"In Montana, you're only a week away from a drought": Ranchers' perspectives on flood irrigation and beaver mimicry as drought mitigation strategies

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On the Ground

- The concept of natural water storage has gained traction as an alternative to traditional dams that can potentially mitigate the impacts of changing precipitation patterns by slowing runoff and increasing aquifer recharge. We investigated the barriers and opportunities for two natural water storage practices, flood irrigation and beaver mimicry.
- We interviewed 8 amenity and 14 traditional ranchers in the Red Rock Watershed in southwest Montana. We found ranchers predominately rely on reactive, rather than proactive drought strategies. Most amenity ranchers had formal drought plans in place, but none of the traditional ranchers had formal drought plans.
- Ranchers perceived the two natural water storage practices differently. While all agreed on the benefits of flood irrigation, they saw the barriers, such as labor issues and loss of efficiency to outweigh the benefits. Many ranchers were skeptical of the benefits beaver mimicry could provide and voiced concerns over the cost, permits, water rights, and operational impacts.
- While there are barriers to both strategies, local agencies and actors can work to build trust and practice flexibility when working with ranchers. Ranchers mentioned potential incentives for implementing these strategies, which local agencies can use when working with them.

Keywords: Beaver mimicry, Drought planning, Flood irrigation, Ranching, Range management.

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Introduction

Drought has the potential to impact both natural environments and human communities, with specific repercussions for agricultural communities. To mitigate drought, water managers and water users often rely on water stored in large reservoirs. However, given the growing recognition of the negative social, economic, and environmental impacts of traditional dams,[1] there is increasing interest in alternative forms of water storage.[2] Natural water storage relies on natural infrastructure to slow spring runoff and increase shallow aquifer recharge and raise groundwater levels. Natural infrastructure is defined as the "strategic use of networks of natural lands, working landscapes, and other open spaces to conserve ecosystem values and functions, while providing associated benefits to human populations" (p. 10).[3]

Flood irrigation and beaver mimicry are two practices that have the potential to enhance natural water storage. In many watersheds, shallow groundwater is responsible for the base flows in rivers and streams, which is especially important during drought years.[4] Groundwater is released slowly compared with surface water, and groundwater does not suffer evaporative losses like streams, lakes, or reservoirs.[5] While these practices offer potential drought mitigation benefits, previous research on the adoption and diffusion of innovation among agricultural producers emphasizes the need for new practices to address practical needs and fit with existing technologies and practices.[6] As such, it is important to understand agriculturalists' perceptions and needs related to drought and natural water storage practices.

We examine how amenity and traditional ranchers in southwest Montana deal with drought, as well as their perceptions of flood irrigation and beaver mimicry as drought mitigation strategies on their property. Our findings highlight barriers and opportunities for implementation that are applicable to regions beyond our case study. We begin with an overview of relevant literature on drought planning, natural water storage, and rancher typologies. Next, we describe

our case study in southwest Montana and our methods for this qualitative study. Our results are presented in four sections: how ranchers plan for and respond to drought, ranchers' views on flood irrigation, ranchers' views on beaver mimicry, and differences between traditional and amenity ranchers. We conclude that although ranchers see the benefits of natural water storage as a drought mitigation strategy, there are important barriers to overcome for ranchers to maintain or return to flood irrigation and/or implement beaver mimicry projects.

Reactive and proactive drought responses

Drought occurs at local, regional, and global scales and is generally understood as a "temporary dry period" or a water deficit compared with normal conditions.[7] Drought affects both human communities and ecosystems.[8] For ranchers, drought can reduce grazing and irrigation capacity, resulting in reduced sale weights, brood herd numbers, and owner equity.[9] Despite drought being one of the most costly natural disasters,[10] drought planning in the United States is not as well-developed as other natural hazards planning.[11] The lag in drought planning can be attributed to how drought acts compared with other natural hazards.[12] Drought impacts are nonstructural, cover large geographic areas, and can be less overt on the landscape.[12]

Historically, drought plans were largely reactive plans or crisis management approaches, concentrating only on the impacts of drought.[13] Wilhite[12] developed the concept of proactive drought planning in the early 1970s. Proactive drought planning or drought risk management "is focused on identifying where vulnerabilities exist and addresses these risks through systematically implementing mitigation and adaptation measures that will lessen the risk associated with future drought events" (p. 5).[13]

Most drought actions, internationally and within the United States, are reactive, in the form of emergency response and relief programs.[13] At the federal level in the United States, there are numerous drought responses available for agricultural producers.[14] The Farm Service Agency provides emergency loans for producers who suffer losses related to crop production or crop quality.[14] The Livestock Indemnity Program provides compensation to livestock producers who suffer livestock deaths from natural disasters.[14] Additionally, the Livestock Forage Disaster Program provides reimbursement to producers who experience grazing losses on pasture or native land that affect livestock.[14]

At the agricultural producer level, drought responses are similarly reactive and often do not use proactive drought actions.[15-17] Some agricultural producers do not see the need to make drought plans because they do not see drought as a specific circumstance requiring a specific strategy.[17] These agricultural producers either view drought as too severe to plan for and prefer to deal with as it occurs, or see drought as one of many challenges they encounter.[17]

