Mitigating the Effects of Climate Change with Beaver Dam Analogues in the Scott River Watershed

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December, 2022

Prepared for Scott River Watershed Council

Introduction

The Scott River Watershed is located in a geologic and ecologically diverse region in Siskiyou County, California about 40 miles south of the Oregon border. This watershed is an important tributary to one of California's largest watersheds, the Klamath River Basin, which is well known for its extensive salmon runs that includes endangered species such as the Coho Salmon (*Oncorhynchus kisutch*) (NMFS, 2014). About half of Scott Valley is privately owned, and according to Siskiyou Resource Conservation District, "the primary use of private land is agricultural in nature, including timber harvest, livestock grazing, and large-scale crop production. Alfalfa, grain, and pasture forage are the most common crops produced in the watershed" (*Agricultural*, n.d.). Native species such as the California pitcher plant (*Darlingtonia californica*) occupy the many meadows in the region surrounded by Jeffrey pines (*Pinus jeffreyi),* both of which are more commonly found to the East Fork of the Scott (CNPS East Bay, 2020). The bedrock in Scott Valley, according to the Scott Valley Watershed Council, dates back around the Late Jurassic and possibly early Cretaceous period and consists of "consolidated rocks whose fractures yield water to springs at the valley margins" (SVWC, 2018). The surrounding upland areas accommodate other endangered species such as the Scott Valley phacelia (*Phacelia greenei*) along with many other perennial and annual species that occupy the many meadows of the region (CNPS East Bay, 2020).

Scott Valley was once historically known as Beaver Valley due to the abundance of the North American beaver (*Castor canadensis*), which in the 20th century were almost hunted to extinction for their water repellent furs (SRWC, 2018). Beavers were once a prevalent species that occupied most of North America year-round, including Scott Valley (Pollock et al., 2015; SRWC, 2018). However, in 1836, a European trapper by the name of Stephen Meek (*Figure 1*) observed the valley filled with beavers who shaped the rivers, ponds, marshes, and meadows that would later be known as one of the finest areas for fur trapping at the time (Beavers Institute, 2018). The area soon was named Beaver Valley after Meek's men trapped about 1,800 beavers alone in 1850, and whose pelts were shipped primarily to Europe, where residents desired waterproof hats made from the beavers' fur, and soon the North American Beaver faced near extinction (SRWC, 2018). Beavers were not the only species affected by the fur trade, as other species that depended on the beavers and their dams suffered as well (O'Keefe, 2021).

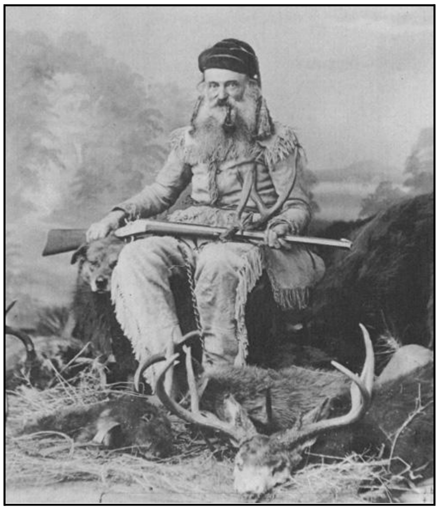

Figure 1: Stephen H. L. Meek, who settled in Beaver Valley in 1836. Photo: Terrible Trail: The Meeks Cutoff; Keith Clark and Lowell Tiller (1967)

These species include the salmon that inhabited the once abundant water systems created by the beaver, such as the endangered Coho Salmon who depend on the beaver dams for habitat (O'Keefe, 2021). The reason Coho salmon are much more impacted than other fish species is due to the fact that this species needs slow moving water in both Summer and Winter, unlike other fish species. Because of this, Coho salmon require beaver dams in order to survive (C. Gilmore, personal communication, December, 2022).

The fur trade was not the only factor that contributed to the destruction of the Scott Valley waterways, fire and mining also contributed heavily. Fire is a naturally occurring process that benefits both plant communities as well as watersheds. Fire provides nutrients and creates more light for new saplings to grow and thrive, as well as other vegetation, by creating more biodiversity that wildlife grazes on or needs for adequate habitat (K. Boston, personal communication, September 2022). Watersheds benefit from fires in a variety of different ways. Fire suppression in many areas throughout the US, including Scott Valley, increase the likelihood of larger, more devastating, wildfires that increase the chance of altering surface hydrology and sediment deposition into the major waterways that house Coho and other salmonid species, as well as wipe out certain species within the forest, which wildlife depends on heavily for survival in said areas (A. Stubblefield, personal communication, October 2022).

In addition to fire suppression, mining was another anthropogenic disturbance to the Scott Valley. The Gold Rush, one of California's most well-known historical events, spelled disaster for the area as gold mining further destroyed the river systems. Mine tailings now completely cover once successful floodplains and miners effectively 'turned the river upside down" (C. Gilmore, personal communication, 2022). From 1936 to 1951, the Yuba Consolidated Gold Fields Company mined the Scott River in order to access placer deposits. They did this by creating a floating dredge that would be used to mine the deposits, and they placed these within a 4.7 mile reach that led downstream of Callahan (Averill 1946).

Climate Change in the Klamath Basin

In the Scott River watershed, as in watersheds across the western United States, the effects of these historic anthropogenic disturbances are compounded by the increasingly apparent effects of climate change. A 2010 report titled "Preparing for Climate Change in the Klamath Basin" summarized many of the anticipated effects of climate change throughout the Klamath Basin based on three global climate models and a vegetation model (Barr et al., 2010). These predictions include an increase in annual average temperature of 2.1°F to 2.6°F by mid-century and 4.6°F to 7.2°F by late-century, with greater increases in summer temperatures than in other seasons. Increases in air temperature will raise stream and river temperatures, likely fueling increased disease outbreaks among aquatic animals and earlier and longer lasting algal blooms (Barr et al., 2010).

While the three climate models in the Barr et al. (2010) report predict varying changes to the amount of annual average precipitation in the Klamath Basin (from a reduction of 11% to an increase of 24%), all three models agree that there will be significant shifts in the timing, amount, and type of precipitation. Both drought and winter storms are predicted to increase in frequency and magnitude in the Klamath Basin (Barr et al., 2010). Longer and more intense droughts will result in fewer opportunities for groundwater recharge and lower spring, summer and fall stream flows, particularly in groundwater-fed waterways. In some cases, streams with already low flows could dry up entirely. More intense droughts may also contribute to wildfire risk; the models predict an 11-22% increase in areas burned by wildfire throughout the Basin by the end of the century (Barr et al., 2010). While more intense and frequent winter storms may bring much-needed precipitation to the region, they would also increase rates of erosion and sedimentation, impairing water quality and infilling the clean gravel and rocks many species of fish rely on for spawning habitat (Barr et al., 2010). Heavy winter rains also threaten to accelerate the premature melting of snowpack, which will reduce the amount of flow in waterways during the snowmelt-driven spring flow recession (Barr et al., 2010).

