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Rancher Experiences and Perceptions of Climate Change in the Western United States

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ABSTRACT

Ranchers in the western United States have long managed working landscapes prone to drought and wildfires. As the frequency and intensity of climate change impacts increase, ranchers will be front-line workers in the climate crisis—both adapting to climate impacts and managing landscapes with mitigation potential. This Forum paper first summarizes recent peer-reviewed research on ranchers and climate change in the western United States and then offers conceptual clarification of climate change adaptation based on this empirical research. Many ranchers remain unconvinced by climate science and express skepticism about long-term and anthropogenic climate change, though this may change as climate extremes intensify. Researchers working with ranchers often avoid climate change terminology, instead focusing on impacts, especially drought. Ranchers adjust their land and livestock management practices, as well as livelihood strategies, to cope with weather variability. Ranchers identify increasing management flexibility and diversifying ranch income as key adaptation strategies. While studies often focus on how to transition ranchers from reactive and toward proactive adaptation planning, few ranchers are actively planning for climatic change. Yet in this ranching context, many practices that begin as reactive coping strategies become longer-term adaptations as the impact, such as drought or recurrent wildfire smoke, persists. As ranchers observe positive outcomes of short-term adaptations or are unable to return to previous strategies, reactive coping strategies become proactive. We provide a conceptual clarification of adaptation in ranching systems, forwarding adaptation as a process, inclusive of a continuum from coping actions to more transformative adaptation strategies. Centering ranchers' experiences, perceptions, and responses related to climate change can help land managers, agricultural advisors, and policy makers increase the pace and scale of adaptation and mitigation in range systems.

Introduction

Ranchers have long experienced and managed environmental uncertainty (Brunson and Huntsinger 2008). In the western United States, generations of ranchers have managed livestock herds on drought-prone arid and semiarid landscapes with unreliable rainfall, giving ranchers in this region a unique set of intergenerational knowledge to respond to changing conditions. Yet the pace and scale of climate change is beyond the scope of past human experience (IPCC 2022).

The physical impacts of climate change, which in the western United States include stressors like rising temperatures, shocks like extreme wildfires, and shifts like changing snowmelt timing, are becoming clearer climate signals as they rise above the noise of weather variability (Pathak et al. 2018; IPCC 2022). These physical impacts of climate change exacerbate market inequities that many ranchers already face, aggravating economic and cultural livelihood losses (Morton 2007; Gliessman et al. 2018; Petersen-Rockney et al. 2021).

With broad consensus that anthropogenic climate change is already occurring with deleterious impacts (IPCC 2022),[1] scholarship on agriculture and climate change has expanded in recent years.

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[1] Atmospheric greenhouse gas accumulations from human activity over the past 3½ centuries have resulted in an estimated average global temperature increase of approximately 1°C (IPCC 2022).

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This work largely focuses on farming from a physical science perspective (Soubry et al. 2020). Social science research has emphasized farmers' climate change beliefs and risk perceptions, primarily in survey-based studies of crop farmers in the Midwest (e.g., Arbuckle 2013; Prokopy et al. 2015; Niles & Mueller 2016; Doll et al. 2017).

Yet rangelands cover 30–40% of earth's ice-free surface and can play an important role in climate change mitigation, which is "human intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC 2014, p. 4). Currently, beef production is a significant source of global greenhouse gas emissions (EPA 2015), but well-managed grazing has potential to facilitate carbon sequestration that offsets these emissions and helps mitigate climate change (Stanley et al. 2018). While significant challenges and unknowns remain around the mitigation potential of rangelands (Biggs & Huntsinger 2021), research and policy developments place great hope in the climate mitigation potential of these working range landscapes to help the United States reach emissions reduction goals (Booker et al. 2013).

Ranching is also a crucial livelihood across the globe, especially for marginalized communities with limited access to prime agricultural lands (Sayre et al. 2013). Adaptation, or the "*process* of adjustment to actual or expected climate and its effects" (IPCC 2022, p. 7, emphasis added), is critical to maintaining both rural livelihoods and the ecosystems we all rely on.

While there is a growing body of academic literature on physical climate change attributes, like modeled climate change impacts on rangeland health (e.g., Archer & Predick 2008; Izaurralde et al. 2011; Reeves et al. 2017), there remains relatively little research that centers ranchers' own experiences of climate change (Soubry et al. 2020). How ranchers manage range working landscapes as the climate changes will have a significant impact on biodiversity conservation, food security, rural economies, and climate change adaptive capacity and mitigation potential (Brunson & Huntsinger 2008; Kremen & Merenlender 2018; Stanley et al. 2018; Petersen-Rockney et al. 2021).

In this Forum paper, we offer a qualitative summary of some recent social science literature on ranchers' perceptions, experiences, and responses to climate change impacts in the western United States by asking:

- How are western US ranchers' beliefs about climate change currently understood?
- How are these ranchers experiencing climate change?
- What actions are western US ranchers taking to mitigate climate change?
- How are these ranchers responding to climate change impacts?

We then offer conceptual clarity for thinking about adaptation in the context of ranchers and rangelands. In our conclusion, we suggest a need for future research to meaningfully consider ranchers' experiences and perceptions in adaptation and mitigation scholarship and action.

Background and Methodological Approach

This Forum paper's intent is to provide a conceptual summary, not comprehensive review, of recent social science literature that centers on ranchers' experiences of climate change in the western United States. As such, our analysis is qualitative, employing academic literature to identify and substantiate the key themes that we summarize and the interpretations that we offer. We evaluated empirical research papers selected on the basis of three inclusion criteria, which we describe later and that provide background to this forum.

Focus on ranchers, distinct from farmers

We focus on summarizing empirical findings from social science studies that were conducted directly with ranchers and that present data and findings on ranchers, distinct from farmers. There are, therefore, many exemplary papers that present data on ranchers and farmers in aggregate that are not the focus of this forum (e.g., Safi et al. 2012; Brugger & Crimmins 2013; Niles et al. 2013; Liu et al. 2014; Smith et al. 2014; Grimberg et al. 2018; Carolan 2020; Howard et al. 2020; Wilmer & Sturrock 2020). While we recognize that the distinction between ranchers and farmers is imperfect, and many ranchers also manage farmland, we feel this focus on working landscape managers who identify as ranchers and manage range systems is warranted, given unique attributes of ranchers that may make their experience of climate change meaningfully distinct from that of crop farmers.