Ranchers, a subset of agricultural producers, have heterogeneous drought beliefs[17] but use similar indicators to assess if they are in a drought.[15,18] These indicators include snowpack levels, low rainfall, and low vegetation growth.[18] Previous case studies have found that ranchers hold differing beliefs about whether they can plan for drought, if drought is just another situation to deal with, if drought is cyclical, or if drought is due to climate change.[16,17,19]

Common reactive drought responses for ranchers include de-stocking, buying feed, receiving federal disaster aid, weaning calves early, selling cattle early, renting pasture, moving livestock to feedlots, diversifying ranch operations, and making off-ranch income.[15,17,20] Proactive drought responses include storing feed, grass banking, conservative stocking rates, resting pastures, and changing livestock types.[15,19,20] Regulatory procedures can delay ranchers' drought responses.[20] Ranchers' drought responses, whether proactive or reactive, typically center around the ranch operation and often miss an opportunity to reduce drought risk by changing water use during drought.[15,17,19]

Natural water storage as a potential proactive drought mitigation strategy

In snowmelt driven watersheds, precipitation is stored as snow during the winter and released as water throughout the spring and summer.[21] In the face of climate change, many regions—including Montana—are experiencing a shift in the timing of snowmelt with earlier spring runoff and less water available during late summer months and an increased likelihood of drought.[22,23] Increasing temperatures are predicted to lead to more rapid, intense, and frequent droughts.[7,22,24] This highlights the need for more water storage to mitigate drought conditions.[2]

The California Roundtable on Water and Food Supply encourages water managers to take a broad view of water storage and suggests "a comprehensive approach to holding back as much water as possible in the landscape for later use while maintaining healthy ecosystems" (p. 2).[25] This approach uses natural ecosystems such as riparian areas, wetlands, and floodplains that retain high spring flows and slowly return groundwater back to the system.[4,25] The concept of natural infrastructure also includes aspects of the working landscapes that can be used to achieve conservation goals, such as natural water storage.[3] The practices of flood irrigation and beaver mimicry serve as two potential strategies for natural water storage to mitigate drought in Montana.

Flood irrigation

Many irrigators have transitioned from flood to sprinkler irrigation systems.[26] Flood irrigation (also known as gravity, surface, or furrow irrigation) typically uses gravity to spread water across the soil surface, saturating the soil profile.[27] In contrast, sprinkler irrigation (which includes center pivot, hand line, and wheel lines systems) applies pressurized water

to crops through spray nozzles, but the soil surface remains largely unsaturated.[27]

Irrigation efficiency is a proportion of water beneficially used by a crop over the consumptive use.[28] Given this definition, sprinkler irrigation is a more efficient irrigation technology that improves the "crop per drop."[29] But, "the definition of efficiency does not account for the social or ecological benefits that can be produced by flood irrigation" (p. 286).[30]

Recent studies have raised new questions about the efficiency of sprinkler irrigation systems and potential benefits of flood irrigation.[31-33] Sprinkler irrigation may actually increase consumptive water use by incentivizing irrigators to expand irrigated acreage, convert to more water intensive crops, achieve marginal yield responses by adding additional water, and/or allowing downstream junior water users to consume more water than previously.[29,31,34-36] Furthermore, conversion to sprinkler irrigation may result in reduced return flows, less aquifer recharge, and lower water table levels.[37-39]

Some argue that when viewed at the watershed or basin scale, nonconsumed water that was previously considered a "loss" at the farm scale (e.g., runoff), is often recovered elsewhere in the system and contributes to surface supplies and groundwater.[29] Flood irrigation and leakage from flood canals can replenish groundwater, promote aquifer storage, boost soil moisture, and provide later season streamflows.[38-41] Irrigation recharge to soil can provide moisture to grow crops, which is a common form of human-caused recharge to groundwater.[42] Flood irrigation can also supplement streamflow later in the season.[41] In many instances, flood irrigation creates and sustains ephemeral and permanent wetlands.[43,44] These wetlands serve as habitats for various species, especially birds and waterfowl.[44,45] However, the effects of changes in irrigation on streamflow and aquatic ecosystems depend on the hydrological and geological conditions, as well as irrigation management decisions, at a specific site.[36]

Beaver mimicry

Beaver mimicry is a conservation technique being rapidly adopted by many stream restoration practitioners.[46] Beaver mimicry refers to practices mimicking the effects of beaver dams, such as the construction of rock dams, wooden posts with willows weaved in between, sod mats, or other techniques.[5,47] While we do not focus on the perceptions of beaver reintroduction, the conservation goals are similar, including restoring intermittent streams into perennial streams, converting losing streams into gaining streams, reducing streamflow and spreading the water's energy to deposit sediments and elevate the streambed of incised streams, creating riparian and wetland habitat, and increasing groundwater storage and aquifer recharge.[5,48,49]

For both flood irrigation and beaver mimicry, further biophysical research is needed to determine when, where, and under what conditions these practices can provide natural water storage and other benefits.[50,51] Simultaneously, more research is needed to understand agriculturalists' perceptions and needs related to flood irrigation, beaver mimicry, and natural water storage as a drought mitigation strategy.[47] Even in areas where natural water storage projects are biophysically feasible, public acceptance and support of these projects will be critical for implementation, especially on private lands. Therefore, it is important to understand landowner and land manager perceptions of drought and natural water storage practices and how those perceptions may differ among different types of ranchers.

