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Centennial Valley Association

Drought Outreach Plan

View of Red Rock River from Stibal Lane – Centennial Valley, Montana.

2019

Prepared by the Centennial Valley Association

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A. What is Drought?

Community Drought Definition

Drought is a natural part of Montana's climate and is predicted to be exacerbated with rising temperatures[1]. Drought periods are predicted to increase globally both in frequency and intensity in the future. However, defining drought is not always an upfront and straightforward process. There are many different parameters that ecologists look at when defining drought, such as reduced precipitation, low soil moisture, or reduced streamflow. There are also a variety of different 'droughts' that have been identified, such as meteorological, agricultural, hydrological, and socioeconomical.

As defined by the United States Geological Survey (USGS), "A drought is a period of drier-than-normal conditions that results in water-related problems"[2]. These problems can range from in the parameters listed above, such as decreased precipitation and declined flows in rivers and streams to water level drop in reservoirs and lakes. Depending on a person's relationship with water, and particularly water deficiency, a drought can affect everyone differently.

Figure 1. The above word cloud depicts the common words repeated in answers from CVA community members from an anonymous drought information survey given by the CVA.

The Centennial Valley Association (CVA) sent out a short, four question survey to various community members to understand how they define drought, how it may affect them, and what resources would be most helpful to them. A common theme was found throughout all the answers – drought being related to a shortage or lack of precipitation. Some of the community members stated a lack of irrigating water, some stated a reduced streamflow affecting fisheries, and others talked about a lack of vegetation. This demonstrated to CVA how drought can affect and impact the various community members of the valley differently.

Purpose of Plan

The topic of drought is an increasingly important topic to the landowners and stakeholders in the Centennial Valley. Due to the valley being primarily an agricultural community, water is an important resource and topic of discussion among landowners. Many landowners have pointed out the lack of resources available in the Centennial landscape that would allow for landowners and other resource managers to make appropriate, effective decisions about water and grazing practices. This is one of the main reasons for constructing this outreach plan.

The purpose of developing this plan is to aid the community and implement a forum on drought awareness, education, and information dissemination, install needed hydrological infrastructure, and improve management decisions in the future. This plan will serve as a starting point for drought resources in the Centennial Valley. It will provide background information on the Centennial Valley's geography, land use history, and climate patterns, the various stakeholders, current and needed monitoring infrastructure, mitigation and response actions, and the plan update process.

B. Centennial Valley Watershed Background

Geography

History of the Evolution of the Centennial Valley

The Centennial Valley, a 385,000-acre high-altitude valley, runs east to west and is defined by the Gravelly, Snowcrest, and Madison Mountain Ranges to the north and the Centennial Mountain Range to the south. The east-west orientation of the Centennial Valley, a rarity in the predominantly north-south oriented Rocky Mountains, is responsible for many of the characteristics that define the valley today.

As the Earth's crust moved two million years ago, it passed over the Yellowstone hotspot, which heated and uplifted the crust, forming a minor fault line that now lies on the north side of the Centennial Mountains, within the Centennial Valley. As the millennia passed, the Centennials continued to rise, and the bedrock dropped several thousand feet, leaving an incredibly deep valley. The mountains surrounding the Centennial Valley were shaped by glacial erosion, with ten glaciations since the Centennials formed.

Figure 2. The above map shows the Centennial Valley in relation to the Snowcrest, Gravelly, Madison, and Centennial Mountain Ranges. Photo credit: ArcGIS Online.

When the last glaciers receded, the slope of the Centennial Valley caused water to drain to the northeast through a river, the remnants of which can be seen by a string of lakes beginning with Elk Lake and extending to the Madison River Valley.

The draining of the valley ended abruptly between 20,000 and 30,000 years ago when a massive landslide northeast of Elk Lake dammed the outlet for the valley. This created Lake Centennial, a massive lake with water levels 60 feet higher than the present levels of Red Rock Lakes. Lake Centennial persisted for thousands of years until a series of shifts in the western geologic fault, at what is now the site of Lima Dam, caused draining that lowered the water to its modern levels of around six feet.

Streams flowed into Lake Centennial from the north and south creating twin sediment deposits on the north and south sides of the lakebed. As the lake drained and the Red Rock River was born, these sediment deposits created a natural partial dam, restricting the drainage and forming Red Rock Lakes. These deep sediment deposits created fertile soil that allows for an incredibly productive environment with a high diversity of life, despite the Centennial Valley's relatively high altitude and latitude.

Utmost Source of the Missouri River Information/History

The Missouri River, the longest river in North America[3], begins in the Centennial Mountains and flows for 2,341 miles before entering the Mississippi River. The river has a drainage basin that encompasses one sixth of the area of the United States (529,350 square miles) and includes areas of 10 U.S. states and two Canadian

provinces[4]. Beginning at 9,100ft. above sea level, near Brower's Spring on Mount Jefferson, the river drops 8,626ft. to the river's mouth at 400ft, with another tributary beginning at 14,295 ft. on Mount Lincoln in Colorado. From Brower's Spring, the headwaters flow into Hell Roaring Creek and down to Red Rock Creek. From the Creek, water flows through the Centennial to Lima Dam and out onto the Red Rock River. The Red Rock meets with the Beaverhead River at Clark Canyon Dam and flows on to the Jefferson River. The Jefferson meets with the Madison and Gallatin Rivers, forming the Missouri River, north of Three Forks, Montana. With such dramatic changes in elevation and travel through ten states, the area the Missouri River basin covers is very diverse in climate, population, wildlife, and land use.

The overall watershed has been defined as having a Continental climate characterized by warm, wet summers and harsh, cold winters. The majority of the Missouri River watershed receives 8 to 10 inches, on average, of precipitation per year[5]. However, certain regions in Montana, as well as Missouri, can receive as much as 40 inches in a given year[5]. The temperature gradient along the watershed can vary from -60^{o}F in Montana, Wyoming, and Colorado in the winter, to 120^{F} in Kansas and Missouri in the summer[5].

The Centennial Valley is a part of the *Upper* Missouri Watershed, which encompasses areas in Montana, Wyoming, southern Alberta and Saskatchewan, and North Dakota. This watershed is characterized by semi-arid shrub-steppe grasslands with sparse biodiversity because of past ice age glaciations. The headwaters in the Centennial Mountains receive a substantial amount of precipitation while the rest of the region receives relatively little precipitation.

Current Habitat Types, Terrain, etc. in the Centennial Valley

The Centennial Valley has been posited as a hotspot for natural biodiversity. It has an abundance of diverse and high-quality habitat types, including wetlands, a sagebrush-grassland mosaic that contain unique sandhills, mid-elevation coniferous forests, aspen stands, and alpine forest communities. It varies in elevation from 6,600ft. at the valley floor to over 10,000ft. at Mt. Jefferson on the southern side of the valley. There are rolling sage brush hills and heavily wooded areas, as well as riparian areas flush with willows.

Figure 3. Red Rock River east of Red Rock Lakes, prior to entering the lakes. Photo Credit: Atalie Brown

Wetlands encompass 45,000 acres of the valley, 25,000 acres of which are protected through the Red Rock Lakes National Wildlife Refuge. The valley also includes over 500 miles of riparian areas. The wetland/riparian areas are identified as one of the highest quality examples of an intact aquatic system in the Upper Missouri basin and the largest wetland complex in the Greater Yellowstone[6]. Riparian/wetland systems account for less than 4% of Montana's land area but are crucial to many species of plants and wildlife[7]. For example, 75% of the wildlife in the Centennial Valley uses the wetlands at some point in their annual life cycle. While some of the wetlands in the valley are manmade, the complex is still considered crucial environment and highly ranked among all the Missouri River wetlands. These wetlands are an important habitat to maintain biodiversity and a healthy ecosystem but are of concern for the future with the implications of climate change. Drying of the watershed and an increase in temperature to this sensitive ecosystem is a major concern for many stakeholders involved.

Approximately 100,000 acres of the total 385,000 acres in the valley are considered grasslands and 130,000 acres are considered sagebrush. There are sandhills located on the northeast side of the valley that host a diverse set of wildlife including, 18 species of mammals, 29 species of bird, two amphibian species, one reptile species, four species of tiger beetles, and 14 species of diurnal butterflies[8]. These sandhills are one of only two sandhill sites in Montana and are crucial for maintaining numerous rare species of plants and animals.