While ranchers are experts at managing weather volatility, they are also uniquely vulnerable to climate change extremes compared with farmers. Primarily or seasonally reliant on rain-fed range systems, for example, ranchers often lack extensive risk-buffering irrigation infrastructure that farmers rely on to cope with drought, heightening western US ranchers' vulnerability to increasing dryness (USDA 2013; McClaran et al. 2015).

Many ranchers also manage herds on public lands, while few farmers operate a significant portion of their agricultural activity on public land. With decreasing public lands grazing and increased reliance on off-farm work, transhumance has decreased in the United States over the past century, limiting pastoral mobility as a key response to changing environmental conditions like drought (Brunson & Huntsinger 2008). Private land development pressure and rising land values also decrease forage access and pose barriers to generational transfer and changing management practices (Eakin & Conley 2002; Gosnell & Travis 2005; Brunson & Huntsinger 2008). Finally, the high proportion of ranches, compared with farms, still operated with family labor presents unique intrahousehold dynamics and opportunities for response to changing conditions (Lobao & Meyer 2001).

Focus on western US region

We geographically focused this Forum on the western United States (Table 1 and Fig. 1). Following Reeves et al.'s (2017) definition of the western United States, we include sections of eastern prairie ecosystems within political borders of western states (e.g., Texas) and exclude important ranching areas in Florida and Hawaii, which have distinct ranching cultures and practices that deserve distinct treatment in a separate Forum. We focus on the western United States because this region is home to a large proportion of global rangelands and ranching livelihoods remain culturally important in many rural communities (Sayre et al. 2013).

Additionally, the most recent IPCC report identifies western North America as having the greatest confidence of anthropogenic contributions to observation changes, particularly recorded increases in agricultural and ecological drought (IPCC 2022, fig. SPM3 medium confidence). Drought and more frequent heat extremes are also raising the likelihood and severity of wildfires in this region (IPCC 2022). Ranchers in the western United States are already observing reduced annual forage availability and increased interannual volatility due to greater drought frequency and intensity (Yung et al. 2015), climate signals that will intensify (IPCC 2022).

Focus on recent empirical social science studies

We focused on empirical studies that were conducted between 2010 and 2021. Given the rapidly evolving nature of climate change

Table 1
Methodological summary.

Study	Location	*N*	Sample	Primary method(s)
Campbell et al. (2019)	Kansas, Oklahoma, and Texas	6601	Scientific Telephone Samples Database	Survey
Coppock (2011)	Utah	509	USDA NASS	Survey
Coppock (2020)	Utah	429	USDA NASS	Survey
Gosnell, et al. (2011)	Montana, Wyoming, Colorado, New Mexico	28	Chicago Climate Exchange, Purposive Sampling	Interviews
Gosnell, et al. (2020)	Montana, Wyoming, Colorado, New Mexico	23	Chicago Climate Exchange, Purposive Sampling	Interviews
Haigh and Knutson (2013)	Wyoming and Nebraska	10	Purposive Sampling	Interviews
Haigh, et al. (2019)	South Dakota and Nebraska	210	USDA NASS	Survey
Haigh, et al. (2021)	South Dakota, Nebraska, Colorado, Wyoming, and Montana	430	USDA FSA	Survey
Kachergis, et al. (2014)	Wyoming	307	Wyoming Stock Growers Association	Survey
Knutson & Haigh (2013)	South Dakota, Nebraska, Kansas, Colorado, Wyoming, Texas, and California	22	Purposive Sampling	Interview
Ma & Coppock (2012)	Utah	429	USDA NASS	Survey
Macon, et al. (2016)	California	102	California Cattlemen's Association (CCA)	Interview
McClaran, et al. (2015)	Arizona	160	Arizona Cattle Growers Association	Survey
Murphy, et al. (2017)	Montana	26	Purposive sample	Case study, interviews and participatory mapping
Roche (2016)	California	507	California Cattlemen's Association (CCA)	Survey
Roche, et al. (2015).	California	507	California Cattlemen's Association (CCA)	Survey
Wilmer, et al. (2016). (2017).	Colorado, Utah, Arizona, Oklahoma, Kansas, Idaho	75	Purposive, Theoretical, and Snowball Sampling	Interviews, case study
Yung, et al. (2015). Stasiewicz & Paveglio (2018)	Montana	35	Purposive, Theoretical. and Snowball Sampling	Interviews, case study
Wilmer, et al. (2016)	Colorado, Utah, Arizona, Oklahoma, Kansas	7	Purposive	Interviews

USDA NASS indicates US Department of Agriculture National Agricultural Statistics Service.

impacts, discourses, and policy, we focused on studies conducted in the past decade to best capture research at the intersection of ranchers' experiences and climate change in a contemporary context. Climate change has become especially politically polarized in the United States (Kahan 2012a), where climate skepticism is higher among rural than urban populations (Howe et al. 2019) and is especially pronounced among farmers and ranchers (Singh et al. 2020), especially men (Liu et al. 2014).

Methodological approach

We conducted key word searches in Google Scholar and checked for completeness by a duplicative search in the archives of *Rangeland Ecology & Management, Rangelands,* and *Ecology and Society* journals particularly relevant to the topic. We used a set of key word searches for "rancher" and "climate change," including synonyms and related terms.[2] Papers that met these three selection criteria were then divided into "focal" and "peripheral" studies to our Forum.[3] Articles that discussed ranchers and farmers in aggregate were designated "peripheral" to this Forum because we could not distinguish between rancher and farmer data (e.g., Safi et al. 2012; Brugger & Crimmins 2013; Niles et al. 2013; Liu et al. 2014; Smith et al. 2014; Grimberg et al. 2018; Carolan 2020; Howard et al. 2020; Wilmer & Sturrock 2020).