Steep reductions in snowpack are one of the most concerning anticipated effects of climate change to the hydrological systems of the Klamath Basin. With warmer temperatures, more precipitation is expected to fall as rain than as snow (Barr et al. 2010). Predictions for annual snowpack levels in the Klamath Basin include a 37 to 65% decrease from baseline levels by 2035-45 and a 73-90% loss by 2075-85 (Hayhoe et al., 2004; Goodstein & Matson, 2004). Without a steady supply of snowmelt to provide inputs to rivers and streams during the dry summer months, stream water quantity and quality will continue to decline in the watersheds throughout the Klamath Basin (Barr et al., 2010). This impact will likely be felt most acutely in undammed river systems such as the Scott River, where there is no opportunity to draw from reservoirs for supplemental flows (SRWC, 2018).

In addition to summarizing the anticipated effects of climate change, Barr et al. (2010) offers many recommendations for adapting and building resiliency into natural systems in the region. Among the recommendations were "increasing beaver populations in appropriate locations" (Barr et al., 2010). This suggestion points to a growing recognition of the role that beavers play in maintaining and repairing the ecosystems they naturally inhabit.

Beaver Dams and Beaver Dam Analogues in Restoration and Resiliency-Building Efforts

Beavers are ecosystem engineers whose activities create a cascade of beneficial effects. These benefits arise from the ways in which beaver dams affect the spatial and temporal distribution of water within a watershed (Pollock et al., 2015). As water slows upstream of a beaver dam, it has additional time to infiltrate into the ground and contribute to base flows as well as to recharge and elevate the water table (Pollock et al., 2003).

This slowing-down of water velocities can also improve water quality, particularly with regard to suspended sediment. Slower moving flows allow sediment more time to settle, and beaver dams themselves can function as long-term sediment sinks (Pollock et al., 2015). When beaver dams are in place, sediment that would become a pollutant downstream can actually become an asset upstream as it aggrades incised channels as it settles, raising the elevation of streambeds and allowing channels to reconnect with their floodplains. (Scheffer 1938, Butler & Malanson 1995, McCullough et al., 2005, Pollock et al., 2007, Polvi & Wohl 2012). Water pooling behind a beaver dam is also forced to spread laterally, increasing the wetted area of land and further enabling groundwater recharge (Pollock et al., 2003). The lateral spread of water has numerous other benefits, including the creation and expansion of side channels and riparian and wetland areas. The resulting increase in channel and habitat complexity can help attenuate the destructive impacts of winter storms, such as erosion and high levels of suspended sediment, while also storing more of this water in the watershed to be released over time (Pollock et al., 2003).

The changes that beaver dams initiate in watersheds have many benefits for aquatic organisms and overall biodiversity. By increasing input and storage of organic matter and by creating more water surface area for sunlight to penetrate, beaver ponds boost primary productivity (Francis et al., 1985). This supports populations of micro and macroinvertebrates, who then support larger organisms, such as overwintering juvenile salmonids (Pollock et al., 2015). Beaver ponds also offer breeding habitat for many amphibians, such as red-legged frogs (*Rana draytonii*) and cascades frogs (*Rana cascadae*) (Pollock et al., 2015), and have been shown to increase local amphibian biodiversity (Müller-Schwarze, 2011). The riparian vegetation and insect-richness of beaver ponds attracts many bird species, and beaver-created wetlands offer invaluable waterfowl habitat (Pollock et al., 2015).

Many of the beneficial processes that beaver dams initiate in ecosystems are those most needed to mitigate the effects of climate change. One recent dramatic example of this was discovered after the 2021 Bootleg Fire in the Upper Klamath Basin. The fire burned 413,717 acres and was the third largest wildfire in Oregon's recorded history (Whitcomb, 2022). When fisheries biologists in the Sprague River watershed went out to assess the damage, they found recently thriving trout populations decimated and waterways choked with soot (Whitcomb, 2022). But biologists also found a five-acre area that had been spared; a complex of 8 beaver dams where the water was clear and trout populations were intact (*Figure 2)* (Whitcomb, 2022). In addition to the riparian vegetation and saturated soils warding off flames, the dams had created a "water treatment plant" of sorts that filtered soot and other contaminants (Whitcomb, 2022).

Figure 2. A complex of beaver dams shielded a portion of Dixon Creek from the 2021 Bootleg Fire. Credit: Charles Erdman/Trout Unlimited (2022).

As ongoing and legacy effects of human activities in watersheds intersect with the effects of climate change, encouraging beaver activity offers one approach for restoring ecosystems and building resilience to future challenges.

Because it is currently not permitted to reintroduce or relocate beaver in California, conservationists have been utilizing beaver dam analogues (BDAs) to mimic the effects of natural beaver dams and in many cases, to attract beaver back to areas they once occupied. A BDA is simply a semi-porous channel-spanning structure built with materials similar to what beaver would use (Pollock et al, 2015). In the Scott River watershed, the Scott River Watershed Council has been experimenting with the potential for BDAs to repair degraded stream systems and assist in the recovery of Coho salmon populations (SRWC, 2016).

Coho in the Scott River

The Scott River supports one of the most productive wild stocks of Coho salmon in the Klamath River Basin (SRWC, 2018). This core, functionally independent population is part of the Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) that was listed as threatened under the Endangered Species Act in 1997 (NMFS, 2014). Although the Scott River population is likely above the depensation threshold (a threshold below which problems with successful reproduction begin to occur), it is considered to be at moderate risk of extinction (NMFS, 2014).. Numerous factors have contributed to reductions in the Scott River Coho Salmon population over time including the effects of mining and timber harvest, agricultural and residential water use, overfishing, dams and other barriers to passage, and the near-elimination of beaver from the landscape (NMFS, 2014). According to the Siskiyou RDC, “currently, approximately 30,000 acres of land in the Scott River watershed are irrigated (about

6% of the watershed) utilizing surface and groundwater sources” (Siskiyou RDC). These stressors have interacted with natural factors such as erosive soils and the drought-prone Mediterranean climate to result in degraded and fragmented habitats (SRWC, 2018; NMFS, 2014). Juvenile Coho Salmon are particularly affected by this given their dependence on off-channel rearing habitat and thermal refugia. The juvenile life stage has been identified as one of the most limiting factors for the Scott River Coho Salmon population (NMFS, 2014).

Beechie et al. (2012) explored the most helpful restoration strategies for ameliorating the effects of climate change on salmon populations in the Pacific Northwest. The authors found that the most helpful restoration strategies are those that focus on “restoring floodplain connectivity, restoring stream flow regimes, and re-aggrading incised channels” – all outcomes that can result from beaver activity or BDAs. The authors summarized 27 different restoration techniques and their ability to mitigate the effects of climate change on peak flows, low flows, stream temperatures, and overall salmon resilience. The reintroduction of beaver was the only technique to have positive effects across every parameter (Beechie et al., 2012).