There are three main forest ecosystems in the Centennial Valley: mid-elevation coniferous forests, aspen stands, and high-elevation forests. The mid-elevation forests surround the valley and precipitation can be double in these stands than what it is at the valley floor. These forests host a variety of wildlife, including the goshawk, great gray owl, and the grizzly bear. The aspen stands in the valley are considered some of the most pristine in southwest Montana. There are approximately 33,000 acres of aspen stands scattered throughout the valley. These are sites of concern for the future regarding climate change and protecting endangered species. Above 8,500 feet in the Centennial Mountains is a mosaic of forest and alpine meadow habitats. These exposed mountain ridgelines and peaks provide a unique habitat for the alpine plant and animal communities. These communities will be highly vulnerable to climate change and are areas of concern for the future.

Land & Water Use in the Centennial Valley

Humans have frequented the Centennial Valley for thousands of years. The valley was well known to many groups of Native Americans. It was frequently visited by branches of the Shoshone tribe, as well as the Blackfoot, Crow, Flathead, Bannocks, and Nez Perce tribes. Observable evidence, such as tepee rings, arrow and spearheads, and pottery shards, have been collected throughout the valley over the years. Groups of Native Americans continued to frequent the valley after the turn of the century and after settlers had begun to homestead the area. Due to the long, harsh winters that were frequent in the valley, it is likely that it was used in the non-winter months for its abundance of fish, fowl, and game.

Figure 4. Looking south at the Centennial Mountains from the north side of the valley. Photo Credit: Atalie Brown

Europeans began settling the valley in the mid-1800s. The inhabitants were interested in the Centennial for the grazing land provided by the rich soil and many streams, but other groups were also present in the valley. Various small-scale mining operations came and went, and the same wildlife that supported the Native Americans began to draw attention from sportsmen. The abundant fish were even harvested commercially for sale outside of the valley and their eggs were collected for government fish hatcheries.

The short summers and harsh winters eventually caused most of the homesteader families in the Centennial to either leave, selling their property to other ranching operations, or to adapt their land use in the valley to summer grazing and moving their livestock out of the valley to overwinter in nearby communities. Few of the recreational hunters and fishermen who traveled to the valley for sport braved the valley during the colder months of the year, a pattern that continues today.

Despite the abundant streams, the valley is generally a dry place, and in dry years the lack of water posed a constant threat for the agricultural community. This constantly looming worry led to the construction of an earthen dam at the west end of the valley in the 1890's, the first incarnation of Lima Dam. This first dam washed out within a decade and was reconstructed in 1908. The dam was not raised to its current height until

1934, funded in part by a grant from the Public Works Administration as a part of President Roosevelt's New Deal. In the intervening decades, the dam has undergone several refits for safety and functionality, and today is operated by the Lima Water Users, providing water for irrigation to 20,000 acres in a typical year, as well as providing stock water for livestock, and ensuring summer flows for fish and wildlife.

Figure 5. Upper Red Rock Lake. Photo Credit: Atalie Brown

There are two shallow lakes that dominate the valley floor: Upper Red Rock Lake (2,206 acres) and Lower Red Rock Lake (1,126 acres), both protected through the Red Rock Lakes National Wildlife Refuge. Both lakes are less than 6 feet in depth and host a wide variety of avian species. At the northeast corner of the valley located at 6,750 feet in elevation is Elk Lake. Elk Lake is approximately 207 acres and 60 feet deep. The major streams that occur upstream of the lakes include: Red Rock Creek, Elk Creek, Tom Creek, Corral Creek, Hell Roaring Creek, and O'Dell Creek. There are also smaller streams that occur throughout the valley. The Lima Reservoir, located at the western end of the valley, is approximately 84,000 acre/feet at 100% capacity. The water users prefer that the reservoir stays above 10,000 acre/feet, as water quality declines any lower. The average capacity is around 70,000 acre/feet.

Agriculture

The Centennial Valley attracted settlers for its rich agricultural value since the 1800s. The lush grasslands were used as summer grazing lands for cattle and sheep. Ranchers no longer graze sheep in the valley, but in 1884 there were 63,000 sheep between Beaverhead and Madison Counties.

The Red Rock River flows through the center of the Centennial Valley and is the main contributor to the Beaverhead River where it joins below Clark Reservoir. The Beaverhead River was one of the first in Montana to be used for extensive irrigation. As mentioned above, the water in the Lima Reservoir is diverted by the members of the Lima Water Users for crop irrigation, livestock water, and to sustain fish and wildlife. Water use is based on the number of shares owned, with each share entitling its owner to 3/10 of a miner's inch of water.

The valley has had a net increase in wetland habitat due to both public and private parties "diverting flows, irrigating land, storing water, and building ponds"[6]. Some landowners in the valley have also participated in cost-sharing programs that allowed new stock ponds to be installed.

There are currently 14 active cattle ranches in the Centennial Valley, with six being generational family ranches. These ranchers utilize their land (owned or leased) for the summer grazing months (June-October), with some staying until late November. Approximately 12,000 head of cattle run in the valley during these months.

Wildlife, Hunting, & Fishing

Wildlife face many threats to their habitat including habitat fragmentation, development, and climate change. The riparian, wetland, and mountain stream that occur in the Centennial Valley are in need of conservation for many reasons, one primarily being that many species rely on them for survival[6].

In 1935, President Franklin D. Roosevelt established the current Red Rock Lakes National Wildlife Refuge located in the Centennial Valley to protect the endangered Trumpeter Swans. The wildlife refuge currently owns 51,386 acres and manages conservation easements on an additional 23,806 acres. There are 260 bird species that have been found in the valley - 70% of all the birds found in Montana. Out of the 260 species, 150 species breed in the valley.

In addition to the elaborate amount of bird and waterfowl species found, there are also a variety of mammals, ungulates, and carnivorous animals. Mice, shrews, bats, pikas, rabbits, ground squirrels, marmots, wood rats, chipmunks, squirrels, beavers, muskrats, gophers, and porcupines can all be found throughout the valley. There are also populations of black bears, grizzly bears, martens, weasels, minks, badgers, river otters, beavers, wolverines, skunks, fox, coyotes, wolves, cougars, lynx, raccoons, and bobcats. The ungulate population consists of elk, white-tailed deer, mule deer, moose, and pronghorn.

There are numerous high springs in the mountain ranges that surround the valley and eventually fill the streams, rivers, and lakes. The lower lakes and streams contain most of the fish. There is an abundance of native and nonnative fish that can be found in the valley today. Arctic grayling, lake trout, Westslope cutthroat trout, burbot, mountain whitefish, white sucker, longnose sucker, longnose dace, and sculpin are some of the native fish that occur throughout the valley. Some of the non-native species include Utah chub, brook trout, Yellowstone cutthroat trout, and rainbow trout.

Two fish species of concern in the valley are the Arctic grayling and the Westslope Cutthroat Trout. The Centennial Valley is one of the few places that the Arctic grayling continues to persist in the lower 48 and the Westslope cutthroat trout has been declining throughout its range, causing concern[9]. Stream health and stream temperature are extremely important to species like these[6]. As members of the salmon family – they need fresh cold-water streams to thrive. The predicted changes in snowmelt runoff, as well as increased annual temperatures could potentially make these waters uninhabitable for these species[6].

The Centennial Valley has always been popular hunting grounds. In the late 1800s, waterfowl hunting clubs began popping up around the valley. Many were put along Upper and Lower Red Rock Lakes and the first hunting laws came along in 1891. Many of these clubs stayed in business until the Refuge took over the land in the 1930s. Hunting is still a popular activity in the valley today. Red Rock Lakes National Wildlife Refuge allows hunting on designated areas within the Refuge for ducks, geese, coots, moose, elk, white-tailed deer, and pronghorn. Hunting is permitted on all other public lands, open block management zones, and private property with permission. Trapping was also a popular source of food and pelts during the mid-1800s.

Outfitting & Lodging

The Centennial Valley is also a desirable place for recreationists. From 1898 to 1907, the M-Y (Monida-Yellowstone) stage line carried tourists from Monida, through the valley, and into Yellowstone National Park. The M-Y outfit consisted of twelve 11-passenger and four 3-passenger Concord coaches, eighty horses, two buggies, and forty employees[10]. Monida and Lakeview each were booming towns with saloons, hotels, a general store, post office, and even a blacksmith.

In 1935, the Selby family obtained a permit that allowed them to establish a hunting and fishing club on Elk Lake, the predecessor to the present Elk Lake Lodge. Throughout the years, Elk Lake Lodge began to add more summer activities and eventually winter activities that attracted adventurists year-round. The lodge still offers guided fishing tours, horseback pack trips, water sports, ATV riding, and space for large event gatherings.

The valley also offers backcountry skiing outfitters. The Lakeview Ski Ranch was opened in 1989 and was equipped with fully functioning wall tents. They specialized in backcountry skiing throughout the pristine Centennial Mountains. The ski ranch is still in business today under the name Hellroaring Powder Guides.