The focal empirical studies of this Forum employed both quantitative (primarily surveys) and qualitative (primarily interviews) methods (see Tables 1 and 2). The inclusion of qualitative studies and the uniqueness of each ranching context make direct comparison of data across studies difficult. Yet qualitative research methods are important when studying potentially sensitive topics, like climate change, as well as nonquantifiable factors, like values and attitudes, that are important to ranchers' experiences (Takahashi et al. 2016).

The authors of this review then engaged in a series of discussions focused on the papers that met our inclusion criteria, with contributions of peripheral papers also considered. In these discussions we summarized papers, identified commonalities and potential areas for future research, and formulated the conceptual points presented in this Forum. We recognize the limitations of our selection and qualitative review processes. Our methods neither allow for a fully comprehensive review article nor provide opportunities for statistical or quantitative analysis of data. A full review article that uses a programmed approach to achieve a more comprehensive and systematic literature review would also be valuable.

Conceptual Summary

Ranchers' climate change beliefs may be shifting

Like farmers (see Prokopy et al. 2015; Soubry et al. 2020), ranchers in the western United States often express skepticism about scientific understandings of anthropogenic causes of climate change, as well as permanency (Knapp & Fernandez-Gimenez 2009; Yung et al. 2015). Political ideology and partisan affiliation strongly impact ranchers' climate change perceptions and beliefs (Liu et al. 2014). Many ranchers identify as conservative (Safi et al. 2012), and few attribute local changes to climate change (Liu et al. 2014).

[2] "Climate change rancher"; "Drought rancher"; "Wildfire rancher"; "Wildfire rangelands"; "Climate change rangeland"; "Drought rangeland"; "Climate change cow calf"; "Drought cow calf"; "Severe weather rancher"; "Severe weather rangeland"; "Severe Weather Rangeland United States"; "Herder climate change"; "Smoke rangeland"; "Rangeland water scarcity climate change United States"; "Rangeland adaptation pathways"; "Rangeland adaptation"; "Rancher adaptation."

[3] Key word searches yielded 103 possible articles. Papers that did not contain original empirical data or data related to ranchers' experiences were removed from this potential pool, leaving 34 papers. Four empirical studies with ranchers were then removed because the connection to climate change was not explicit (Fisher 2016; Lazrus 2016; Barton et al. 2020; Wilmer et al. 2020).

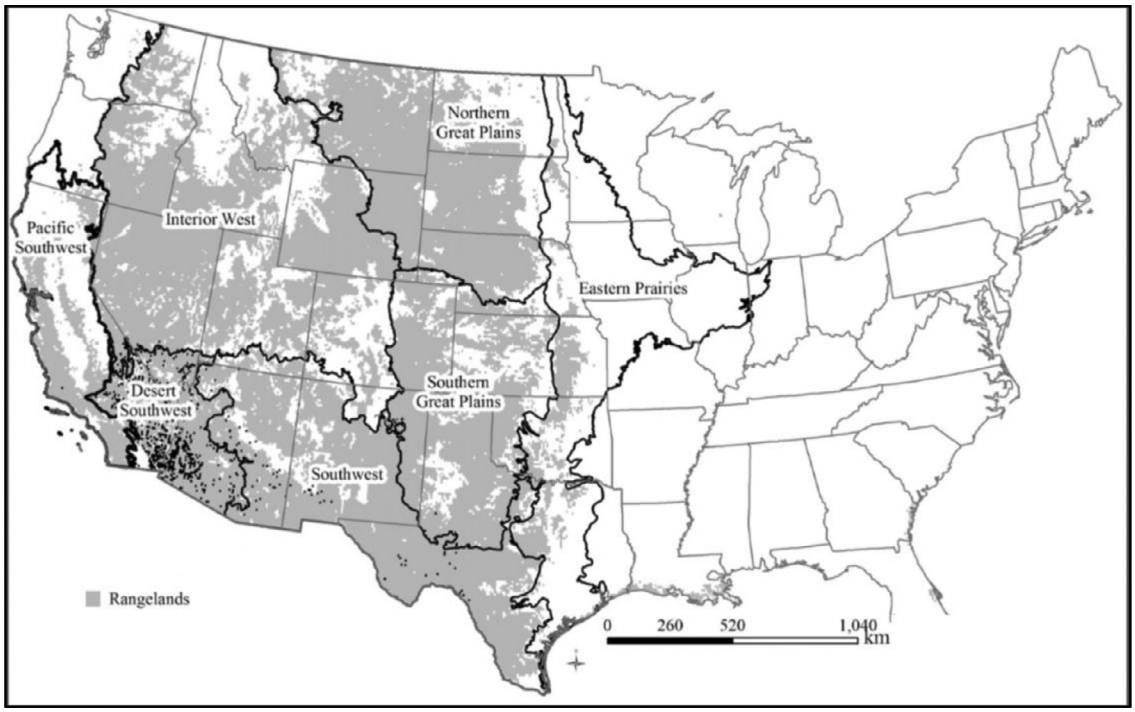

Fig. 1. Forum review area, adapted from Reeves et al., 2014. In our definition of "Western US," we include western states and the eastern prairie ecosystems within them since many studies are conducted at a regional or state boundary scale. We have excluded Hawaii and Florida, which are important ranching states and warrant a distinct treatment in a separate paper.

Table 2
Ranching adaptions to drought.