Amenity and traditional rancher typologies

A landowner typology can be a useful heuristic for understanding the different value systems, perceptions, and socioeconomic factors influencing land management attitudes and behaviors.[52] Gosnell and Travis[53] developed a typology for large landowners (i.e., owners of 161 hectares [400 acres] or more) that included traditional ranchers, part-time ranchers, amenity buyers, investors, corporations, developers, conservation organizations, and others (such as federal agencies). We have adapted this typology to focus on the similarities and differences between just traditional and amenity ranchers. Traditional ranchers are defined as full-time ranchers whose majority income is generated from their operation; run the ranch as a family or generational operation; and/or compare their livelihoods, incomes, or values to those of amenity ranches.[53] In contrast, amenity buyers are defined as those who do not rely on the ranch as a major income source; acquire their ranches for recreation or other benefits; and/or employ a ranch manager for agriculture production management.[53]

Montana, like much of the American West, is experiencing an influx of amenity migration to rural landscapes. Amenity migration involves suburban or urban populations moving seasonally or permanently into historically extractive (e.g., mining, ranching, and timber) landscapes.[54,55] New amenity landowners usually bring different environmental views, rural ideals, and land management desires, which can have consequences for community dynamics, land use, and policies.[55,56] Traditional landowners are equipped with local knowledge and often rely on natural resources for their livelihoods.[56] Often, amenity landowners value conservation and have the financial means to implement such practices, though they may lack the local knowledge to do it.[56] Amenity migrants struggle with their desires for an "authentic" rural landscape that comes from the agriculture production industry while also preferring environmental or conservation improvements.[54] The economic consequences associated with amenity migration include the commodification of the rural lifestyle, higher land prices as more amenity migrants buy out ranches or farms, focus on recreation or conservation practices over production, and an inflow of capital that can benefit local economies.[55] Certain data, such as population changes, migration, residential development, nonlabor income, and travel and tourism employment, can be used to assess amenity migration in a region.[57] As we describe below, the case study site in southwest Montana is experiencing an influx of amenity migrants.

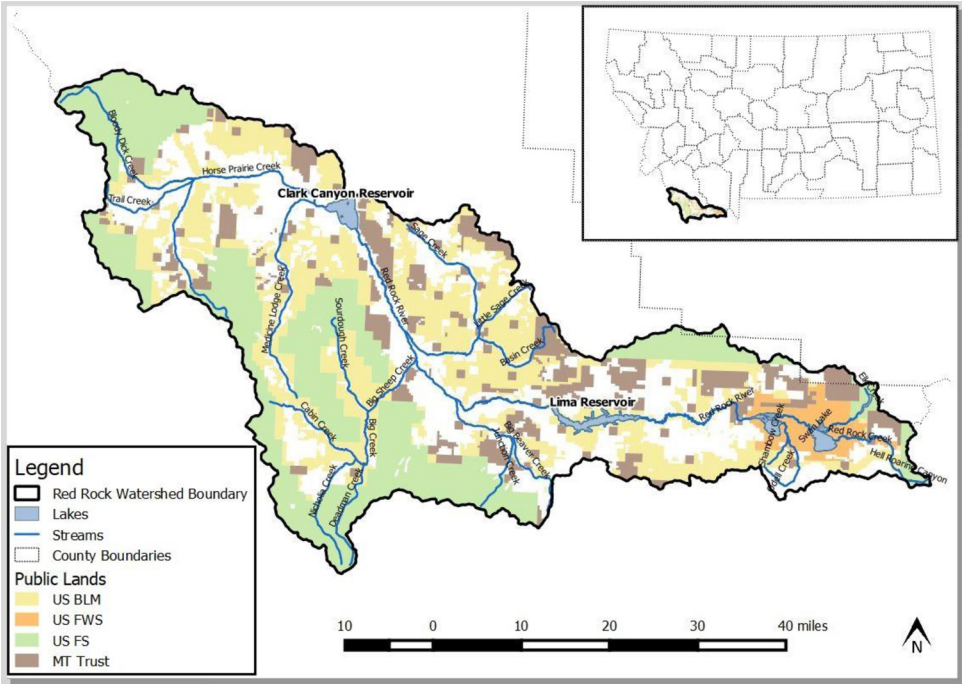

Figure 1. Red Rock Watershed in southwest Montana showing waterways and land ownership.

Therefore, we used an amenity and traditional rancher typology to understand the differences between these groups.