The Centennial Outfitters is an outfitting business that has been operating since 1987. They provide packing and outfitting services during the hunting season and provide trail rides during the summer months. The Red Hawk Lodge hosts the Centennial Outfitters overnight guests visiting the valley.

The Centennial Valley also offers unique rental opportunities through the J Bar L Ranch. J Bar L offers multiple houses and cabins throughout the valley available for rent to visitors of the valley. They also offer services for large groups, events, and families.

Climate/Precipitation

Climate conditions around Montana and the world are dynamic, variable, and changing[11]. Montana's natural and managed resource economy depends critically on the climate and stakeholders will need to have resources readily available to make sustainable management decisions. There are many resources made available to the public regarding climate data and climate change.

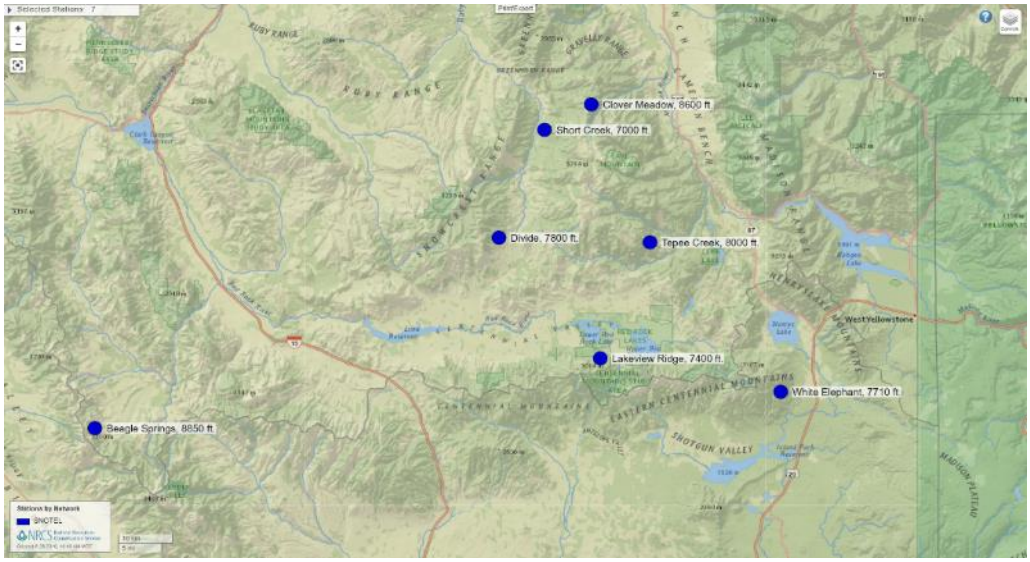


Figure 6. The above map shows the seven NRCS SNOTEL stations that surround the Centennial Valley: Clover Meadow, Short Creek, Divide, Tepee Creek, Lakeview Ridge, White Elephant, and Beagle Springs. Courtesy NRCS.

The 2017 Montana Climate Assessment provides key information on important sectors and identifies where the knowledge gaps lie. It strives to identify which topics surrounding climate change are important to Montanans and ensuring the state's economic and cultural viability. This includes three important sectors: water, forest, and agriculture.

The Natural Resources Conservation Service (NRCS) provides an up-to-date online map of SNOTEL data (including snow depth and snow water equivalent (SWE)), precipitation, streamflow, and reservoir storage. The NRCS provides four SNOTEL sites that have historical climate data relevant to the Centennial Valley. Three of the SNOTEL sites are in Montana: Divide, Tepee Creek, and Lakeview Ridge. The White Elephant site resides in Idaho to the southeast. There are also three other sites that surround the valley, two to the north: Clover Meadow and Short Creek, and one to the west - Beagle Springs, that provide more data for the greater surrounding area (Figure 6).

The valley floor sits at approximately 6,600ft throughout the valley. The Divide station is located at 7,800ft, the Lakeview Ridge station is at 7,400ft, the Tepee Creek station is at 8,000ft, and the White Elephant is at 7,710ft. Although these are all higher than the valley floor, they still paint a picture of what is occurring around the valley. Snow melt is a critical source of freshwater for landowners in the valley, therefore knowing SWE data is important for making sound water management decisions throughout the year.

Historical Climate Data

The Palmer Drought Severity Index (PDSI) is frequently used to quantify long-term drought using temperature and precipitation data, but does not account for delayed runoff (snow or ice)[12]. The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) produces monthly PDSI reports for different regions in the United States (Figures 7 & 8). According to data from the National Oceanic and Atmospheric Administration[13], using the PDSI, the years between 1960-1969 in southwestern Montana were moderately wet years with the exception of 1961 in which the area experienced an extreme drought. Between 1970 and 1979, the years were mostly in the mid-range or moderately wet. The winter months of 1975-1976 were extremely wet. The 1980s began as wet years, having extreme moisture between 1982 and 1985 and finished with an extreme drought between 1988 and 1989. Between 1990 and 1999, moisture remained relatively in the mid-range for the first half of the decade and turned into moderate-extreme moisture during the second half. The water year of 1995-1996 experienced extreme moisture. The beginning of the 21st century, was brought in with a severe-extreme drought that lasted three full years (2000-2002) and lingered for another two (2003-2004). The remaining half of the decade landed in the mid-range. 2010-2011 began as a moderately moist year, followed by a severe drought in 2012-2013. A visual representation of this data can be found in the Section J, Section B.

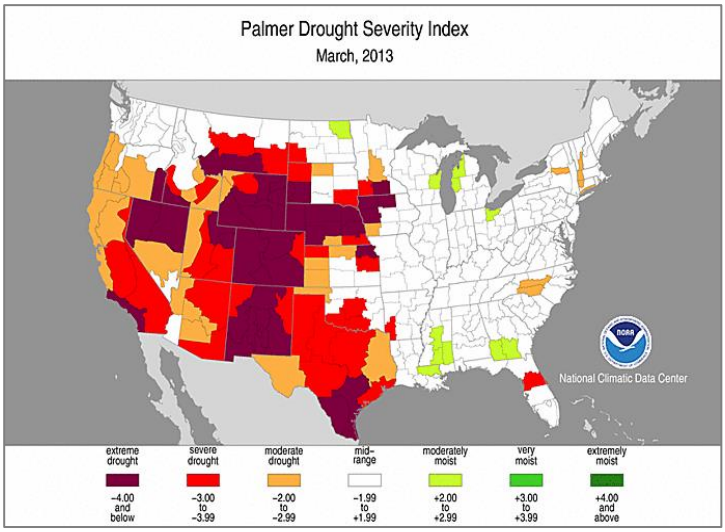


Figure 7. The above image shows the PDSI for every county in the US during a dry year for the Western US, March 2013. https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/

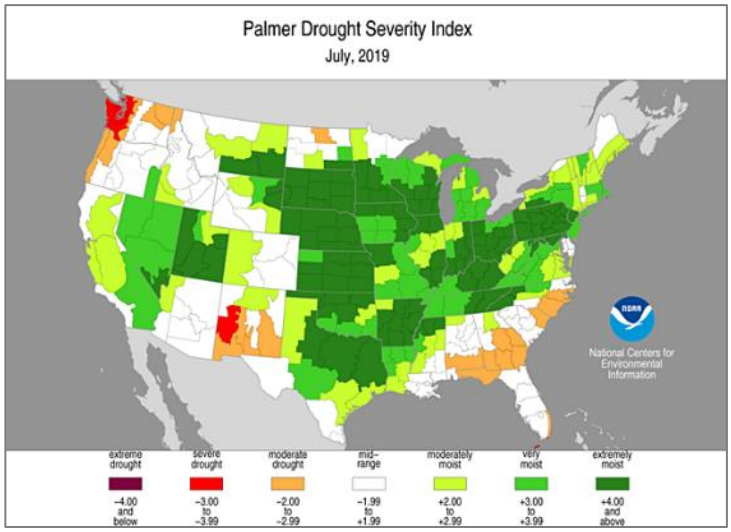


Figure 8. The above image shows the PDSI for every county in the US for July 2019. https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/

The four SNOTEL sites that surround the valley have been collecting precipitation, snow depth, and snow water equivalent (SWE) data for approximately 40 years. The sites may not accurately represent what happens on the valley floor, but they do paint a picture of what happens slightly up the elevation grade. The White Elephant site, by far, receives the most precipitation of the four sites. It can receive 20 more inches of precipitation than the other three sites. Over the past four decades, it has averaged between 41.4” and 47.6” of precipitation. It has had a low of 30.3” in 2015 and a high of 63.4” in 1997. The Tepee Creek site has averaged between 23” and 26.8” of precipitation over the last four decades. It had a low of 17.3” in 2015 and a high of 37.5” in 1984. The Divide site has averaged between 20.9” and 23.8” of precipitation over the last forty years. It had a low of 14.3” in 1988 and a high of 36.2” in 1984. Over the last 40 years, the Lakeview Ridge site has averages between 23.3” and 28.2” of precipitation. It had a low of 15.3” in 1994 and a high of 42.9” in 1995.