BDAs in the Scott River Watershed

In 2014, the Scott River Watershed Council (SRWC) and its project partners constructed California’s first BDAs on Sugar Creek, a tributary of the Scott River. This was followed by the placement of BDAs on other Scott River tributaries including Miners Creek in 2015, a side channel site off of French Creek in 2017, and Rattlesnake Creek in 2018. Monitoring of these sites has yielded results that suggest BDAs can function in a similar fashion to beaver dams, increasing surface flows and groundwater levels and improving Coho Salmon habitat. Charnley (2018) summarized the results of 2016 and 2017 monitoring reports by the SRWC. A selection of these results is listed in Table 1.

Table 1. Select results from Scott River Watershed Council's beaver dam analogue projects. (Charnley, 2018; SRWC, 2016; SRWC, 2017).

Parameter	**Location**	**Outcome**
Surface Water	Sugar Creek and a Scott River side channel	1,600 linear ft of stream above and below BDAs that typically ran dry in the summer retained flow throughout the summer months
Ground Water	Sugar Creek	During high winter and spring flows BDAs increased groundwater recharge and storage capacity
Stream Temperature	Sugar Creek	New cool, deep-water pools were created
Habitat	Sugar Creek	The volume of aquatic habitat in BDA ponds increased by 40% between 2016 and 2017
Habitat Rearing Capacity for Fish	Sugar Creek	By 2017, habitat rearing capacity increased by 2,000% over pre-project conditions
Beaver Activity	All sites	Beavers have been active at all BDA sites since their installation

While these BDA projects have so far occurred in the lower elevation tributaries of the Scott River, SRWC has begun investigating the potential for the installation of BDAs as part of subalpine meadow restoration projects.

Mountain meadows have been likened to sponges, soaking up winter and spring precipitation and snowmelt and releasing these stores in the summer and fall (Rodriguez et al., 2017). This leads to attenuation of peak flows, extended summer base flows, increases in groundwater storage capacity, and reduced in-stream water temperatures (Climate Change Resource Center, n.d.). Additional benefits conferred by healthy mountain meadows include carbon sequestration, water filtration, and the harboring of high levels of biodiversity (Yarnell et al., 2020; Lubetkin et al., 2017).

Unfortunately, meadow degradation is widespread across much of the western US. Livestock grazing, the removal of riparian tree species, fire exclusion, logging, road building, and other historic land uses have led to simplification and incision of many meadow channels. This channel incision increases erosion and siltation downstream, decreases habitat quality, impairs meadows' ability to store and release water at critical times, and encourages the establishment of non-meadow species (Climate Change Resource Center, n.d., Yarnell et al., 2020). The encroachment of conifers into meadows is an additional concern. While partially attributed to similar sources as channel incision, conifer encroachment seems to be largely driven by climate variability and change (Lubetkin et al., 2017). One model based on an analysis of 340 subalpine meadows in the central Sierra Nevada predicts that these meadows will have fully converted to forest by the end of the twenty-first century (Lubetkin et al., 2017).

Meadow restoration efforts have increased in recent years, in part due to the recognition that healthy meadows can help buffer the effects of climate-change related decreases in snowpack and earlier snowmelt. In California, mountain meadows were recently identified as part of the state's water infrastructure, making them eligible for the same forms of funding as other water infrastructure (CA Legis. Assemb. 2016, Hunt et al., 2018). Meadow restoration may take many forms but is often centered around reconnecting incised channels with their floodplains. The effect of meadow restoration can be substantial. In the central Sierra Nevada, reconnecting an incised meadow channel with its floodplains increased summer baseflow 5-12 times above pre-restoration levels, even during sustained drought conditions (Hunt et al., 2018). Not surprisingly, beaver and BDAs factor into many restoration projects. A project in Childs Meadow near Lassen National Park explored restoration through both cattle exclusion and the installation of BDAs (Yarnell et al., 2020). Post-project monitoring revealed that water elevations were "highly mediated by the degree of beaver activity and groundwater elevations near the BDA ponds were higher when the ponds were maintained" (Yarnell et al., 2020). Monitoring of nearby natural beaver dams yielded similar findings (Yarnell et al., 2020).

Meeks Meadow

The Scott River Watershed Council has identified Meeks Meadow as a location where the installation of BDAs could generate benefits downstream and in the meadow itself. Meeks Meadow is a tiered meadow system at the southern base of Etna Mountain in the Klamath National Forest. Located at approximately 6,200 feet elevation, the lower meadow contains Meeks Meadow Lake, which feeds Meeks Meadow Creek (*Figure 3*). Meeks Meadow Creek then flows into French Creek, a large tributary of the Scott River and extremely important Coho Salmon rearing stream. French Creek is among the highest priority streams for restoration in the Scott River Watershed given its historic high densities of Coho Salmon redds, its high habitat intrinsic potential, and the fact that it provides critical cold water refugia for juvenile Coho Salmon (SRWC, 2018, NMFS, 2014).