Case study site: The Red Rock Watershed

The Red Rock Watershed is a 4,092 square kilometer (1,580 square mile) snowmelt-driven watershed located in southwest Montana and serves as a headwater basin to the Missouri River (Fig. 1). The Red Rock Watershed falls mostly within Beaverhead County, with a small area located in Madison County. Of the 56 counties in Montana, Beaverhead County is one of the top five water withdrawers for irrigation, withdrawing between 1.5 million to 3.1 million cubic meters (400 to 832 million gallons) per day.[58] A water rights database query showed that 91% of water rights in the Red Rock Watershed are based on surface water extraction.[59,60] This is slightly less than the statewide statistics, which show surface water provides 99% of irrigation water withdrawals in Montana.[36] In the Upper Missouri River Basin (which includes the Red Rock Watershed), agriculture accounts for 98% of all diversions from the Missouri River.[61] Statewide, from both groundwater and surface water sources, irrigated agriculture accounts for 96% of all water diverted or withdrawn for consumptive use.[4]

A recent report on irrigation efficiency in Montana notes that as the largest consumptive water use in Montana, irrigated agriculture can "profoundly influence water supply and availability" (p. 3).[36] This report shows that of 10 basins in Montana, the Missouri Headwaters (which includes the Red Rock Watershed) has the third most acres converted from flood to sprinkler irrigation. An estimated 34,681 hectares (85,700 acres) have been converted to sprinkler irrigation with 23,876 hectares (59,000 acres) converted to center pivot systems and 10,805 hectares (26,700 acres) converted to other sprinkler irrigation systems.[36] In this basin, the annual percentage of streamflow coming from groundwater is among the highest in the state (67-84%).[61] The water supply for the City of Dillon, the seat of Beaverhead county, is derived exclusively from groundwater.[62] It is located in the Beaverhead watershed, downstream of the case study site.

Although Beaverhead County is one of the largest in area in Montana, it has a population of only 9,371 residents.[63] Roughly 70% percent of residents work within the county in management, professional, service, or sales careers.[64] Agriculture makes up 10% of total employment in the county.[64] Beef cattle operations are the main type of farm activity within Beaverhead County, and the county often has the largest quantity of beef cows, making it the top producer of beef within the state.[65] From 1990 to 2016, the county experienced an 11% population increase while the United States experienced a 29% population increase.[66] While there was not a significant population increase in the county during those years, net in-migration accounted for 39% of the population change from 2000 to 2017.[67] Available data for 2000 to 2010 also shows residential development increased 60% in the county, compared with a 12% national increase.[67,68] In 2016, second homes made up 15% of the homes in the county, compared with the United States average of second homes of 4%.[67,68] Changes such as population, in-migration, and residential development highlight an amenity migration influence in the county.

Given the recent changes in irrigation practices, the importance of groundwater contributions to surface streamflows, and increased amenity migration to the region, we found this to be an ideal case study site. Additionally, nonprofit organizations were considering the potential for implementing natural water storage projects in the watershed and were interested in having a better understanding of the perceptions of landowners related to these practices (email, personal communication with a Nature Conservancy staff member, May 31, 2017).

Methods

We conducted a total of 23 interviews with landowners and ranch managers in the Red Rock Watershed from late August 2017 to mid-February 2018 after Institutional Review Board approval. We continued interviews until we had reached saturation, or the point when no new information emerged.[69] Interviews ranged from 30 minutes to 1.5 hours, with an average interview lasting about 55 minutes. A key informant provided an initial list of ranches or ranch owners. Other potential contacts were identified by a snowball sampling technique, where interviewees suggested additional people to interview.[69] We used a semistructured interview guide (Appendix A)[69] to ask questions about drought experiences, drought responses (proactive or reactive), and innovative strategies for dealing with drought on their property. Interviewees were then given handouts (Appendix A) with pictures of flood irrigation, sprinkler irrigation, and beaver mimicry and a brief description of natural water storage to clarify these practices. Most of the interviewees used center pivot systems and often used the term "sprinkler" to denote a center pivot system. Interviewees were then asked to describe their experiences with these practices and what they saw as the advantages and disadvantages to each practice.

Of the 23 interviews conducted, one interview was not transcribed nor included in the final analysis because the interviewee was not a rancher. The remaining 22 audio recorded interviews were transcribed, analyzed, and coded for themes using NVivo software (version 12). The first round of coding took a deductive approach focusing on themes expected to be present in the interviews. The second round of coding used an inductive approach, searching for themes that emerged from the interviews.[69]

Using the adapted typology described earlier, we classified interviewees as traditional or amenity ranchers. Amenity ranchers employed a ranch manager to direct day-to-day operations, and some compared their ranch to traditional ranches. We spoke with amenity ranch managers, as the amenity owners were unavailable. In this case study, all the amenity ranch owners were absentee owners, who did not primarily live on the ranch or in Montana. The amenity ranch managers' answers were interpreted as the views and goals of the amenity ranch owner. Of the interviewees, 14 were classified as traditional ranchers and eight as amenity ranch managers.

All the interviewees ran cattle operations, except one who had a bison operation. Ranches ranged in size from 405 to 121,406 hectares (1,000 to 300,000 acres). All the ranches except one had a stream running through the property; they all relied on water for irrigation or stock water. Ranchers primarily used irrigation water for feed crops like hay and alfalfa along with some water use on pasture lands. Fourteen ranchers used a mix of flood and sprinkler irrigation on their fields. Five ranchers used only flood irrigation and two used only center pivot irrigation. One amenity ranch manager did not irrigate the ranch within the case study watershed but irrigated ranches outside the watershed.