Adaptation	Rancher adaptation	Primary study methods	Citation	Process direction (Fig. 1)	Importance score[1] (1-3)
Destocking	71%, $N = 479$	Survey	Roche (2016)	Reactive	2.1
	44%, $N = 430$[2]	Survey	Haigh et al. (2021)		
	77%, $N = 460$	Survey	Coppock (2011)		
	63%, $N = 391$	Survey	Haigh et al. (2019)		
Purchasing feed or hay reserves*	64%, $N = 415$	Survey	Haigh et al. (2019)	Reactive	1.8
	66%, $N = 495$	Survey	Coppock (2011)		
	70%, $N = 479$	Survey	Roche (2016)		
	36%, $N = 391$[3]	Survey	Haigh et al. (2021)		
Add off-farm income	23%, $N = 479$	Survey	Roche (2016)	Reactive	N/A
Apply for government assistance	40%, $N = 479$	Survey	Roche (2016)	Reactive	N/A
Stock conservatively or reduce stocking rates	35%, $N = 479$	Survey	Roche (2016)	Proactive	N/A
	65%, $N = 503$	Survey	Coppock (2011)		
Rest pastures	24%, $N = 479$	Survey	Roche (2016)	Proactive	2
Rotational grazing	90%, $N = 160$	Survey	McClaran et al. (2015)	Proactive	2.4
Improve water resources for livestock	76%, $N = 499$	Survey	Coppock (2011)	Proactive	1.9
Improve irrigation for hay production	67%, $N = 491$	Survey	Coppock (2011)	Proactive	1.9
Diversify family income	68%, $N = 493$	Survey	Coppock (2011)	Proactive	N/A
Monitor rangeland	90%, $N = 160$	Survey	McClaran et al. (2015)	Proactive	2.4
Monitor resources (e.g., forage, water)	9 of 10	Interview	Haigh & Knutson (2013)	Proactive	N/A
Maximizing rangeland health and flexibility pre-drought	10 of 10	Interview	Haigh & Knutson (2013)	Proactive	N/A
Determine critical dates and decision rules	7 of 10	Interview	Haigh & Knutson (2013)	Proactive	N/A

[1] Yung et al. (2015) also found purchasing feed/hay reserves, reducing stocking rates, and leasing additional lands to be common practices, but the article did not include the number of ranchers who used specific practices, so data from Yung et al. (2015) are not included in this table.

[2] Haigh et al. (2021) asked ranchers whether they destocked more than normal, rather than at all, which could be the reason for the noticeably lower percentage.

[3] Haigh et al. (2021) asked ranchers whether they purchased feed more than normal, rather than at all, which may explain the noticeably lower percentage.We extend Roche's (2016) definitions of reactive practices, those that are adopted in response to drought, and proactive practices, which are adopted to prepare for future drought by emphasizing process wherein reactive can become proactive. Importance scores (McClaran et al., 2014) are averaged on the basis of ranchers' perceptions of the importance of a practice for adaptation to drought (1 = low importance, 2 = moderate importance, 3 = high importance).

Through interviews with 35 ranchers in Montana, for example, Yung et al. (2015) found that most ranchers were skeptical of anthropogenic climate change, attributing observed changes in climate to natural variation and maintaining faith that the climate would return to "normal" following impacts like drought. The "cognitive dissonance" of some ranchers' reluctance to engage with climate change may stem from a rupture between ranchers' core values and beliefs and information about climate change that directly threatens those values and beliefs (Bradshaw & Borchers 2000).

Emerging evidence suggests that as climate extremes become more frequent and intense, ranchers' beliefs in climate change may be shifting. A survey of ranchers in the southern Great Plains, for example, found that more than half of ranchers (62%, $N = 6$ 601) believed in climate change's anthropogenic origins (Campbell et al. 2019). These ranchers were more likely to support mitigation efforts, including climate change policies that might infringe on ranching operations, than those who remained skeptical of anthropogenic contributions to climate change (Ibid). While these shifts appear promising for increased mitigation action, it is worth noting that a growing body of research among farmers and ranchers in aggregate suggests that the relationship between belief and action is complex and nonlinear, and belief may not be as crucial, especially to adaptation, as previously thought (Davidson et al. 2019; Findlater et al. 2019).

As climate change signals emerge, ranchers are more willing to engage in discussions about climate change, its risks, and potential solutions. In a series of interviews and focus groups with 26 residents of a small ranching town in Colorado (9 of whom were ranchers), Murphy et al. (2017) found that conceptualizations of place were critical for adaptation to climate change. The potential of a hot and dry future concerned residents, as ranchers believed they would not have the capacity to manage water and forage reductions. Importantly, residents identified the cultural loss of their way of life as the single greatest threat of climate change. Cultural identity loss was entwined with fears of more urban development if climate change forced ranchers to leave their land, likely—residents feared—to be replaced by subdivisions and absentee landowners. Many residents were willing to consider "previously inconceivable or economically irrational" adaptation actions, such as damming a local river, in order to save the "character" of their town (Murphy et al. 2017, p. 447). Notably, Murphy et al. (2017) found that participants were *only* willing to engage in a dialogue about climate change if that discussion avoided causes and blame.

We observed similar care taken by other researchers when discussing climate change. Many avoided the terminology of "climate change" and "global warming" when collecting data on the topic with ranchers (e.g., Knapp & Fernandez-Gimenez 2009; Ma & Coppock 2012; Gosnell et al. 2020; Yung et al. 2015; Murphy et al. 2017). Most researchers engaged with ranchers around the *impacts* of climate change, rather than naming climate change itself. Additionally, many manuscripts only discussed climate change in the introduction or conclusion sections, as a way of couching empirical work in broader environmental change.

Researchers may avoid explicit discussions of climate change because of its politically charged nature in rural and agricultural US contexts (Kahan 2012a; Singh et al. 2020). Concern about alienating farmers and ranchers by discussing climate change has also been noted among farm advisors (Grantham et al. 2017). It is therefore not surprising that other groups who rely on building trust with ranchers, like researchers, may avoid these politically polarized terms. Beyond adapting terminology to different cultural contexts, these findings also suggest opportunities for diverse stakeholders to identify deeper shared values, beliefs, concerns, and motivations as the ecological, social, and political context of rural places changes.

Experiences of climate change focused on drought

While ranchers in the western United States are, in many ways, preadapted to fluctuations in water availability, drought frequency and severity in these regions is increasing rapidly due to anthropogenic climate change (IPCC 2022). It is unsurprising, therefore, that the majority of articles focal to this Forum topic focused on drought.