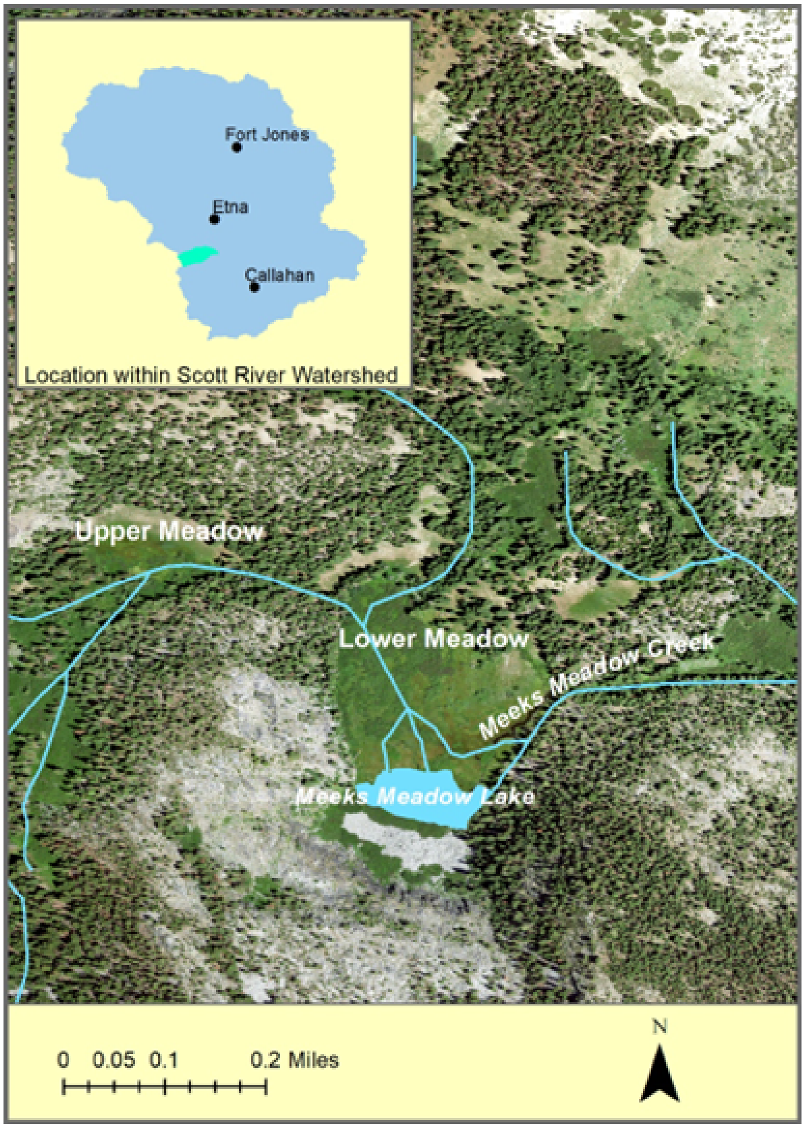

Figure 3. Meeks Meadow in the Scott River Watershed (Gegg-Mitchell, 2022. Created using Esri's ArcGIS software).

In addition to its connectivity to French Creek, Meeks Meadow would also be an appropriate location for BDAs given its recent occupancy by beaver. SRWC staff observed a natural beaver dam at the meadow outlet in the early 2000s (*Figure 4*), however there have not been signs of beaver activity in several years (C. Gilmore, personal communication, November 2022).

In 2017, SRWC and its project partners installed groundwater monitoring wells and established aspen monitoring transects throughout Meeks Meadow as part of an effort to understand how mountain meadows function over time and how climate change may be affecting ecological and hydrological processes. If BDAs are installed at Meeks Meadow, this existing monitoring infrastructure presents an opportunity to obtain detailed data on how BDAs impact groundwater levels and vegetation communities, informing this and other efforts.

Figure 4. Beaver dam at the outlet of Meeks Meadow, October 14, 2002. (SRWC, n.d.).

Conditions in Meeks Meadow

Intense livestock grazing and fire exclusion have both factored into degraded conditions in Meeks Meadow. Fire exclusion in particular has contributed to the encroachment of conifers into meadow vegetation (C. Gilmore, personal communication, November 2022).

In an attempt to better understand conditions in and around Meeks Meadow, we gathered and analyzed data related to snowpack, vegetation, and precipitation. We also wanted to see if we could detect any trends consistent with predictions of the effects of climate change in the region.

Methods/Description of Analysis

Snowpack data were sent from those at the Scott River Watershed Council, who compiled data from 5 monitoring stations. Snowpack level was collected April 1st for the years 2000 to 2022 as described in *Section i.* below. Historical aerial images were used to compare vegetation cover in *Section ii.*

Snowpack data were separated out to only include Snow Water Equivalent of five sites: Dynamite Meadow and Middle Boulder in the Scott Mountains, Etna Mountain and Swampy John in the Salmon Mountains, and Box Camp in the Marble Mountains. Data were listed out to show how much snowpack was recorded on April 1st of the given year, and then compared between all 22 years of recording. According to the USDA and the US Forest service, who also used the same monitoring stations as we did, "April 1st is an important date for surveying snow because early April is historically when the snowpack is at its maximum; hence this date has the greatest weight when the state forecasts annual water availability"(*Klamath National Forest - News & Events*, 2022).

Using a regression, we were able to see what the relationship was between snowpack and the year. What we found was that there is little statistical significance between the amount of snowpack given per year, with the only significant site being Middle Boulder (*Figure 6*)**.** Snowpack level has been gathered every year on April 1 since 2000 to 2022, thus giving a good baseline set of data in the above 5 monitoring stations. What we can see is that there is a steady decline in snowpack levels at all stations, with all declining especially around the years 2014 and 2015 for most of the stations. This could explain why, in section ii, there seems to be less greenery in *Figure 13.* It could also explain why the small streams on the top right side of the pond are now dried up in 2016, but still visible in 2014. Additionally, the Forest Service stated from their own analyzation of the data gathered on April 1st showed that, as of 2022 "the snowpack is at 16% of the historic average snow height (snow depth) and at 18% of the historic Snow Water Equivalent ("SWE", measure of water content) across all survey points" (*Klamath National Forest - News & Events*, 2022).

Total annual precipitation data for Callahan, California, were gathered from the Western Regional Climate Center and from the California Department of Water Resources Data Exchange Center. Water year 2018 was excluded due to gaps in the data. The weather station in Callahan is 17.5 miles southeast of Meeks Meadow Lake and the closest station with long term precipitation data.

i. Snowpack Level: April 1

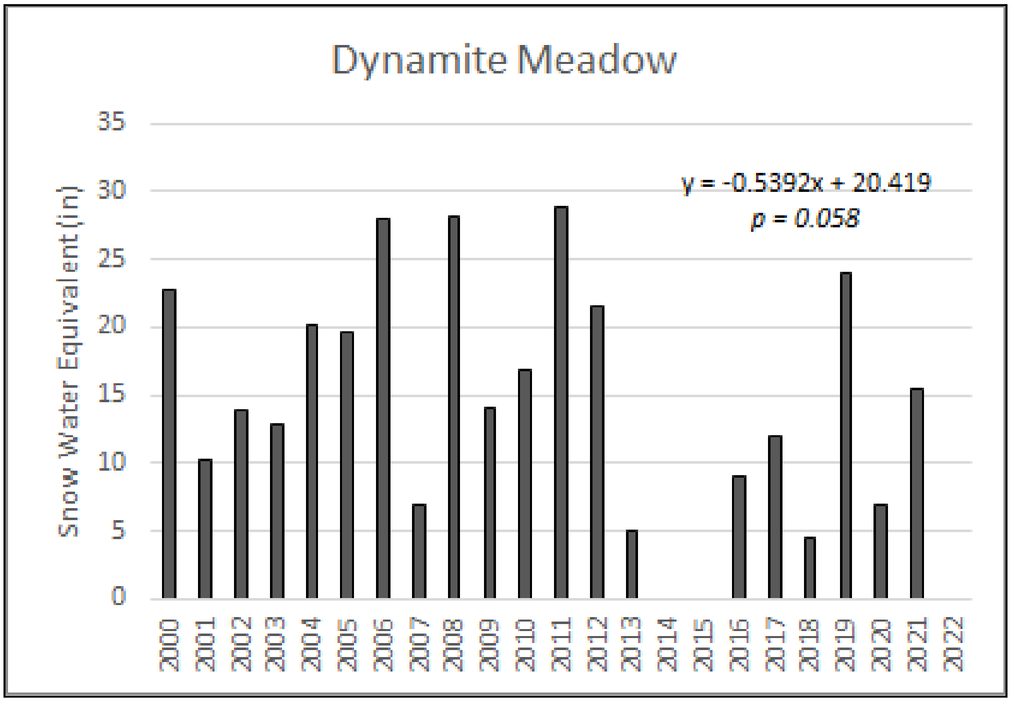

Figure 5. April 1 snowpack levels at the Dynamite Meadows monitoring station in the Scott Mountains, 2000-2022.