2017-2018 Water Year Climate Data

According to historical data, the 2017-2018 water year was like the past 20 years of data. The table below summarizes the 2017-2018 data (precipitation and SWE) in comparison to historical values.

2017-2018 Water Year Data, Centennial Valley, MT								
	Divide		Tepee Creek		Lakeview Ridge		White Elephant	
	2017-18	Historical Average	2017-18	Historical Average	2017-18	Historical Average	2017-18	Historical Average
Highest Precipitation – Month (in)	5” (June 2018)		4.5” (March 2018)		4.5” (March 2018)		6.6” (February 2018)	
Total Precipitation Accumulation (in)	24.3”	22.9”	24.1”	25.2”	25”	25.9”	44.8”	44.7”
Highest increase in SWE – month (in)	4” (March 2018)		4.8” (March 2018)		4.1” (March 2018)		6.8” (Feb. and March 2018)	
Highest SWE Value (in)	11.1”	11.51”	13.9”	14.15”	9.2”	10.75”	28.9”	28.23”

The above table summarizes the 2017-2018 Water Year climate data, including precipitation and snow water equivalent (SWE), in comparison to historical averages for four SNOTEL sites surrounding the Centennial Valley: Divide, Tepee Creek, Lakeview Ridge, and White Elephant (ID).

Future Climate Predictions

In 2017, the Montana Institute on Ecosystems wrote the Montana Climate Assessment that examined three major sectors that climate change will affect in Montana: water, forests, and agriculture. The Assessment came to four major conclusions across Montana: 1) the annual average daily temperatures have risen between 2.0-3.0°F between the years 1950-2015, 2) changes in seasonal precipitation have occurred between 1950 and 2015 – resulting in decreased winter precipitation and increased spring precipitation, 3) Montana is projected to warm in all geographic locations, seasons, and under all emission scenarios through the 21st century, and 4) across the state, precipitation is projected to increase in winter, spring, and fall, and to decrease in the summer.

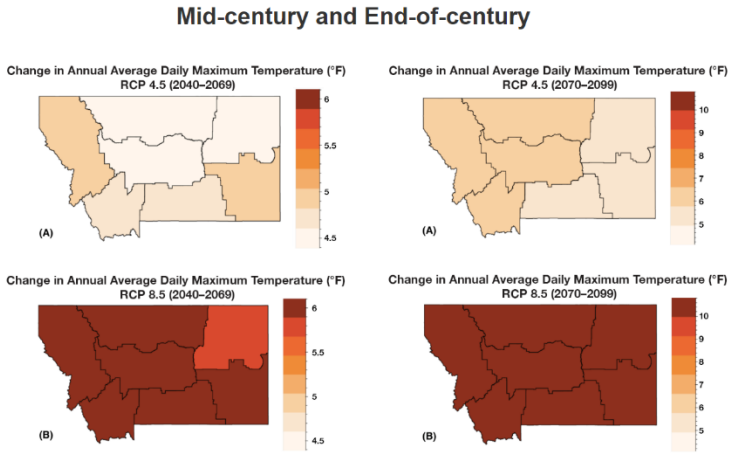


Figure 9. The projected increase in annual average daily maximum temperature (F) for each climate division in Montana for the periods 2049-2069 and 2070-2099 for (A) Stabilization (RCP4.5) and (B) business-as-usual (RCP8.5) emission scenarios. Image: montanaclimate.org

Montana depends on water for nearly all aspects of the economy, therefore understanding how climate changes may impact the water cycle throughout Montana is crucial to making sound management decisions. In

Montana, winter snowfall accumulates in the mountains and then will melt throughout the spring to produce streamflow and recharge aquifers. The projected changes in temperature that were listed in the key findings, will affect how the water enters Montana, when in the year, how it is distributed, and how it will move from one component of the water cycle to another. The rising temperatures will reduce the snowpack, alter streamflow patterns, and place additional stress on Montana's water supply. The rising temperatures, as well as the changing snowpack and runoff, will also exacerbate the drought periods that have always been and will continue to be a part of Montana's climate.

Agriculture is a key industry in Montana, including both crops and livestock, throughout the state and in the Centennial Valley. Assessing how climate change will impact ranchers in the Centennial Valley is a multi-faceted and complex problem. There are many levels of uncertainty in the projections. However, utilizing strategies to cope with this new uncertainty and variability in the climate and availability of water will help face this change. Some projected changes that could impact the ranchers of the Centennial Valley are decreased streamflow and less reliable irrigation capacity due to the changes in the snowpack and increased temperature allowing for invasive weeds, such as cheatgrass, or weeds with a lower forage quality, to thrive.

Every component of agriculture has a complex relationship to the climate and having the social and economic resilience to be able to adapt to a future of climate variability will be at the utmost importance going forward. In 2015, the gross income for all cattle and calves in the state was over $2 billion dollars. Adaptation during times of uncertainty will help ranchers alleviate the hardships that climate change may cause. For example, stockpiling feed and using protein and energy supplements when forage is inadequate.

It is predicted that the projected temperature and precipitation increases for Montana may be favorable for forage for a short period of time, but will eventually become disruptive after adaptation thresholds are passed[11]. A warmer climate could allow for invasive weeds to increase their distribution and density. Invasive weeds, like cheatgrass, tend to decrease forage productivity which will affect the ranchers that graze in the valley. These grasses can also increase wildfire risk and frequency[11]. The Montana Climate Assessment advises that, "Climate change effects will simultaneously alter forage quality, along with quantity and species distribution, and these components affect animal nutrition"[11].

There are many factors that can increase wildfire severity and frequency in the valley. These include invasive plant species moving in, warming temperatures, and the suppression of fire. Wildfires are becoming more frequent and more intense and it is projected to stay that way into the future. Catastrophic wildfires pose a threat to all wildlife species in the valley. These are all factors to be considered moving forward into the future for both ranchers and all interested stakeholders in the Centennial Valley.

Figure 10. Photo Credit: Atalie Brown

C. Development

CVA Background

The Centennial Valley is one of the last undeveloped landscapes in Montana, connecting the Greater Yellowstone Ecosystem to protected areas in central Idaho and the Crown of the Continent. The valley is the utmost source of the Missouri Headwaters, providing vital migration corridors and home to iconic wildlife, such as grizzly bear, elk, moose, sage grouse, trumpeter swans, and arctic grayling. The Centennial is also a productive, working landscape that has been

ranched for over one hundred years by multi-generational families who share a common goal: preserving the integrity of the land and water to benefit the community and wildlife concurrently.

Founded by landowners in 2007, the Centennial Valley Association (CVA) strives to preserve traditional ranching as a way of life, and maintain quality open space, wildlife habitat, water quality and wildlife migration corridors, as they exist today for future generations, by creating opportunities and rallying landowners, agencies, and community members to unite and support agriculture and conservation. CVA creates a venue for landowners to have a powerful voice in the area and allow for proactive, community-based collaboration for conservation with private-public partnerships. CVA fosters a range of projects and initiatives that include: 1) protecting the landscape's environmental health by managing invasive species, maintaining biodiversity and migration corridors, monitoring stream health and water availability, and supporting collaborative approaches to aid sage grouse, grizzly bear, wolves and Arctic grayling recovery, and 2) promoting safety, awareness and enjoyment for the community and visitors via updates and resources on remote travel conditions, water availability, bear awareness, and emergency services.

The CVA's support for community partnerships and sustainable stewardship practices is helping to protect the Centennial Valley's ecological integrity and its undeveloped character. The CVA protects the history, culture, and the community that cherishes the unique qualities of this remote landscape.

The CVA provides a community forum to successfully establish change in the Valley; partnering with The Nature Conservancy (TNC), Red Rock Lakes National Wildlife Refuge (RRLNWR), Beaverhead County, the Bureau of Land Management (BLM), Montana Department of Natural Resources and Conservation (DNRC), U.S. Forest Service, University of Utah Taft-Nicholson Center, local landowners, and many others. The CVA is critical to sustaining community-based conservation and creating lasting, effective relationships. Because of relationships between partners working together, the Centennial Valley has remained a viable, healthy, and undeveloped landscape.

What can CVA bring to the community regarding drought?