Despite the many flexible strategies ranchers employ to manage water uncertainty, drought can be devastating. Seventy-five percent of ranchers surveyed in Utah reported negative impacts from drought, especially on forage supplies, water availability, and cattle productivity (Coppock 2011). Similarly, more than half of ranchers surveyed following Wyoming's 2013–2014 drought reported negative impacts to grazing capacity, profitability, and winter feed availability, as well as decreased irrigation water availability, calf weaning weights, and livestock reproductive rates (Kachergis et al. 2014).

Already economically precarious, ranchers can experience further economic risk from climate change as, for example, irrigation water access to grow forage crops diminishes and hay prices rise (Coppock 2011; Haigh et al. 2019; Haigh et al. 2021; Roche 2016). Both interannual variability and climate extremes can lead to decreased revenues and increased debts as ranchers engage strategies like reducing herd sizes, buying hay, and leasing additional land (Yung et al. 2015). Drought-induced financial hardships also lead to decreased psychological well-being, especially related to uncertainty about worsening impacts (Macon et al. 2016) and their economic consequences (Howard et al. 2020).

When large numbers of cattle are sold during extreme droughts, ranchers report financial and emotional hardship (Wilmer et al. 2016). Economic risks of climate change can also magnify across scales, rippling through the highly concentrated beef industry as, for example, ranchers across a region destock during drought, which depresses market prices as more cattle are sold to just a few large companies that set market terms and prices (Howard 2016; Wilmer et al. 2016). The economic impacts of coconcurrent drought with poor cattle prices and high feed costs (Eakin and Conley 2002) generate significant distress and anxiety, negatively impacting ranchers' mental health (Howard et al. 2020). Ranchers also report higher interpersonal tension and alcohol consumption due to the experience of destocking during drought, which one rancher in California described as being "kind of like you're mourning" (Yung et al. 2015, p. 285). Even during nondrought years, anxiety about potential droughts can be distressing and, as one rancher in Utah observed, are "in every rancher's mind" (Wilmer et al. 2016, p. 218).

While ranchers' experiences of climate change are overwhelmingly negative, a few studies found that some individual ranchers reported neutral or positive aspects of their drought experience. Some ranchers, for example, reported that coping through droughts provided opportunities to better prepare and plan for future drought (Wilmer et al. 2016). Others reported developing their problem-solving and preparedness skills through drought experiences (Coppock 2011; Macon et al. 2016). Access to water or high-quality hay also buffered negative drought impacts for some ranchers, even spurring some ranchers with abundant water and infrastructure to report neutral or positive experiences during drought, like their ability to sell the same number of cattle as during nondrought years (Coppock 2011).

Additionally, ranchers may perceive climate change as contributing to greater interannual variability without ultimately effecting the value of their ranch, which is often primarily the land, not the cattle operation (Brunson & Huntsinger 2008). For example, Haigh et al. (2019) found that most ranchers in the northern Great Plains reported little to no harm to their overall ranch value

despite describing significant interannual losses, including forage losses > 25% during a 2012 drought, as well as harm to rangeland health, animal production, and cash reserves. Due, at least in part, to the steady increase in agricultural land values nationally (Fairbairn 2020), this finding suggests that ranchers may not be concerned about the impacts of climate change on their ability to "cash out" if, or when, they leave ranching.

Ranchers' perceptions of mitigation

While a growing body of physical science research examines ranching practices and rangeland carbon sequestration potential (e.g., Stanley et al. 2018), we found that recent social science work has focused on ranchers' perceptions and motivations around mitigation tools, particularly carbon markets.

Distrust of government actors that might implement carbon markets, along with the 2009–2010 collapse of the carbon price on the Chicago Climate Exchange, have contributed to ranchers' wariness of carbon trading programs (Gosnell et al. 2011). Even for ranchers who do participate in in carbon markets, both climate change mitigation and the limited financial gain from participation are low priorities in structuring their decision making (Gosnell et al. 2020).

Instead, ranchers consistently identify co-benefits of rangeland improvements from carbon sequestration practices as stronger motivators of adaptation, which is unsurprising given that forage productivity and rangeland resilience are critical for economic viability (Roche et al. 2015; Gosnell et al. 2020). Even when ranchers are motivated to adopt certain management practices because of mitigation potential, it remains difficult to verify causality between the implementation of specific management practices and increased carbon sequestration or measure how much carbon is sequestered for specific lengths of time (Gosnell et al. 2011).

Researchers have also identified ranchers' belief that ecological conditions will return to normal as a barrier to climate action (Yung et al. 2015). In response, researchers have suggested that educating ranchers on mitigation and adaptation strategies, like drought-preparation tools, could increase knowledge-sharing networks, which in turn could facilitate communication between ranchers and institutional support systems like Cooperative Extension, academics, and government agency staff (Coppock 2020).

Notably, Ma and Coppock (2012) observed both limited rancher knowledge of carbon sequestration and an inverse relationship between knowledge and opinions of carbon sequestration. Despite 70% ($N = 497$) of ranchers in Utah reporting that they did not know what rangeland carbon sequestration was, a majority of respondents (63%) said that they had a negative opinion of it, and opinions grew more strongly negative as knowledge increased (Ma & Coppock 2012).

Climate change education efforts across US populations, especially "attempts to scare people into greater action," can backfire, leading to reduced climate action (Weber 2010, p. 332). Similarly, education efforts that aim to increase scientific literacy around climate change are rarely effective in shifting beliefs or perceptions among those who self-identify as conservative, as many ranchers do (Safi et al. 2012), whereas scientific literacy and climate change concern are correlated among those who identify as liberals (Kahan 2012b).

Within this context, increased interest in rangeland carbon capture and storage demands a better understanding of how to encourage and support rancher adoption of mitigation practices. Carbon markets and climate change educational efforts in their current form are not highly effective and could be improved by taking ranchers' experiences and perceptions into account and focusing outreach on mitigation co-benefits. Research on carbon sequestration could, for example, ask ranchers about their own priorities and appropriate payment sizes (Biggs et al. 2021). Additionally, findings specific to ranchers' perceptions of carbon markets may provide helpful insight into how to structure public policy to engage rural land managers and users more effectively in carbon sequestration efforts.