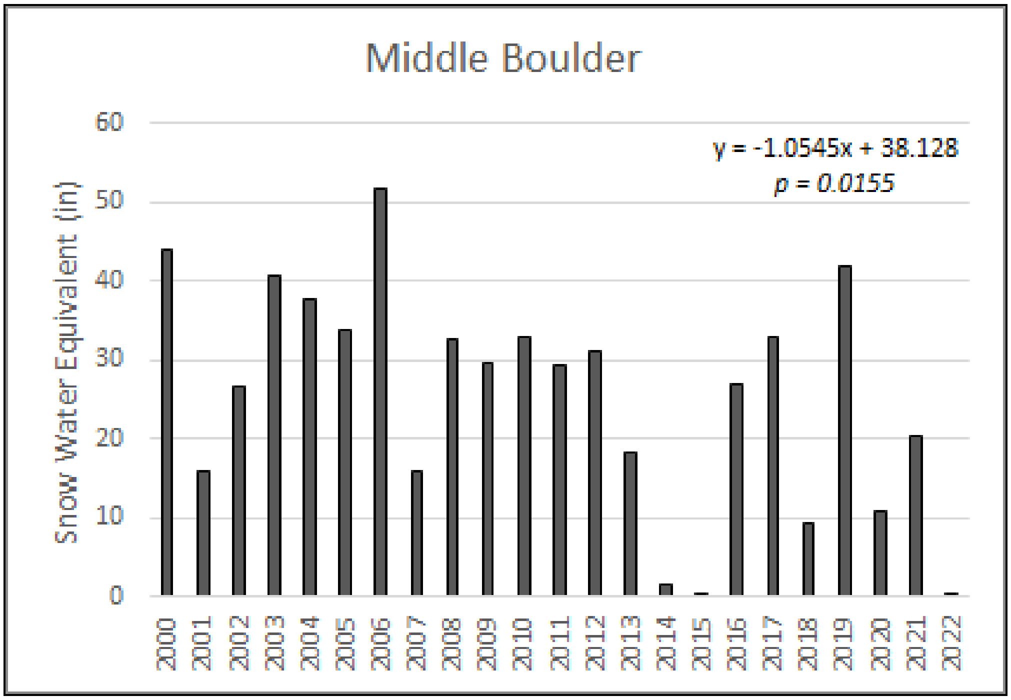

Figure 6. April 1 snowpack levels at the Middle Boulder monitoring station in the Scott Mountains, 2000-2022.

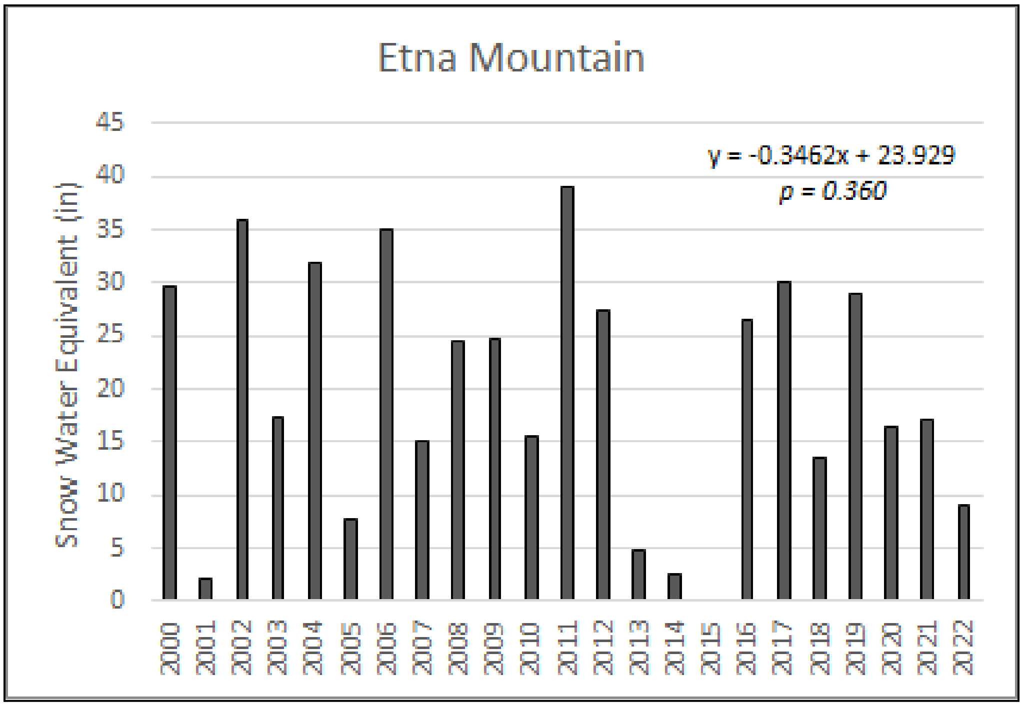

Figure 7. April 1 snowpack levels at the Etna Mountain monitoring station in the Salmon Mountains, 2000-2022.