As mentioned above, the CVA currently provides a community forum on a variety of topics including wildlife habitat and connectivity, preserving ranching and open space, invasive species control, and recreational safety in the Centennial Valley. Drought is an increasingly important topic to CVA's stakeholders and the Centennial Valley's landowners. Landowners in the valley have expressed the lack of drought and water resources and CVA is attempting to fill that gap. The CVA can provide resources and information to the public regarding the hydrological resources in a clear and concise manner through newsletters, social media updates, and housing informational and educational materials and meetings on drought.

Providing this data to the Centennial Valley's landowners and stakeholders is important in providing vital data to help inform their individual management decisions. CVA is not a regulatory agency, and therefore will not be mandating any specific action during times of drought, but through providing community members with easy access to the data it will allow for more informed decisions.

Drought planning into the future

The Montana Climate Assessment states that, "Multi-year and decadal-scale droughts have been, and will continue to be, a natural feature of Montana's climate; rising temperatures will likely exacerbate drought when and where it occurs"[1]. With drought being a part of Montana's climate, being proactive and understanding steps that can be taken before and during dry periods will be crucial to making informed management decisions. There are numerous resources and informational materials that landowners can use to help inform their management decisions.

D. Stakeholders

Stakeholders of the Centennial Valley

Despite being a remote landscape, diverse groups utilize the Centennial Valley and Upper Red Rock watershed. They are ranchers, the Lima Dam Water Users, local landowners, outfitters, loggers, Red Rock Lakes National Wildlife Refuge, The Nature Conservancy, other state and federal agencies, and recreationalists that work and play in the valley daily.

The Role of Stakeholders

Stakeholders that wish to be more involved will be in contact with CVA to determine the roles and responsibilities they can assist with. An example of a way a stakeholder can be more involved is to host a CoCoRaHS Rain Gauge on their property and conduct citizen science anytime precipitation falls by measuring the gauge and sending the data to CVA. CVA would also like stakeholders to provide feedback on the program and ways that the program can be enhanced and improved upon.

Communication with Stakeholders

Each stakeholder group uses water differently. The CVA plans to host separate meetings with different stakeholders, focusing on the involvement of community leaders first, to gauge what needs are desired by each. This will allow us to be more individually focused on the needs of all stakeholders to design and implement a plan everyone can be happy with. CVA will also communicate more broadly through newsletters, social media, and email correspondence. Some newsletters may also be mailed through the U.S. Postal Service to reach certain stakeholders.

E. Drought Monitoring

As part of the outreach efforts, CVA will be compiling and summarizing existing monitoring occurring in the valley, as well as installing new infrastructure to expand the current monitoring efforts. This section will summarize what the current infrastructure is, CVA proposed additional infrastructure and monitoring, and how CVA plans to share the collected data.

Current Infrastructure

Montana Fish, Wildlife, and Parks (FWP) currently monitor streamflow at 11 sites throughout the Centennial Valley. These are occurring on West Creek, Long Creek (3 sites), Metzel Creek, Narrows Creek, Antelope Creek, Corral Creek (2 sites), Tom Creek, and Odell Creek (2 sites).

The Natural Resources Conservation Service (NRCS) provides up to date SNOTEL (snowfall and snowpack) data, precipitation, streamflow, and reservoir storage on their online platform. This data is all uploaded via satellite and does not require physical monitoring. There are four SNOTEL sites that provide data relevant to the Centennial Valley, three located in Montana (Divide, Tepee Creek, and Lakeview Ridge) and one in Idaho (White Elephant). Although the White Elephant site does not flow

Figure 11. Beaver mimicry structure on J-L Long Creek Property. Photo Credit: Kara Maplethorpe

into the Centennial Watershed, it is located on the backside of Mt. Jefferson, which resides primarily in the Centennial Valley. It allows us to estimate how much moisture is hitting the east end of the valley. There are also two sites north of the Centennial Valley between the Snowcrest and Gravelly Ranges, Clover Meadows and Short Creek, and one site to the west of the valley, Beagle Springs, that will provide information that may be useful for our stakeholders. A map of these sites can be seen in Figure 6.

There is one NRCS Snowcourse site in Lakeview that helps highlight the snowpack occurring at a lower elevation. Snowcourse sites are permanent sites that require physical data collection that is then submitted to NRCS and uploaded online. This is monitored by the Red Rock Lakes National Wildlife Refuge (RRLNWR).

The United States Geological Survey (USGS) has two active staff gage sites in the Centennial Valley. One is located on Red Rock Creek and one near the Lima Dam Reservoir. These allow us to view real-time streamflows on their online platform.

The Bureau of Land Management (BLM) has a Remote Automated Weather Station (RAWS) weather station located in the Centennial Valley sandhills. RAWS stations are often located in remote locations and are used to observe potential wildfire conditions. It collects daily data on temperature, wind speed, precipitation, and humidity.

The Nature Conservancy (TNC) does hydrological monitoring along Long Creek in the Centennial Valley. They are monitoring streamflow and groundwater levels on their property. In 2015 and 2016, TNC installed beaver mimicry structures to reconnect the historic floodplain on the Long Creek property. By doing so, they anticipated an increase in groundwater levels. The data they collect compare streamflow to groundwater levels. This data will be a great addition to the Drought Outreach Plan, as it highlights groundwater levels throughout the season, in that area, and could help predict what groundwater levels in the rest of the valley may be like.

Although there is precipitation monitoring occurring at the higher elevations surrounding the valley, the precipitation monitoring occurring throughout the valley floor is minimal. Our proposed monitoring additions will show how much precipitation is falling on the valley floor and expand on the other monitoring listed above.

Needed Infrastructure

CVA proposes installing additional monitoring tools such as CoCoRaHS rain gauges, a NRCS snowcourse site, a snow pillow at the existing BLM weather station, and two additional staff gauges in the Centennial Valley. This will require having a steady source of monitoring funding. Meetings held with community and stakeholders helped determine the needed infrastructure.

CoCoRaHS Rain Gauges

Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) is a community-based network of volunteers that measure and map precipitation across the country. They provide low-cost precipitation measurement tools that allow for a high-quality of data for many users and applications. There are currently two rain gauges being monitored in the valley: one at Red Rock Lakes National Wildlife Refuge and one at the Nature Conservancy Sandhills Preserve Headquarters. CVA proposes putting eight additional CoCoRaHS rain gauges across the valley at the following locations:

1. Monida Hill (CVA Kiosk)
2. Brundage Lane (South Side) – possible landowner monitoring
3. Elk Lake Road
4. Alaska Basin (CVA Kiosk or possible landowner monitoring)
5. Red Rock Pass

6. Long Creek Road – possible landowner monitoring
7. Wolverine Creek
8. Lima Dam (Mayberry Place)
9. The Nature Conservancy Sandhills Preserve Headquarters (already monitored)
10. Red Rock Lakes National Wildlife Refuge (already monitored)

Using the CoCoRaHS rain gauges to measure precipitation will be beneficial to the monitoring that is already occurring. It allows us to have more hydrological information in areas of the valley that streamflow or groundwater measurements may not be occurring. Knowing how much precipitation is falling during the field season can allow landowners to make informed decisions, such as when and where to graze. For example, some of the pastures have stock tanks with streams/springs that will dry up and having the precipitation data throughout the grazing season will assist in knowing when and where the rain has fallen.

