across the state, who represented a wide range of water users and interests and who offered unique perspectives and information. Thank you to everyone who offered guidance, ideas, and support throughout the planning process.

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Stakeholders

Approximately 150 stakeholders from across Montana contributed on-the-ground knowledge and ideas about drought impacts and adaptation strategies through their participation in Regional Stakeholder Group meetings. In addition, several hundred others volunteered their time and energy to offer invaluable insights on their personal experiences with drought through one-on-one interviews and survey responses.

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Adaptation Profiles

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Rising Trout Help Raise Awareness
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Seeding the Future
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Simple Structures Lead to Healthier Streams
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The Benefits of Biochar
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Using Traditional Knowledge to Inform Climate Science and Adaptation
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DNRC staff

Countless DNRC staff from the Water Resources, Conservation and Resource Development, Trust Lands Management, and Forestry Divisions supported the development of this plan through meeting discussions, content review, website support, grant and budget management, and effective leadership.

Funding

Plan development was supported by funds appropriated by the 2019 State of Montana Legislature and a Drought Contingency Planning Grant from the Bureau of Reclamation (Agreement No. R21AC10071, 2020).

State and DNRC Leadership

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Photo by Sean R. Heavey

ENDNOTES

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Suggested Citation

Montana Department of Natural Resources and Conservation. (2023). *Montana Drought Management Plan*. Helena, MT: Montana State Print & Mail.

Photo by Sean R. Heavey

2500 copies of this document were published at an estimated cost of $3.90 per copy, for a total cost of $9,741.95, which includes $9,741.95 for printing and $0.00 for distribution.

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