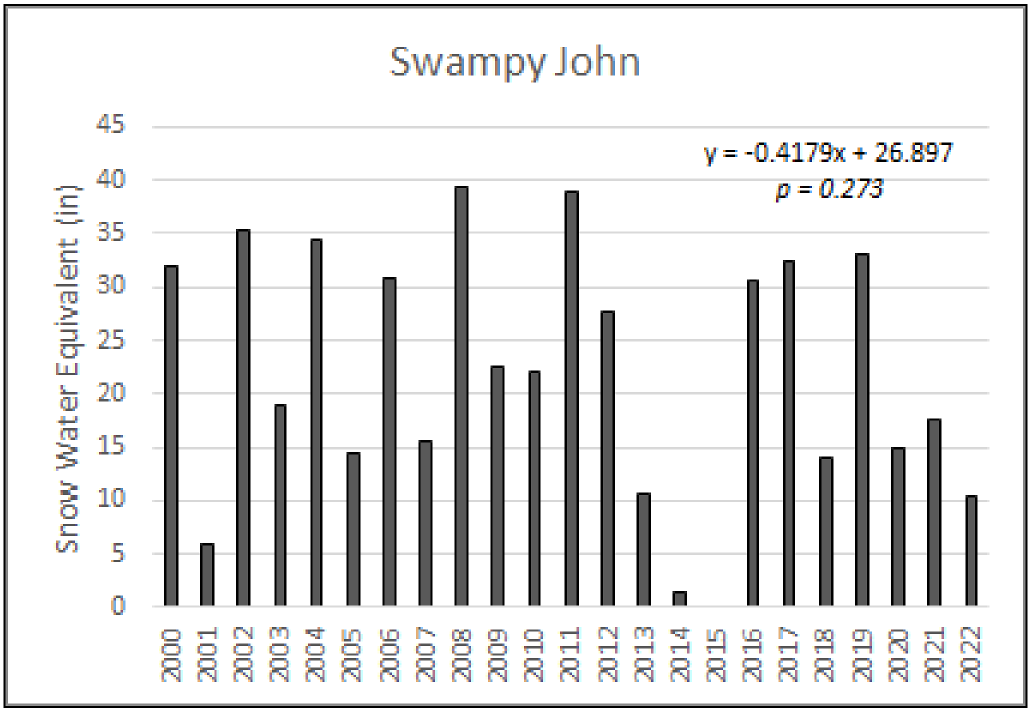

Figure 8. April 1 snowpack levels at the Swampy John monitoring station in the Salmon Mountains, 2000-2022.

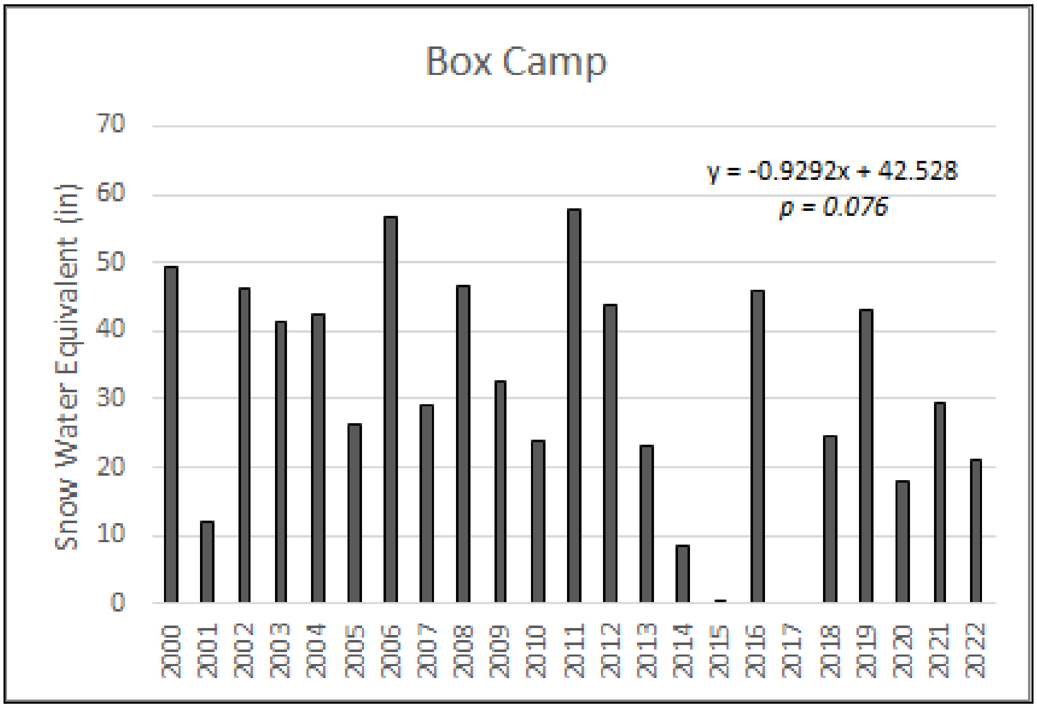

Figure 9. April 1 snowpack levels at the Box Camp monitoring station in the Marble Mountains, 2000-2022.

ii. Changes in Vegetation Cover: 1993 – 2016

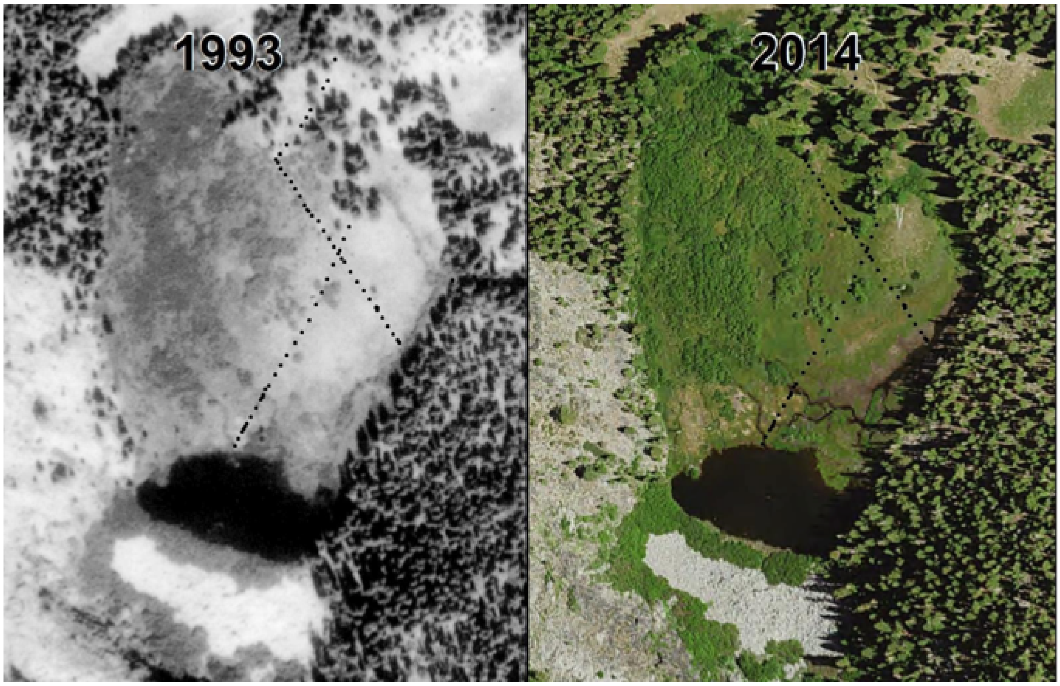

Figure 10. Vegetation cover in Meeks Meadow, 1993 and 2016.