Rancher demographics were relatively homogeneous. All ranchers interviewed were men and white. Nine ranchers were born in the area and five ranchers had run their operations for 20 years or more. There were five ranchers who had lived and ranched in the area for over 10 years and three ranchers who had lived and ranched in the area for 5 years or less. Three of the ranchers interviewed were retired.

Results

Responses to drought

Drought plans — None of the 14 traditional ranchers had formal drought plans in place whereas five of the eight amenity ranch managers had formal, proactive drought plans. One amenity ranch manager saw proactive drought plans as essential in the livestock business, stating, "As a rancher, we always have drought management plans. We have to have that." Another amenity ranch manager discussed the indicators he used in his drought plan governing how he changed his management strategy. He said, "We have different dates of the year where if we don't have so much moisture by then, we'll cut the numbers [of cattle] back."

Reactive drought responses — Regardless of whether they had a drought plan in place or not, all ranchers employed some form of proactive and/or reactive strategies, depending on the circumstance. The most common reactive drought responses among all interviewees were selling cattle early at lighter weights, buying hay, moving or shipping cattle, destocking or changing cattle numbers on the pasture, and using less water or shutting off water early. Sixty-three percent of ranchers sold cattle early as their main reactive response. Many of these ranchers saw reduced hay production as the reason to sell cattle. One rancher said, "We're unable to produce the amount of hay we needed to produce. We had cattle, we had to sell light calves early that year, so it's drastic when you're in this business." Another rancher talked about buying more hay in hopes of avoiding his "worst case scenario" of selling cattle, "[I] usually wind up having to buy more hay. I can usually get by with just that." Even though many ranchers in the area received some type of crop, livestock, or commodity federal assistance in the past 20 years,[70] interviewees

did not mention federal government assistance as part of their drought response strategy.

Proactive drought responses — Ranchers mentioned fewer proactive responses to drought compared with reactive responses. The most common proactive responses were having a grazing plan, changing grazing management, storing hay, or developing springs and wells. One rancher explained his proactive response, which included storing hay and changing his grazing management. He said, "Basically, preparation for drought is just a cushion of maintaining a little extra hay, maintaining a little extra pasture, and being able to not run at your maximum amount every year."

For some ranchers, their proactive strategies developed after experiencing drought in the area for many years and deciding to get ahead of the next drought. For others, their proactive responses were a product of their grazing management goals. For instance, three amenity ranch managers talked about their grazing plan as a way to increase production but also take better care of the land, which would hopefully provide a buffer when drought did hit. One amenity ranch manager explained his use of rest rotation pastures:

> *Pretty much everything is rest rotation pastures here. We always rest a pasture every year. That helps for nutrient load, from grass production, from drought. So, we're always going in on fresh pasture the next year. That always helps us. So even in a drought you have a little time to take to make a good decision.*

Another amenity ranch manager used intensive grazing and reduced hay production as part of his proactive drought strategy. He said:

> *We don't hay much anymore. We're just doing intensive grazing for the most part. We have cattle there for short periods, like 24 hours, and move them. If we can leave some canopy, that's the biggest thing we see. We just don't get the water back. We don't let things get dry again.*

Flood irrigation

Benefits of flood irrigation — All ranchers viewed flood irrigation favorably in that it replenished aquifers and groundwater. One rancher talked about the benefits of flood irrigation by contrasting it with a sprinkler system, "The problem is with a sprinkler, as you know, we don't replenish the water table with it or recharge the aquifer." Another rancher added that flood irrigation provided streamflow. He said, "I think the biggest thing is the more ground you can flood irrigate, the better it returns to the streams." Another rancher talked about the benefits for a downstream neighbor and for springs in the basin, saying:

> *I would think if you were a neighbor downstream, it would probably be beneficial if somebody upstream went back to flooding. You could potentially get some sub water [groundwater] out of it. If there are springs on their property, it might increase those springs. I would think [that] would be beneficial.*

Barriers to flood irrigation — Ranchers described four main barriers to maintaining—or returning to—flood irrigation systems: labor issues, productivity concerns, views on water use efficiency, and water rights concerns.

First, 86% of ranchers saw the labor issues associated with flood irrigation as a barrier to maintaining the practice. Labor issues included finding people with the willingness and expertise to flood irrigate. One rancher described the challenges, saying, "The big problem you have with flood irrigation is the labor involved. You've got a lot of ditch maintenance, headgates, ditches, diversions in the river." Another rancher talked about labor in terms of expertise, "My biggest concern would be labor today. Because I've tried to find somebody that has a little bit of experience to help with some flood irrigating on our 800 acres that we still flood. It's tough." Previous studies also have found labor to be a constraint for flood irrigation practices.[30]

Second, ranchers discussed the production disadvantages associated with flood irrigation and described sprinkler irrigation as more productive. Ranchers used "production" in two ways. One referred to irrigating and using land to grow crops that was not previously irrigated under flood irrigation. For example, one rancher explained the desire to use sprinklers on all of the available land:

> *There's pivots in this valley that have taken less productive ground and made it more productive by putting a pivot on it. Because maybe you couldn't get at the top of the circle or top of the pivot, you couldn't get that water up there, now you can with a pivot system.*

Ranchers also used the term production to refer to the productive capacity of the land in terms of crops per acre increasing under sprinkler irrigation. Another rancher explained the increased production in specific terms for his operation:

> *You figure under sprinkler, you should get a good three tons to the acre out of a hay crop. Well at $100 bucks a ton, that adds up. You take a thousand acres out of production and put it into 300 [acres] or 400 [acres] of flood, it's going to be huge.*

A third barrier to maintaining flood irrigation is that over half of the ranchers believed that the efficiency gains of sprinkler irrigation resulted in less water use. One rancher concisely described sprinkler irrigation efficiency. He said, "The pivots, I think, do an amazing job of more efficiently spreading water." Seventy-two percent of interviewees also commented on the increased production they received from sprinkler irrigation either by crop per acre or putting more acres into production. The wide-spread perception that sprinkler irrigation results in more efficient use of water is contrasted with results from recent studies that question the efficiency of sprinkler irrigation (see Perry et al.,[31] Berbel and Mateos,[32] and Scott et al.[33]).

Fourth, water rights were identified as a concern by 14 ranchers. However, ranchers offered divergent views on water rights in terms of converting back to flood irrigation after switching to a pivot irrigation system. Some ranchers thought that irrigators who currently used sprinkler systems would need more water to adequately convert back to flood irriga-

tion. These ranchers thought if someone's sprinkler system had been in place for many years (as most had) their water rights could have been re-adjudicated resulting in that person having rights to less water since a sprinkler is more efficient. One rancher's response encompasses many of these ranchers' views. He said:

> *When you move from one system to another, in particular from flood irrigation to a pivot, you quote unquote use water more efficiently. For example, let's say to flood irrigate it took 200 inches to irrigate 100 acres. With a pivot, it might only take 50 inches of water to irrigate. Then the DNRC [Department of Natural Resources and Conservation] will take that extra 150 inches because you're not using it. There's no beneficial use.*

In contrast, other ranchers reasoned that if a person had a water right, changing it back to flood irrigation would not matter. As one rancher said, "State wise, the NRCS [*sic*] water rights might look at you kind of funny. But I don't know that they could do anything or would object because it is your water." In fact, according to Montana law, water users can change their irrigation method without seeking approval from the state's water rights agency.[36] However, there is confusion because if a water user wishes to change another aspect of their water rights (e.g., point of diversion, place of use, purpose of use, or place of storage), they must seek permission and show the change will not increase their consumptive use beyond historic levels.[36]

Eight ranchers commented that their neighbors were free to do what they wanted on their own private property until it affected their own water rights. One rancher discussed what would happen if his neighbor converted back to flood irrigation. He said, "As long as it didn't affect my irrigation at all, whatever they did above me…I wouldn't have a problem at all. It's their private property. But if it affects my irrigation or my water rights or something like that…and I don't see anybody doing that."

An unlikely future — Despite recognizing the benefits of flood irrigation for groundwater recharge, ranchers felt that converting back to flood irrigation was unlikely. Due to the frustrations with finding labor and concerns about agricultural production and water rights, none of the interviewees could think of an incentive or a situation where a rancher would convert back to flood irrigation in earnest. Three ranchers mentioned that if significant funding were available or someone wanted to convert as an environmental gesture, it might be an option, but they did not see that as a likely scenario. One rancher talked about the possibility of converting to flood irrigation for the environmental benefits but did not think it would actually happen. He said, "That's about the only thing I can think of is that you get yourself a little 'atta boy' for trying to get the aquifer back up." Another rancher confirmed that converting back to flood irrigation was not going to happen. He said, "You can keep the flood irrigation you have but I don't think you can go back to it."

Beaver mimicry

Ranchers are not yet convinced of the benefits — Many ranchers were not familiar with beaver mimicry projects before the interview. Ranchers' perceptions toward beaver mimicry projects were mixed. It is also likely that ranchers' previous experiences with beavers or similar projects influenced their perceptions toward beaver mimicry projects. As discussed above, groundwater recharge was seen as a beneficial outcome. However, as discussed below, not all ranchers were convinced beaver mimicry would provide the necessary water storage.

Barriers to beaver mimicry — Ranchers described four main barriers to beaver mimicry projects including cost, permitting, water rights concerns, and operational concerns.

Seventeen ranchers cited cost, within that group, 13 cited permitting as the biggest barriers to implementing beaver mimicry projects. One rancher based his concern about the cost of beaver mimicry projects on his experience with other restoration projects. He said, "For a rancher that say, is just flood irrigating his pastures, to spend the money it takes for restoration. You'll never recoup it. We figure it takes about $1,000 per mile to do [stream restoration]. So that's a huge expense." As discussed below, financial assistance was seen as the main incentive that could be used to encourage ranchers to adopt this practice.