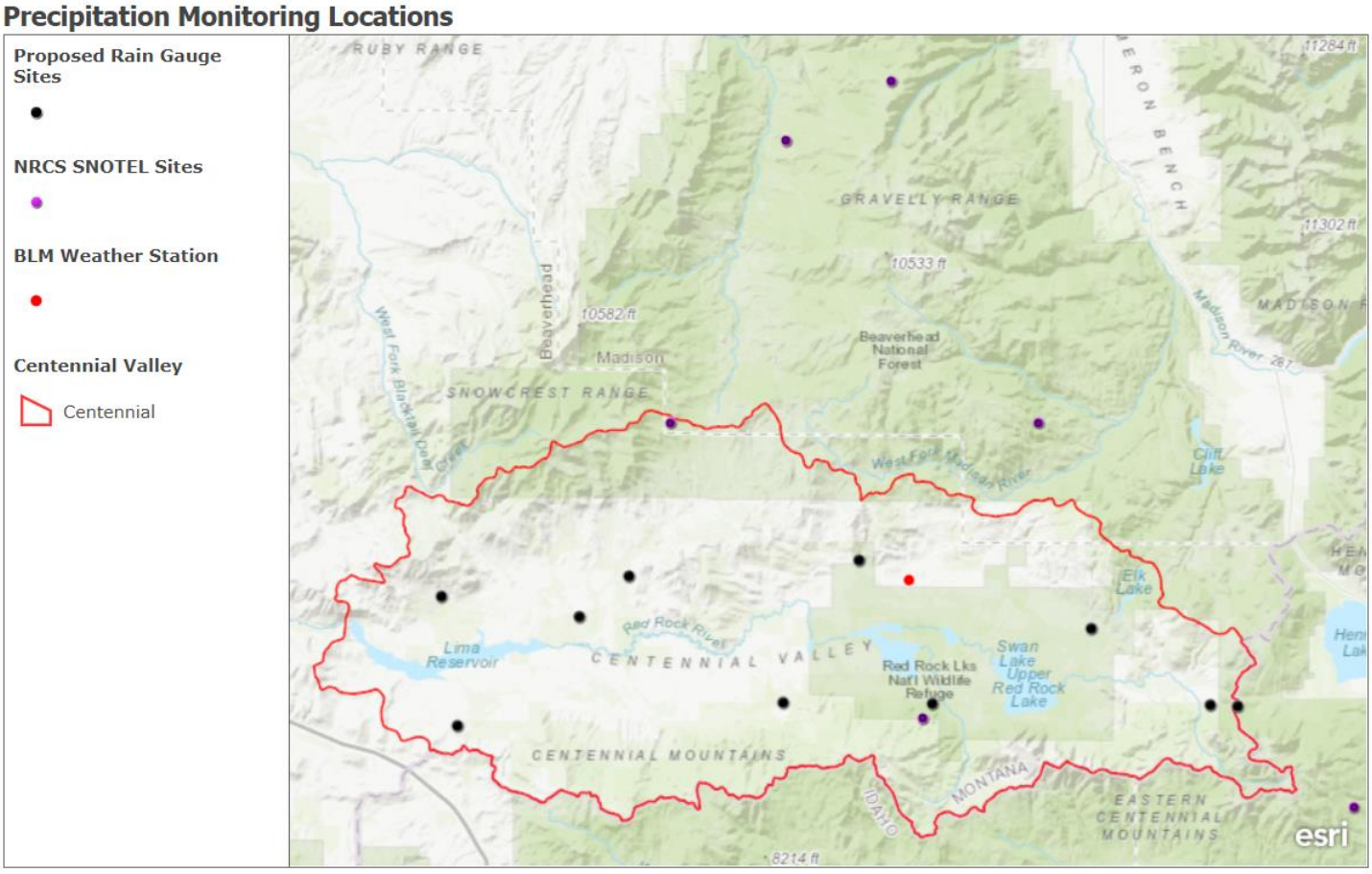


Figure 12. The above map shows the locations that precipitation monitoring will be occurring throughout the valley, including the proposed rain gauge locations.

Addition of NRCS Snowcourse Site

The addition of a NRCS snowcourse site to the north side of the valley would allow for a more comprehensive look at year-round precipitation patterns. The lower elevations of the valley do not have enough winter snowpack data, and this would help off-set the knowledge gaps. This will take collaboration between the CVA and NRCS to determine an appropriate site and monitoring plan.

Addition of Snow Pillow

A snow pillow is a snowpack measuring device that is often added to automated weather reporting stations. It measures the snow water equivalent (SWE) of the snow lying on the snow pillow. CVA proposes adding a snow pillow to the existing BLM weather station in the sandhills. It would allow for more insight into what is occurring in the valley during the winter months when there are fewer inhabitants and less monitoring occurring. This will take collaboration between the CVA, the BLM, and NRCS.

Staff Gauges

Staff gauges are tools used to measure water levels in various bodies of surface water. CVA proposes installing additional staff gauges at Corral Creek (west side, near Monida Hill) and Wolverine Creek (northside of the valley) to gain a better understanding of water levels throughout the valley.

Monitoring Dollars

The CVA will need to continue to find hydrological monitoring funding sources. Funding has been secured through the monitoring season of 2020.

Monitoring Plan

CoCoRaHS

The CoCoRaHS rain gauges will be monitored after any precipitation event during the field season (May – October). This monitoring will be done by the Drought Coordinator, alongside voluntary landowners, and other CVA employees. Given the amount of rain gauges and their locations throughout the valley, it may be required to have other CVA employees traveling to that portion of the valley to check the gauges after a storm. Some of the gauges will be located on private property and if the residents are willing to check them after a storm, they will also assist in the data collection. The Drought Coordinator will oversee collecting data, coordinating with partners and other employees, and compiling any data that was collected. It is unknown how often the monitoring will occur given the variability of weather from year to year.

Staff Gauges

Staff gauges and streamflows will be monitored bi-weekly every month during the field season (May – October). The Drought Coordinator will take these measurements with the assistance of the Invasive Weed Coordinator or a summer field technician. The Drought Coordinator will also be assisting Montana Fish, Wildlife, and Parks with their bi-weekly staff gauge and streamflow monitoring in the valley. This monitoring will be shared between CVA and Montana FWP.

Compiling Data Sources

The Drought Coordinator will compile the data collected by the CVA and the partners into a bi-weekly report that will be distributed to interested stakeholders and landowners. CVA will summarize the online and satellite data that is collected around the valley, such as the NRCS SNOTEL data, snowcourse data, and data from the BLM weather station in the sandhills. CVA will also compile and summarize the hydrological stream data that is collected by Montana FWP, USGS, and TNC.

Sharing Data with Stakeholders

CVA will share the collected and compiled data with all interested stakeholders through multiple outlets. During the field season, a short bi-weekly update will be sent out via-email and posted on the website. This will contain the streamflow information that was collected that period, as well as precipitation data. A full report that

compiles all the data listed above will also be sent out monthly to interested stakeholders. The amount of reporting will be reduced during the winter months to a short monthly update.

Providing the hydrological data to stakeholders will allow the landowners to make informed land management decisions. It can inform decisions such as where and when to graze, preparing for irrigation near and outside of Dell and Lima, Montana, predict wildfire likelihood, and potential shut down of private roads.

It is important to note that the CVA is not a regulatory agency and is not mandating any actions from stakeholders or landowners related to this hydrological monitoring. The purpose of the monitoring and sequential dissemination of information is to simply monitor hydrological conditions and provide that information to relevant parties.

F. Vulnerability Assessment

The benefit of a risk and vulnerability assessment is to identify who and what in the Centennial Valley will be most affected by drought. The areas in the valley that CVA identifies as being vulnerable during periods of drought are agricultural irrigation, stockwater levels, fish and wildlife, recreational activities, and reservoir operations. The forested lands, rangelands, riparian areas, and floodplains can become vulnerable under drought conditions, as well. Using potential indicators to predict a when a drought period may happen or begin can help mitigate the impacts a period of drought will cause.

Agricultural irrigation is highly vulnerable during drought periods, especially with surface water supplies. This can cause an impact to agricultural production through the inability to divert or convey water into various fields, through the unequal distribution of water, and a possible increase conflict over water usage and water rights. Some potential indicators to watch out for out for would be streamflow, return flow, snowpack, and precipitation measurements. Understanding these values throughout the year will be beneficial to making informed irrigation decisions.

Stockwater levels are also highly vulnerable during periods of drought. These levels are affected by both surface water and ground water. Some of the potential impacts are insufficient water supplies in stock ponds or stream and river sources, and the potential for wells or natural springs to go dry. Watching pond elevations, as well as stream and canal flows, will indicate if a drought period is approaching or occurring.

Figure 13. Arctic grayling, a sensitive species found in the Centennial Valley.

Fish and wildlife are moderately to highly vulnerable during times of drought – specifically regarding surface water. There are potential impacts to fish species that may rely on certain water temperatures, such as the Arctic grayling, that could result in reduced spawning amounts and possibly death. Monitoring of streamflows, water temperature, and snowpack levels will be important to alleviate these impacts. If both surface water and ground water are affected, there is potential for impacts to wildlife species that are sensitive to increased temperature and a reduction in habitat, such as the wolverine, grizzly bear, sage-grouse, and moose. Snowpack levels and rainfall amounts should be monitored for surface water and ground water levels.

Recreational activities in the valley, such as fishing, camping, and hunting, can be affected by decreased surface water and ground water. There can be an increased risk of wildfire during drought periods, as well as more backcountry restrictions put in place. Like many of the other vulnerable sectors, monitoring of the snowpack levels and rainfall amounts will help plan for these drier periods.

The Lima Dam provides water to its users throughout the year. The reservoir operations of Lima Dam can become highly vulnerable during times of drought. It can result in a decreased amount of water that is released to its users, resulting in less water for irrigation and agriculture. Streamflow monitoring, reservoir capacities, and snowpack data should all be monitored to help make informed decisions during periods of drought.