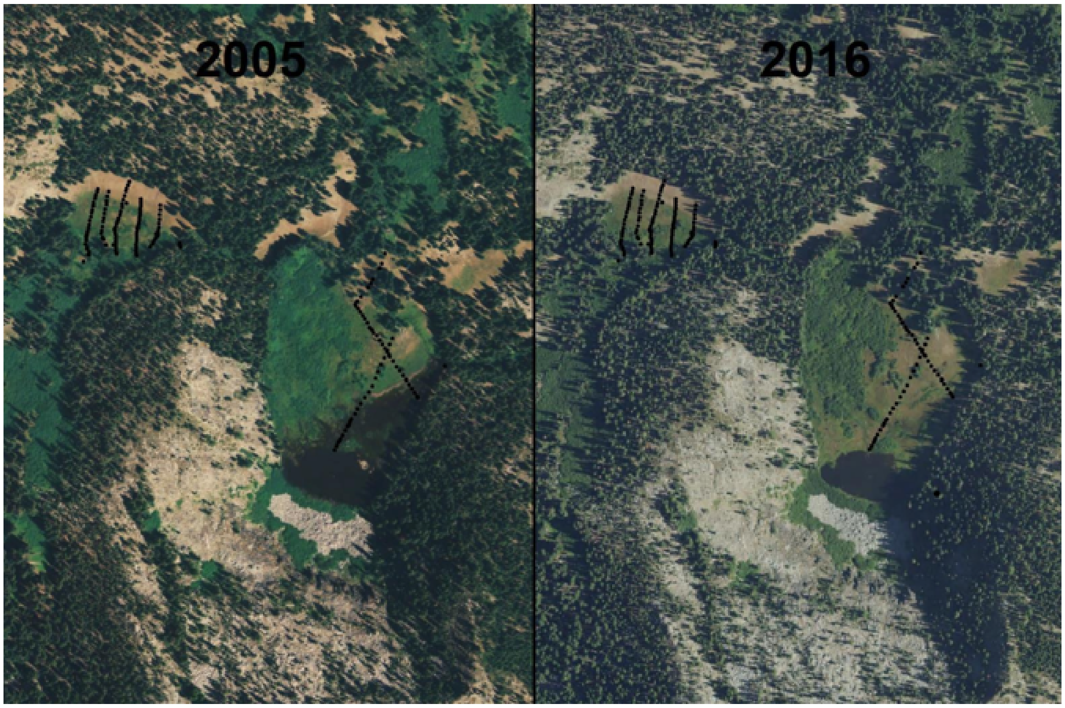

Figure 11. Vegetation cover in Meeks Meadow, 2005 and 2016.

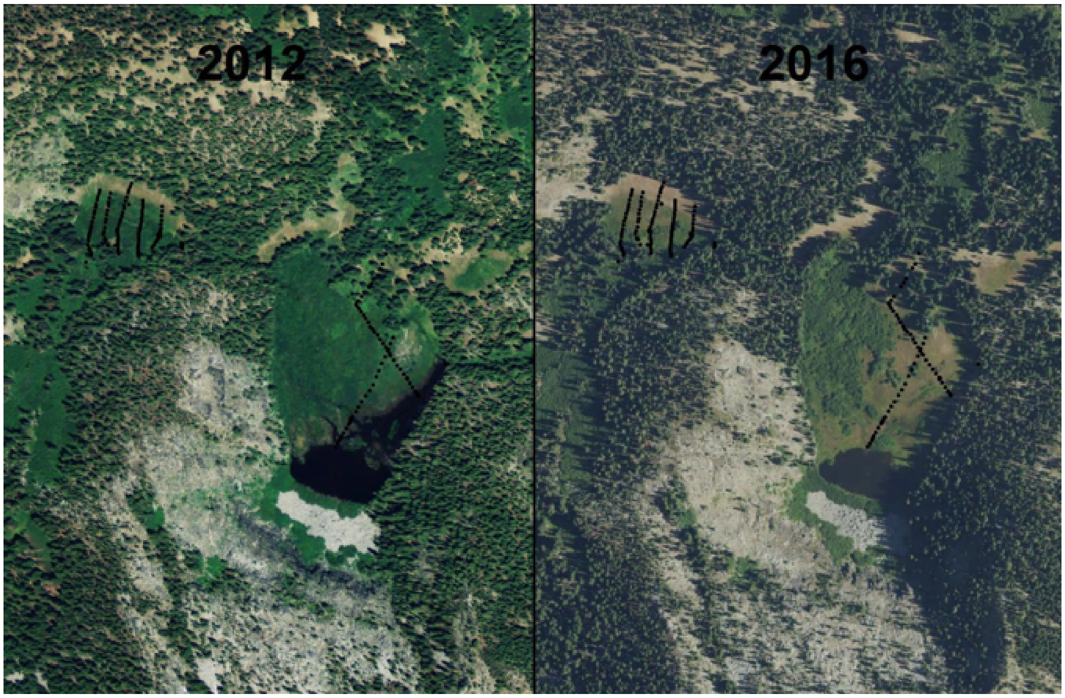

Figure 12. Vegetation cover in Meeks Meadow, 2012 and 2016.

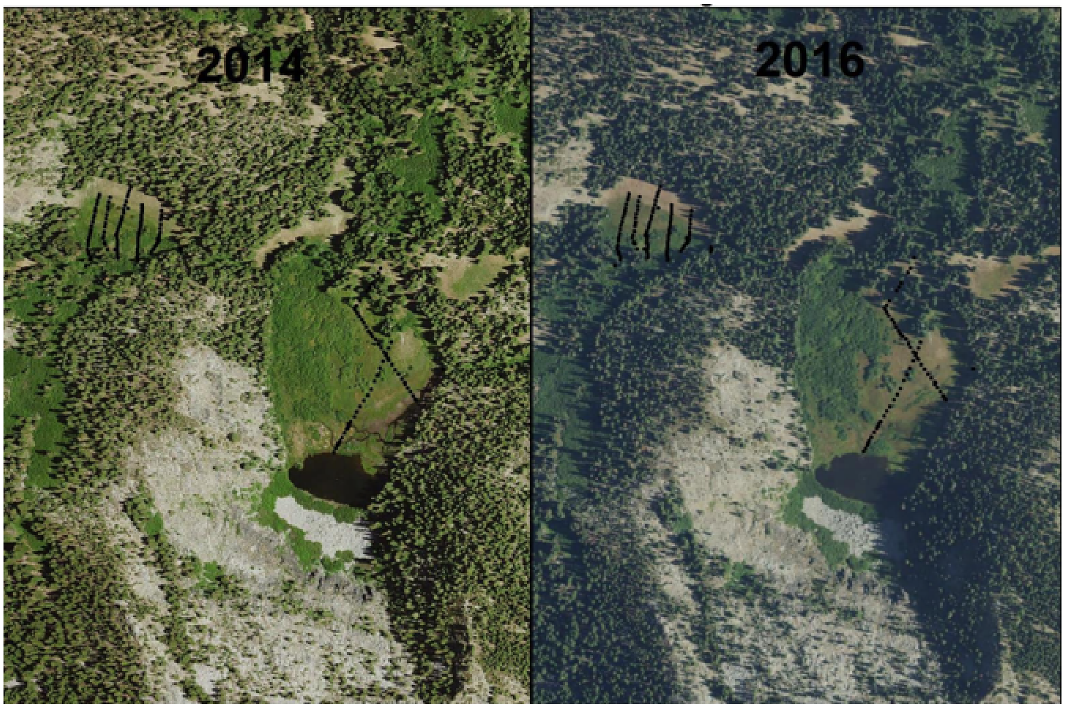

Figure 13. Vegetation cover in Meeks Meadow, 1993 and 2016.