The other major barrier identified by ranchers was permitting, including concerns about water rights. However, ranchers were split over how big of a barrier permitting was. Some ranchers saw permitting as a minor regulatory step, with a permit being easily obtained at the Conservation District office. As one rancher said, "If it's just a 310 [permit] that we get here in Beaverhead County, that's not too unreasonable." In contrast, however, another rancher viewed obtaining a permit as much more of a burden. He said:

> *I wanted to do a few things [in the river] and they make you jump through a lot of hoops. So, I just finally, I threw up my hands and said I'm done doing the 404 and 310 permit. It just wasn't worth it. I thought it would have benefitted things, but they put up a lot of…they had their own idea of what I needed to do.*

Another rancher added his dislike of the permitting process. He said, "Christ…you just look at this Red Rock [River] and you've got to get a 310 permit."

Like the discussion about water rights and flood irrigation, ranchers reiterated they would not want to interfere with their neighbor's water rights and would not want anyone interfering with theirs. They emphasized that people were free to implement flood irrigation and beaver mimicry projects as long as it did not affect someone else's water rights. However, ranchers held divergent views on if a beaver mimicry project would affect water rights. Some ranchers thought if a basin was adjudicated and one person put in a beaver mimicry project, the water used in the project would be part of that person's existing water rights. One rancher said, "If you're doing stream restoration, it wouldn't be a problem for anyone that

was in an adjudicated area. Because they're going to get their water from the water commissioner, no matter what."

In contrast, another rancher saw neighbor relations as more contested, in that people would not allow him to implement these strategies because it may negatively affect them. He said:

> *Anything like [beaver mimicry projects], yeah those are great ideas and they're cool, but you won't get them to work up here because people fight it. Any kind of change is perceived as a negative use of the water. They would rather see it run by than let me have it. That's the reality.*

Nine ranchers saw beaver mimicry projects as impractical and interfering with daily ranch operations. As one rancher said, "From an operational standpoint, [beaver mimicry projects] don't make sense. Maybe from an environmental standpoint, it does." Although the interviewer reiterated beaver mimicry projects did not entail reintroducing or relocating beavers to private property, some ranchers spoke of their experience with beavers and how they affected ranch operations. Some ranchers spoke of letting beavers build on their property in the right locations while others spoke of their dislike for them. One rancher said, "Honestly, if [beavers] build in the wrong spot, they're kind of a pest." There was also concern about how effective a beaver mimicry project would be in providing water storage. For example, one rancher questioned how much water beaver mimicry projects could store, saying, "I can't believe that would do much good. [Beaver mimicry projects] wouldn't store enough water… I think it's just a fantasy." This contrasts with other findings,[47] where ranchers in other areas in the American West found the water storage benefits provided by beavers exceeded the disadvantages.

Financial assistance needed for future adoption — Sixty-eight percent of ranchers recommended financial help, through grants or cost share programs, as the main incentive to implement beaver mimicry practices. One rancher stated, "Funding, that motivates. If you want to get something done… offer [ranchers] some money. That's what it boils down to." Another rancher echoed the sentiment, he said, "If there was a way to subsidize the cost of the actual construction then I think people would be more on board with it." Other incentives such as technical assistance, added land value, or trained crews were only mentioned a handful of times.

Differences between amenity and traditional ranchers

The results illuminate three main differences between amenity and traditional ranch operations. First, amenity and traditional ranches had different goals for the land. Amenity ranch management goals usually stemmed from the desires of the owner, which varied from wanting to see more elk on their property to reintroducing bison on the landscape to providing recreation for anglers and friends to managing the land as an investment. One amenity ranch manager described one of the goals of the ranch, "[For] the owner of the ranch, one of their visions and dreams is to move some elk on the place." A different amenity ranch manager stated that the recreation value of the ranch drove many stream restoration projects. He said, "The primary reason for a [stream restoration project] was fishing [and] that's how we got [it] sold to the owner." These findings align with the findings of other amenity migration studies.[55,56]

In contrast, traditional ranchers spoke of their goals as primarily economic, such as growing grass and raising cattle. They also had an interest in protecting the water and land. One traditional rancher said, "Probably the biggest thing is we make our living, this ranch we operate under, is our only income. So, we're going to protect our land, the resources we have, to continue this whole environment we live in." Another traditional rancher went further, voicing his frustration that people assumed that the economic goals of ranchers did not coincide with resource management goals. He said:

> *Ranchers have become somewhat offended by the fact that people say, 'Well, you're not taking care of the resource.' That's not true. Ranchers take care of the resource better than anybody else could because they're the most concerned about making a living on it.*

Second, three traditional and two amenity ranch managers pointed out the uneven financial resources available to amenity ranches that made it easier for them to implement new strategies. One traditional rancher spoke of the ability for amenity ranches to put in stream restoration projects due to their wealth and remarked it was impractical for a traditional owner. He added, "A cattleman can't do [stream restoration projects]." An amenity ranch manager agreed with that sentiment as he discussed one of his restoration projects. He said:

> *Not everybody and not every year are you able to financially do these [stream restoration projects]. That project took a couple years to pay for. We were in a different situation at the time than the average rancher. Fully aware of that. The family operation would have probably waited until there was a program to help them with that.*