During times of drought, the various habitats of the valley, forested lands, rangelands, riparian areas, and floodplains, can become vulnerable. The forested lands are affected by both decreased surface water and ground water levels. Some of the potential impacts are an increased risk in wildfire occurrence and severity, as well as conifer encroachment into the valley floor and meadows. Some other potential impacts include a reduction in the amount of Animal Unit Months (AUMs) grazing on forested leases and increased impacts to low stream flows and watering areas – including challenges for livestock finding water. There will also be indirect impacts to producers and their home pasture with decreased forage in the forested leases. Some potential indicators that can be monitored include soil moisture levels, stream flows, precipitation amounts, and vegetation indices – such as increased conifer encroachment and invasive species expansion.

The expansive network of rangelands in the Centennial Valley can also become vulnerable during times of drought. Decreased amounts of surface water and ground water can lead to a reduced amount of available forage resulting in increased pasture rotation and/or increased supplement (hay) expenses earlier in the season. The rangelands can also become more susceptible to an increase in invasive species encroachment due to the changes in climate. Invasive species will typically be able to easily outcompete the native species. Monitoring of vegetation changes and erosion can be early indicators of reduced water availability.

The riparian areas and floodplains can be impacted during drought periods through vegetation stress, reduced recruitment of riparian species (i.e. cottonwood and willow), and increased erosion of streambanks. Monitoring of streamflows, vegetation changes, and soil moisture can all inform stakeholders to make more informed management decisions.

G. Mitigation Strategies

Mitigation Actions

The Centennial Valley Association holds a unique position in that it is not a regulatory organization and are not mandating any actions during drought periods. The potential for positive action that CVA has is in education, information dissemination, and connecting and collaborating with and between stakeholders regarding partnerships, technical expertise, and potential funding sources.

Existing Plans to Assist in Mitigation Strategies

Montana State Water Plan

The Montana State Water Plan (MSWP) was completed in 2015 and provides recommendations to guide state water policy and management in Montana in the coming years. There are near, immediate, and long-term recommendations that encompass information for the state officials and citizens of Montana to better deal with the complex challenges that come with managing water resources. There are five major areas that the MSWP provides recommendations for: Water Supply and Demand, Water Use Administration, Water Information,

Ecological Health and Environment, and Collaborative Water Planning and Coordination. Many of the recommendations involve exploring new opportunities and funding opportunities, supporting monitoring studies, providing incentive programs, working with local water users, working with legislature, and continuing to support ongoing projects and endeavors. Some of the recommendations that are applicable to the Centennial Valley and its stakeholders regarding water supply and demand are to: increase water use efficiency and water conservation, the state increasing the flexibility to manage water resources through storage and the rehabilitation of existing infrastructure, exploring the use of natural storage and retention to benefit water supplies and ecosystems. The plan also prioritizes supporting proactive and coordinated efforts to reduce invasive species and protect endangered species. This is something that the Centennial Valley is already supporting and collaborating on. The Water Plan also emphasizes the importance of collaboration and communication between different parties and agencies. The Centennial Valley is unique in the collaboration that already occurs between so many agencies. This is something that will be important going into the future.

NRCS Sage Grouse Initiative

The Sage Grouse Initiative is a "new paradigm for conserving at-risk wildlife and America's western rangelands that works through voluntary cooperation, incentives, and community support" (SGI Website). It is led by the USDA's Natural Resources Conservation Service and has partnered with 1,474 ranchers across 11 western states. It is funded through the Farm Bill and allows partners to work on projects that benefit both wildlife and the agricultural community. They work on projects such as fence modifications and installation or restoration of stockwater systems. This could be a potential funding source for landowners in the Centennial Valley that can help mitigate effects from climate change in the future while also benefiting wildlife. Some landowners in the Centennial Valley have already utilized this NRCS funding to assist with the installation of livestock stockwater tanks across the landscape. This allowed the ranchers to conduct rotational grazing which can have beneficial effects on the landscape. More information can be found in the References Section.

Centennial Valley Association Mitigation Strategies

Education and Information Sharing

One of the main ways CVA will contribute to mitigation efforts is through education and sharing information. This includes compiling and sharing the hydrological data that is collected in the valley, as mentioned in the Monitoring section. Providing this data to the water-users can help them better prepare for drought periods and promote voluntary mitigation efforts. CVA will be sharing a summary of the hydrological data collected throughout the field season, May – October, on a bi-weekly basis to all interested parties and stakeholders. CVA will also provide monthly updates throughout the winter months on snowpack information.

Another avenue is to hold community meetings in the Spring and Fall to share educational materials, exchange information, and establish everyone's role in drought mitigation. This will be something that CVA will trial run this field season.

Some examples of mitigation strategies that CVA can share with stakeholders are listed below.

Improvements to Existing Irrigation Systems

As a part of expediting conflict resolution and facilitating temporary changes in water rights, accurate flow measurements and control are necessary. In many cases this would be best served by upgrading existing infrastructure such as gates and weirs. Another option that is commonly suggested is the construction of off-stream stock tanks. These allow for storage of water, extending the time before the impacts of drought are felt, as well as helping to maintain stream water quality and preventing damage to natural water storage features during low water periods. Alterations to the soil around open stock

ponds has also been shown to increase water retention times. These options can be expensive and identifying potential funding sources (disaster prep, NRCS, private groups) would greatly increase the likelihood of people utilizing these measures.

Improvements to Natural Water Retention

Depending on individual stream conditions and structure, there are a variety of methods that can be employed to increase natural water retention. Stream side vegetation such as willows and sedges can alter the structure and soils of stream banks in ways that allow for retention of both surface and sub surface water. Structural changes, such as fascines and beaver analog structures, can slow water passage and restore historic flood plains. These changes can also encourage the growth of streamside vegetation. The viability and effectiveness of these solutions are largely based on the stream in question, and the process can get technical and expensive, so again a list of organizations to contact for potential advice and funding would be useful.

Conifer Removal

Conifer encroachment on sagebrush steppe poses a dual threat during drought. Conifers rely on access to large amounts of water to facilitate the movement of nutrients up and down their trunks, a process that necessitates the loss of water to the atmosphere. These losses can be significant and have been known to drastically alter water availability on small streams. The second issue that arises with conifers is that they become a fire hazard once they become dry due to lack of water resources. There are currently conifer removal operations in multiple parts of the valley.

Communication and Collaboration

Communication and collaboration are two critical elements to drought mitigation. CVA can serve as a facilitator between different landowners and private and public agencies. The Centennial Valley is unique in that so many different agencies, non-profits, and landowners come together with similar goals. These partnerships will be crucial moving into the future.

H. Response Actions

Existing Plans

There are two existing plans that address response actions during times of drought – the Water Rights Compact with Red Rock Lakes National Wildlife Refuge and the Lima Dam Water Users Agreement.

The Water Rights Compact is between the State of Montana and the U.S. Department of Fish & Wildlife – Red Rock Lakes National Wildlife Refuge. It was ratified and signed into Montana Law in 1999 and ensures water for wildlife consumption and habitat, as well as administrative uses, such as wildfire suppression. It lays out the consumptive use guidelines, natural and minimum flow guidelines, and basin closure guidelines. A minimum flow was established for three creeks at the point that they enter the Wildlife Refuge: Red Rock Creek at 15 Cubic Feet per Second (cfs), Odell Creek at 11 cfs, and Tom Creek at 1.4 cfs. The Fish & Wildlife Service shall cease any of its own diversions prior to it reaching minimum flow at the following: Red Rock Creek and its tributaries upstream from the point of measurement when measured flow is approximately 25 cfs, when measured flow is approximately 20 cfs on Odell Creek, and when measured flow is approximately 5 cfs on Tom Creek.

There are two landowners, that have senior and junior water rights, in Alaska Basin that could impact flows into Red Rock Creek. The Refuge and the landowners have an agreement to ensure a minimum of 15cfs in Red Rock Creek. When Red Rock Creek hits 25cfs, the Refuge contacts landowners so they may prepare for the

possible trigger announcement. At 18cfs, the junior water rights holder will cease irrigation activity, which could ensure that the creek stays above 15cfs. If streamflow continues to drop and hits the 15cfs trigger, the senior water rights holder will cease irrigation activity and no irrigation activity will occur until streamflow is above 15cfs.

The first iteration of the Lima Dam was constructed in 1890, with major rebuilds and work being done in 1908, 1934, 1993, and 2001. The Lima Dam structure is owned by the state of Montana, but the water contained within the reservoir is owned by the Lima Dam Water Users (also known as the Beaverhead County Red Rock River Water and/or Sewer District). The reservoir at full capacity can hold ~84,000 acre/feet of water (~70,000 acre/feet average) and users typically do not drop the reservoir levels below ~10,000 acre/feet. Over 8,000-acre feet are diverted each year and 20,000 acres will typically be irrigated from the reservoir. The Lima Dam Water Users have an internal agreement that helps during years of drought or dryness. It helps ensure too much water is not being diverted and that there will be enough water remaining for dry years.