Figure 14. Vegetation cover in Meeks Meadow, 2022 (Google Maps).

Vegetation cover through Meeks Meadow has been seen to change drastically throughout history. As shown in *Figure 12,* there is seemingly a drastic decrease in vegetation cover between 2012 and 2016, with most of the meadow now appearing much dryer in 2016. Not only this, but the streams that can be seen on the top right side of the small pond, the small streams encroaching inland are now covered completely. There is the possibility, since a beaver had previously occupied this pond sometime from 2012 to 2016, it could explain why the streams are not present in 1993 as well as no longer present in 2016.

Total Annual Precipitation, Water Years 1990-2021

Total annual precipitation measured in Callahan, California since water year 1990 shows wide variability *(Figure 15).* Mean annual precipitation for 1943-2016 measured 20.87 inches, and several years exceed this while others dip far below. Water year 1994, which was one of the driest years in the period (12.36 inches), was followed by one of the wettest years in the period (32.4 inches) in 1995.

While climate models vary in their predictions of climate change's effect on annual precipitation in the Klamath Basin, most suggest that both drought and winter storms will increase in frequency and magnitude. If this is the case, the interannual variability already seen in total annual precipitation will likely increase, putting further stress on already strained ecosystems.

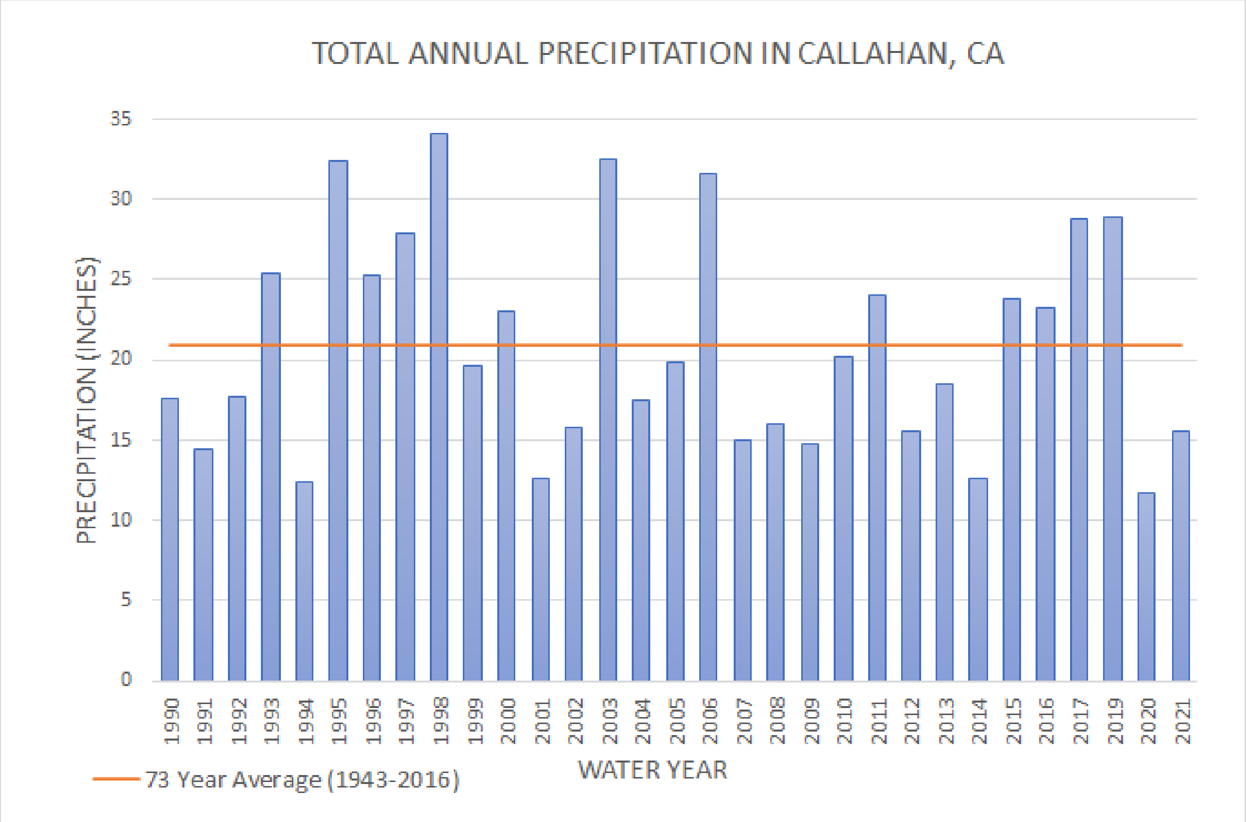

Figure 15. Total annual precipitation for water years 1990-2021 in Callahan, California.

Conclusion

Similar to other areas within the Scott River Watershed, Meeks Meadows has experienced the impact of anthropogenic disturbances throughout modern history. The arrival of White settlers into Beaver Valley led to a drastic decline in beaver populations, which led to a subsequent diminishment in beaver dams and thus a decline in the health and function of Scott Valley waterways. The gold rush also brought along many different disturbances like the disposal of mine tailings on riverbanks as well as increased timber harvesting, both of which led to a further decline in the quality of the watershed. As climate change brings warmer temperatures, longer and more intense droughts, decreased snowpack, and more severe and frequent winter storms to the Klamath Basin, strategies are needed to maintain ecosystem integrity. As we can see from our data points, there is clear evidence of climatic changes such as increased temperatures leading to decreased snowpack. These changes can lead to lower water levels and decreased water quality, which impacts plant and animal communities within the meadow and downstream of it.

Within the Scott River Watershed, the installation of BDAs at Meeks Meadow could create benefits for French Creek and its Coho population through attenuating the damaging effects of peak flows during winter storms, improving water quality, and increasing groundwater storage in the headwaters- providing cooler and more continuous flows throughout the summer and fall. BDAs could also help preserve meadow vegetation communities in Meeks Meadow, ensuring the meadow can continue to provide habitat and continue carrying out its beneficial functions. Installing BDAs would also likely help attract beavers back to the area who could eventually assume maintenance of BDAs and create additional dams. In ecosystems like Meeks Meadow that are threatened by multiple stressors, allying with beaver through the construction of BDAs offers a promising approach for restoring and maintaining the natural processes that sustain balance and resilience.

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