Third, some amenity ranch managers believed they were more willing to work with the government or other organizations than traditional ranchers. However, 55% of interviewees said they had good relationships with government agencies, nonprofits, and other resource management entities. There was not a consensus among either amenity or traditional ranchers on the elements of a good partnership. However, flexibility, trust, and being local were each mentioned at least four times by both amenity and traditional ranchers. Half (3 amenity; 8 traditional) of the ranchers recommended the Natural Resource Conservation Service (NRCS) as the entity they would prefer to work with or receive technical assistance from for natural water storage projects. One rancher elaborated on his trust in the NRCS. He said, "I would say the NRCS, people have good faith in them. They can get their hands on good technical papers. So that is where [the information about natural water storage projects] would have to come from."

Limitations

Our case study highlights perspectives on drought and proactive drought mitigation strategies like flood irrigation and beaver mimicry among traditional and amenity ranchers in the Red Rock Watershed in southwest Montana. We recognize there are some distinct characteristics of this case study, such as its high rate of amenity migration; recent changes in irrigation practices; groundwater and surface water interactions; high presence of nonprofits and local, state, and federal entities; and a State Water Plan that encourages the consideration of natural water storage.[4] We also note our study was constrained by time and financial resources. We focused on one watershed, rather than a cross-case comparison, which may have provided additional insights. We used a standard qualitative approach to interview 22 large landowners about potentially sensitive topics (i.e., water rights and practices that may affect water availability in the watershed). While a statistically representative quantitative approach may have yielded additional insights, the potentially sensitive topics and exploratory nature of the research were not well suited for a mail or email survey. Despite these limitations, we believe our case study offers insights applicable to other watersheds, especially those experiencing amenity migration, changing irritation practices, groundwater and surface water interactions, altered precipitation and run-off patterns, and increased drought. Those who work closely with ranchers and other large landowners would benefit from understanding their perspectives and creating mutually beneficial opportunities.

Conclusion

Like previous studies on drought strategies among ranchers, our study found ranchers in the Red Rock Watershed predominantly rely on reactive drought actions, such as selling cattle early and buying hay. However, some ranchers also mentioned proactive drought actions, such as grazing management and storing hay. When analyzed by rancher type, we discovered five of the eight amenity ranchers had formal drought plans in place, but none of the traditional ranchers had formal drought plans. This suggests an opportunity to work with traditional ranchers to develop formal drought plans. Our findings on trust and information sources suggest local agents from the NRCS or other local actors could be most effective in this role, especially if their approach is flexible.

Our study also examined ranchers' views on flood irrigation and beaver mimicry as two potential strategies for enhancing natural water storage as a drought mitigation strategy on their property. We found amenity and traditional ranchers acknowledge the benefits of natural water storage. They described how flood irrigation can increase groundwater storage and affect streamflows. However, not all ranchers were convinced beaver mimicry would be able to provide the necessary water storage.

There were barriers to each of these strategies that may prevent wide-spread adoption. The major barriers to flood irrigation include labor issues and loss of production. There was also concern among some interviewees about how water rights would be affected if a rancher converted back to flood irrigation. While interviewees believed financial incentives might work to keep existing flood irrigation in practice, they could not imagine a scenario that would incentivize ranchers to convert from a more efficient sprinkler system back to flood irrigation. We did not ask ranchers about the feasibility of increasing the flow rate of their sprinkler irrigation systems in the spring to mimic flood irrigation conditions. This is a potentially interesting avenue for future research in the fields of hydrology and social science. Additionally, ranchers viewed sprinkler irrigation systems as a more efficient use of water, even when they acknowledged it allowed them to irrigate additional acres. This contrasts with recent research questioning the efficiency of converting from flood to sprinkler irrigation systems and suggests another important opportunity for further research within both the hydrological and social sciences.[29-39]

Ranchers expressed that the main barriers to beaver mimicry practices were financial. Despite having more financial resources, even amenity ranchers saw stream restoration projects such as beaver mimicry as an expensive endeavor. Most ranchers recommended financial assistance as the primary incentive to encourage the implementation of beaver mimicry practices. But even with possible financial support, many ranchers explained that using their limited time to implement or maintain beaver mimicry projects would take away from operating their ranch. Ranchers were also concerned about the lack of clarity around permitting and water rights implications, as well as disruptions to their operation from flooding or beavers themselves. For agencies, practitioners, and nonprofits interested in promoting beaver mimicry, our findings suggest partnering with local agencies, such as the NRCS, building trust, and adopting a flexible approach that accounts for the needs and concerns of landowners could improve perceptions of beaver mimicry among ranchers.

We conclude that the following could help address key barriers to natural water storage projects: 1) financial assistance; 2) clarity of regulatory processes and requirements; 3) more scientific studies on how these projects affect groundwater and surface water availability; 4) integrated drought planning at local, state, and federal levels; 5) relationship building and communication between governmental agencies, nonprofits, and landowners; and 6) incorporation of local knowledge and perceptions into drought planning and natural water storage projects.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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