Responses to climate change impacts increased ranch flexibility and diversified income

In response to climate change impacts, ranchers often prioritize ecological and economic diversification (Coppock 2011; Yung et al. 2015; Roche 2016; Wilmer et al. 2016; Coppock 2020). For example, cattle ranchers who raised goats, sheep, dogs, or horses were able to take advantage of differences in species foraging behaviors (Wilmer et al. 2016), as well as multiple markets (Yung et al. 2015), during drought periods. Raising cattle for different markets by, for example, adding stocker or custom grazing enterprises to cow/calf operations, was another key diversification strategy that ranchers cited as increasing their operations' flexibility in drought conditions (Kachergis et al. 2014; Haigh et al. 2019).

Diversifying income through off-ranch jobs, especially in industries less vulnerable to climate variability, can help bolster ranchers' incomes during drought years (Coppock 2020). In the Great Plains and the Colorado Plateau, for example, some ranchers chose to add new operations to their ranches during crisis periods, although more ranchers diversified their income by engaging in paid off-ranch work (Wilmer et al. 2016). In a survey of 479 California ranchers, Roche (2016) found that nearly a quarter of ranchers pursued off-farm employment during droughts, while almost half applied for government assistance.

In addition to diversification, ranchers often increased the flexibility of various aspects of their operation both in response to and in preparation for climate change impacts (Coppock 2020). Changing herd size, accessing alternative feed sources like grass banks or hay reserves, and/or destocking on short notice were cornerstones of flexible drought response (Knutson & Haigh 2013). Flexibility in feed purchases was often described as an especially key response to drought (Coppock 2011; Roche 2016; Haigh et al. 2019; Haigh et al. 2021). The most commonly reported flexibility strategy that ranchers employed during climate crises was destocking, either by selling adult cows, or younger and lighter weanlings (Coppock 2011; Roche 2016; Haigh et al. 2019; Haigh et al. 2021).[4] Researchers consistently found that destocking early during a drought can mitigate adverse financial, operational, and rangeland health impacts (Coppock 2011; Knutson & Haigh 2013; Haigh et al. 2021).

Another strategy that recent research has focused on is drought planning. Drought plans generally encourage ranchers to determine ahead of time what actions they will take if drought indicators are met by certain times of year. Ranchers who rely on drought indicators, such as low snowpack or low spring or summer rainfall (Coppock 2011), can take advantage of responsive flexibility built into their operations to take action, such as destocking earlier, thus mitigating some negative financial and ecological impacts of drought (Haigh et al. 2021). Drought plans often include longer-term measures, too. For example, maintenance of healthy rangeland through rotational grazing, leaving more residual dry matter, or conservative stocking during nondrought years can help ranchers maintain more robust forage supplies to buffer droughts when they do occur (Haigh & Knutson 2013; McClaran et al. 2015).

Research suggests that ranchers are most likely to implement a drought plan (Roche 2016) or other preparatory strategies

[4] Seventy-one percent of respondents in Roche's 2016 survey mentioned destocking ($N = 479$), and there were similar rates in surveys by Haigh et al. (2021) (44% $N = 430$), Coppock (2011) (77%, $N = 460$), and Haigh et al. (2019) (63%, $N = 391$).

(Coppock 2011) if they have previous experience with particularly severe weather events. For example, the number of ranchers with drought plans doubled from 14% to 29% among Utah ranchers after the 1999–2004 drought (Coppock 2011). Whether drought planning consistently translates into actions, however, remains unclear. Haigh & Knutson (2013) found that drought planning increased the likelihood that ranchers in Wyoming and Nebraska would implement effective adaptation practices, but Coppock (2020) found that ranchers in Utah implemented few or none of their planned practices during drought, often reporting a limited sense that drought preparation was necessary.

While drought plans may not directly turn into action, planning for drought can increase ranchers' sense of control (Haigh & Knutson 2013) and confidence in dealing with droughts (Coppock 2011). This sense of control or personal capacity is self-reinforcing—ranchers with more robust drought preparation tools perceive drought threats as less severe, suggesting that they are more confident in their ability to respond to drought, and those who are confident in their response tools are more likely to prepare for drought (McClaran et al. 2015).

It is important to note that experiences with extreme droughts can also *decrease* ranchers' confidence in their ability to cope with drought. After the extreme 2011–2014 drought in California, 82% of surveyed ranchers expressed concerns that their ranching operations would not be able to persist through another extreme multiyear drought (Macon et al. 2016). These empirics suggest that drought management strategies alone are insufficient for ranchers to respond to, and persist through, unprecedented droughts. While drought plans are helpful for ranchers to mitigate drought impacts (Haigh & Knutson 2013; McClaran et al. 2015; Wilmer et al. 2016; Coppock 2020; Haigh et al. 2021), having a plan does not, of course, insulate ranchers from experiencing the impacts of severe drought (Kachergis et al. 2014).

Studies have also queried farm structure and farmer attributes of who implements drought plans but yielded unclear, and sometimes contradictory, results. For example, some studies found that operators with larger ranches were more likely to engage in drought planning than those with smaller ranches due to greater resource access and flexibility (Kachergis et al. 2014; Haigh et al. 2021). Yet McClaran et al. (2015) found no correlation between drought planning and herd size.[5] Similarly, some studies found that ranchers with more formal education were more likely to adopt drought planning tools (Coppock 2011), while others found no correlation between adaptation planning and education (Haigh et al. 2021). One study found that older ranchers are less likely to engage in proactive drought management, likely because they expect to stop ranching in the near future (Coppock 2020), while other studies found no correlation with ranching experience levels, which, while not a perfect proxy for age, are often correlated (McClaran et al. 2015; Haigh et al. 2021). Ultimately, across diverse ranch attributes, ranchers' desire to diversify and increase flexibility offers potentially fruitful pathways for public policy programs to support working landscape adaptation and mitigation.