CVA Suggested Response Actions

The CVA's role in response actions is through the dissemination of information to all stakeholders in the valley. As mentioned in the monitoring section of this plan, CVA will be conducting streamflow and precipitation monitoring throughout the valley. CVA will also be monitoring temperature, reservoir levels, snowpack levels, stream staff gages, and all the hydrological data that our partners collect in the valley. This includes data from Montana Fish, Wildlife, and Parks, the Nature Conservancy, the Natural Resources Conservation Service, the Bureau of Land Management, U.S. Geological Survey, and U.S. Fish & Wildlife at Red Rock Lakes National Wildlife Refuge. All this information and data will be compiled into a bi-weekly report that will be sent to stakeholders from CVA. The report may also use predictive models and data from previous years to forecast the next month's hydrological data. This would allow landowners to make management decisions based on real-time data and updated management.

I. Update Process

After the first full year of implementation (2020), a community meeting will be held to review the plan and the monitoring that was done that season. This meeting will result in suggestions from stakeholders on what areas were most successful, which areas need improving, and what topics should either be removed or added to the plan. CVA will continue to review the plan annually after the first year. Community and stakeholder feedback will always be considered and reviewed, as this plan is for them.

J. Links, References, Supplemental Data, and Relevant Publications

Section A – What is Drought?:

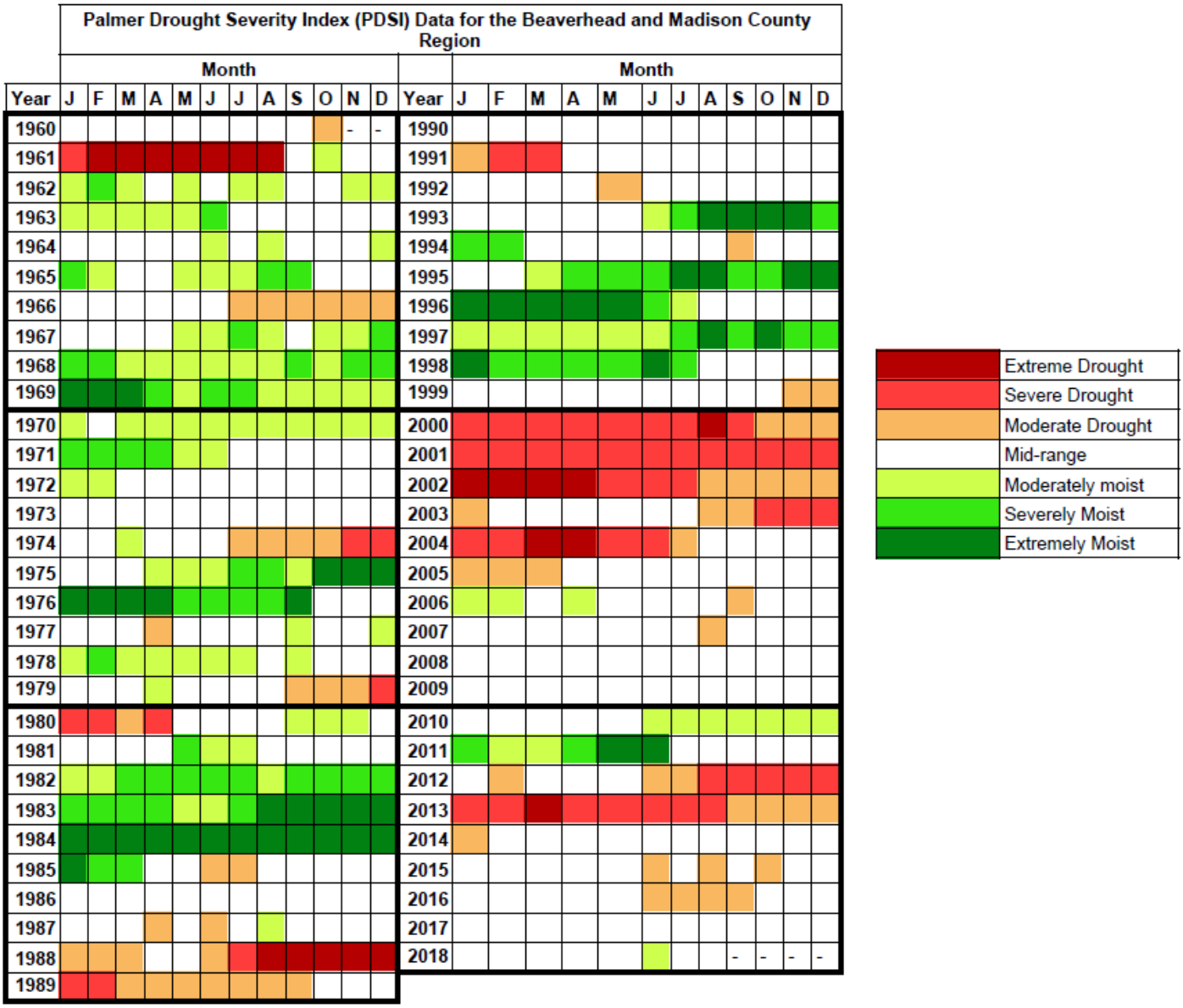
- What is Drought?
  - https://ca.water.usgs.gov/california-drought/what-is-drought.html
  - https://www.usgs.gov/special-topic/water-science-school/science/droughts-things-know?qt-science_center_objects=0#qt-science_center_objects
  - https://water.usgs.gov/ogw/drought/

Section B – Centennial Watershed Background:

- Historical References:
  - Centennial Valley 1820 – 1930, a Journey through Time, Volume 1

- Centennial Valley, 1930 – 2014, a Journey through Time, Volume 2
- Agencies & Recreation in the Valley:
  - Red Rock Lakes National Wildlife Refuge: https://www.fws.gov/refuge/red_rock_lakes/
  - Elk Lake Resort: https://www.elklakeresortmontana.com/
  - Hellroaring Powder Guides: https://www.skihellroaring.com/
  - Centennial Outfitters: https://www.centennialoutfitters.com/
  - J Bar L Ranch: https://www.jbarl.com/
- Climate Data:
  - NRCS SNOTEL Data: https://www.wcc.nrcs.usda.gov/snow/
  - 2017 Montana Climate Assessment: http://montanaclimate.org/

Palmer Drought Severity Index (PDSI) Data: The table below visualizes the Palmer Drought Severity Index (PDSI) data for Beaverhead and Madison County from 1959-2018. It shows the drier years in red and the wetter years in green.



Section C - Development:

- Centennial Valley Association: http://www.centennialvalleyassociation.org/

Section D – Stakeholders:

- U.S. Fish & Wildlife Service - Red Rock Lakes National Wildlife Refuge: https://www.fws.gov/refuge/red_rock_lakes/
- The Nature Conservancy: https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/centennial-valley/
- The Bureau of Land Management: https://www.blm.gov/office/dillon-field-office
- U.S. Forest Service: https://www.fs.usda.gov/bdnf/
- Montana Department of Natural Resources & Conservation: http://dnrc.mt.gov/

Section E – Drought Monitoring:

- Montana Fish, Wildlife, & Parks: http://fwp.mt.gov/
- United States Geological Survey (USGS): https://waterdata.usgs.gov/mt/nwis/current?type=flow
- BLM Weather Station: https://raws.dri.edu/cgi-bin/rawMAIN.pl?mtMRED
- Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS): https://www.cocorahs.org/
- NRCS Snowcourse Sites: https://www.wcc.nrcs.usda.gov/snowcourse/

Section G – Mitigation Actions:

- Natural Resources Conservation Service – Sage Grouse Initiative: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/plantsanimals/fishwildlife/?cid=stelprdb1047022
- Sage Grouse Initiative Website: https://www.sagegrouseinitiative.com/
- Montana State Water Plan: http://dnrc.mt.gov/divisions/water/management/docs/state-water-plan/2015_mt_water_plan.pdf
- Local NRCS Service Center: https://offices.sc.egov.usda.gov/locator/app?service=page/ServiceCenterSummary&stateCode=30&cnty=001

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10. Elk Lake Resort. *Our Historic Montana Lodge Abounds With Interesting Stories From Montana's Past*.

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13. National Oceanic and Atmospheric Administration. Historical Palmer Drought Indices | Temperature, Precipitation, and Drought | National Centers for Environmental Information (NCEI). Available at: https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/overview. (Accessed: 22nd October 2018)