Rancher Climate Action: Conceptual Clarification of Adaptation

As the summary indicates, there is a need for greater conceptual clarity around ranchers' experiences of climate change. Few studies make a clear distinction between *impacts of* and *responses to* climate change. For instance, economic losses—frequently discussed in empirical studies of ranchers and droughts—were partially due to decreased revenue because of drought-impacted forage reduction that led to lower weight gains and partly due to the common drought response of destocking. Herd reduction, or destocking, could be categorized as an *impact* because of its negative financial effects or as a *response* because it is an action taken by the rancher in response to drought. On the basis of ranchers' perception of their own agency, we offer a potential distinction between climate change *impacts*—situations wherein ranchers perceive themselves as holding little agency regarding the consequences of climate change impacts—and *responses*—actions taken directly by those managing working landscapes.

We also found that conceptualizations of those responses, or adaptations, lack clarity and consistency. In the context of climate change, ranchers' actions are often categorized into overlapping, and sometimes contradictory, descriptors like proactive, reactive, preparedness, risk-management, and planning (see Table 2). For example, Roche (2016) uses the word "planning" to refer to any proactive drought mitigation strategies, whereas Haigh et al. (2021) uses "planning" specifically to refer to the development of structured drought plans. Roche (2016) offers a distinction between *proactive* strategies adopted to prepare for climate change impacts and *reactive* strategies adopted in response to those impacts (Roche 2016). Yet other scholars describe realities that muddy this distinction as ranchers employ reactive but forward looking "risk-management tactics" (Coppock 2011), or "coping practices to prepare for drought" (McClaran et al. 2015). Similarly, specific management practices are not consistently classified. For example, diversifying income was categorized divergently as both a "preparedness" (Coppock 2011) and a "reactive" (Roche 2016) adaptation strategy.

This opacity highlights a gap between ranchers' experiences of climate change impacts and scholarship on the topic. While much scholarship on adaptation divides actions cleanly into "reactive" coping and "proactive" adapting categories, ranchers' experiences in these studies capture the on-the-ground reality that adaptation is a *process* that occurs on a spectrum with directional movement (Fig. 2). What may start as a reactive, short-term coping strategy, such as destocking during a drought, can become a proactive, long-term planned strategy as drought persists and lower stocking densities become planned. A crisis *necessitates* response to cope through it and *capacity* can allow for planning before future crises (Haigh et al. 2019). Ranchers' goals vary, too—some may seek to maintain, or return to, their current operation structure. Others may prioritize varying degrees of preparedness that transition, even aggregating over time to transform, their operation to a new state (Wilson et al. 2020). Establishing conceptual clarity around adaptation in ranching and refocusing on adaptation as process is one way to center ranchers' experiences in climate change discourse.

Debates about conceptual understandings of adaptation are alive in scholarship on social-ecological systems. The IPCC states that in ecological systems, adaptation includes "autonomous adjustments through ecological and evolutionary processes," while in human systems "adaptation can be anticipatory or reactive" (IPCC 2022, p. 7). Some scholars argue that anticipatory adaptation should be differentiated from reactive coping responses (Adger et al. 2005; Fischer 2019). This distinction has a temporal element, where adaptations are generally long term and coping strategies are short term, even temporary (Ibid). The intent and quality of action, and their outcomes, can also be differentiated. Coping strategies may address immediate deleterious impacts while leading to maladaptation that exacerbates underlying causes, long-term impacts, or vulnerabilities of other groups (Koontz et al. 2015). Planned adaptations may then lead to more environmentally sustainable and socially equitable outcomes because decision makers and institutions can more fully include multiple stakeholders and balance tradeoffs of different actions (Ibid).

[5] McClaran et al. (2015) only reported herd size, not ranch acreage.

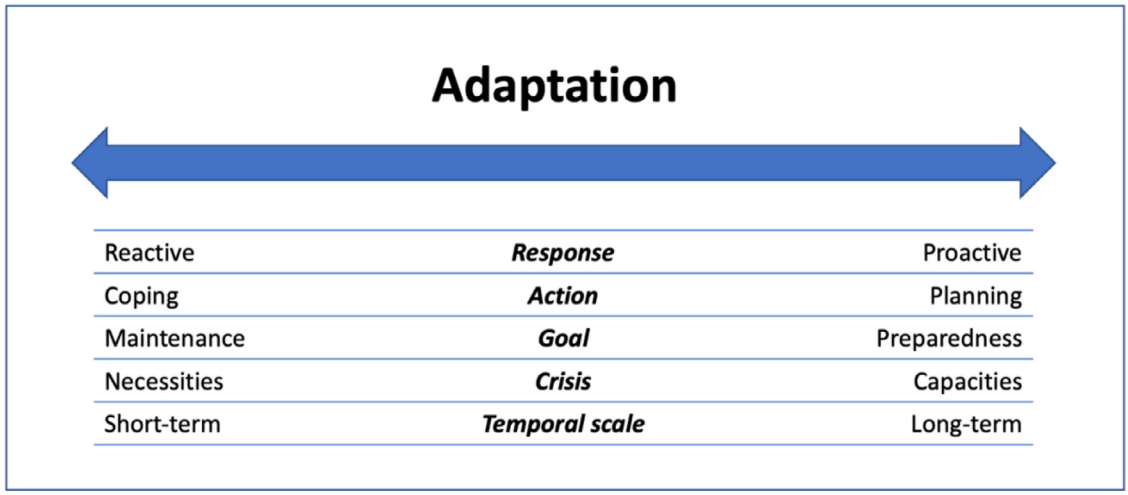

Fig. 2. A conceptual diagram that focuses on adaptation as process. Rather than understanding the noted concepts as categories, we place them along a spectrum informed by rancher experiences that clarifies adaptation in ranching in ways that may be more legible to ranchers. For definitions, see response (Roche 2016), crisis (Haigh et al. 2019), and temporal scale (Fischer 2019).

Alternatively, some scholars argue for a broader definition of adaptation, suggesting that adaptation can be conceptualized in stages, from coping with change, to managing risk, to systemic transformation (Chhetri et al. 2019). We find this conceptualization, as a starting point, more applicable to ranchers and climate change in the western United States. Adaptations can include both reacting to current crises and preparing for future crises, and this distinction is not always neat. Distinctions that exclude reactive or coping strategies from adaptation may be less relevant in ranching contexts where short-term changes shape, and often become, long-term changes. Refocusing adaptation on the suite of practices and strategies ranchers employ to respond to change may be more explicable and welcoming to ranchers who are already engaged in ongoing *processes* of adaptation. Ranchers are continuously and iteratively adjusting their operations to short- and long-term changes and outcomes. Rather than categorizing actions into coping and adapting, we therefore suggest that organizing adaptation practices by their processual direction—"proactive" or "reactive"—may be more legible to ranchers' experience (see Fig. 2).

Ideas for Future Research

Many studies about ranchers' experiences of climate change focus on shocks, especially droughts (with important exceptions, see e.g., Murphy et al. 2017). A focus on climate change shocks may skew our understanding of rancher action toward reactive adaptations. More empirical research on ranchers' experiences of climate change stressors, such as overall hotter conditions, and shifts, like earlier spring snowmelt, may elucidate a wider range of proactive adaptation strategies. Additionally, more comparative research of ranchers in different regions with divergent social and ecological contexts could provide robust opportunities for comparison.

An additional comparison would be how ranchers' responses to climate change correspond with scholarship on adaptation and mitigation best management practices (BMPs). Developing new tools, such as efficacy indices (e.g., McClaran et al. 2015), can help determine which management strategies are most effective for responding to climate change, mitigating future harm, and avoiding potential pitfalls. Because current responses to climate change impacts shape future adaptive capacity (Petersen-Rockney et al. 2021), including tradeoffs and maladaptation potential, comparisons of potential BMPs are crucial. Compost application may, for example, increase soil carbon storage while also increasing nitrogen and phosphorus runoff (Biggs & Huntsinger 2021). Co-developing tools and metrics with ranchers through participatory research processes can help bridge divergent understanding of BMPs. For example, while ranchers report rotational grazing, rangeland monitoring, and drought plans as having the highest efficacy in adapting to drought, they report adopting less effective strategies, like buying feed and reducing herd size, just as frequently (McClaran et al. 2015). In addition, understanding ranchers' perceptions of currently underused BMPs, like (re)introducing beavers or beaver dams to stream ecosystems to increase water and forage availability (Charnley et al. 2020), may help build bridges between stakeholders.

Research is also needed to understand how rapidly shifting structural dynamics, like the rise of rangeland owned by nonoperator landlords (Bigelow et al. 2016), shape climate change experience, perception, and action. For example, how is decision-making authority distributed on ranches with different ownership structures? How can frontline workers, such as ranch hands, address climate change-induced problems when they arise and before they magnify? How does owning versus renting land, or grazing on private versus public land, impact ranchers' capacity to adapt and mitigate? It is also important to interrogate how marginalization of certain rancher identities intersects with adaptive capacity. How, for example, are women ranchers and ranchers from identities and backgrounds underrepresented in ranching experiencing and responding to climate change?

The relationships between ranchers and institutional actors who mediate access to public finances, technical assistance, and other resources (such as Cooperative Extension advisors and government agency staff) remain understudied. Considering that ranchers regularly discussed distrust of government in the context of climate change (Wilmer et al. 2016; Davis et al. 2017; Stasiewicz & Paveglio 2018), studies that highlight opportunities to bridge the divide between institutional actors and ranchers are especially needed. Future research can, for example, help identify strategies to coordinate responses to climate change across decision making levels and ecological scales (see Biggs et al. 2021 for an example of how to evaluate hybrid governance within complex policy landscapes).

Given ranchers' reliance on community and family reciprocity (Yung & Belsky 2007), research on intracommunity and intrahousehold effects of climate change is warranted. For example, how do household roles shift in response to climate change? How are climate change impacts distributed within households or communities? Who within ranch labor hierarchies bears additional adaptation-related work? Do multigeneration ranchers respond differently than first-generation ranchers? How do community relations change with climate change? Recognizing that ranchers operate within ecological and social matrices, it is important to better understand how ranching communities can work collaboratively to respond to climate threats. Regional collaborative efforts like Rangeland Fire Protection Associations (Wilmer et al. 2016; Davis et al. 2017; Stasiewicz & Paveglio 2018) and grass banks (Murphy et al. 2017) offer promising examples and future possibilities for collaborative research and action.

Implications and Conclusions

Incorporating ranchers' perceptions of climate change, including their experiences and responses to its impacts, into scholarly discourse is crucial to developing effective policies and programs that increase the pace and scale of climate change adaptation and mitigation. This Forum paper has summarized recent empirical social science on ranchers' experiences of climate change, offered conceptual clarity on ranchers' response to climate change impacts, and begun to articulate future research directions that can support ranchers and policy makers in building a more sustainable and equitable climate future.

The framing of initiatives to increase climate change action is important to the success of these efforts. For example, framing climate mitigation as a ranchers' responsibility, without acknowledging that they are not the primary drivers of anthropogenic climate change,[6] may fuel resistance to participation. Coalition building might, instead, include ranchers in efforts to hold powerful firms and the governments that facilitate their extraction from rural communities responsible for contributing to rural livelihood grievances and greenhouse gas emissions (Ashwood 2018; Edelman 2021).

Climate change programs may also be more successful if they recognize and reward the stewardship ranchers already provide. Appealing to ranching values, including place-based identities (Murphy et al. 2017) and co-benefits of adaptation and mitigation, like reducing off-ranch inputs, offer promising opportunities to increase rancher climate action (Davidson et al. 2019). Future research can work to better center ranchers' perspectives in determining the landscape of BMPs, tradeoffs, and maladaptation outcomes. Doing so will provide more useful information about the costs and benefits of various adaptation and mitigation strategies.

Given the tremendous spatial and temporal diversity of range systems, as well as the uniqueness of each ranch—in terms of resource endowment, ecological conditions, social goals, etc.—prescriptive actions are unlikely to be effective. Additionally, ranchers might be hesitant to engage with policy or educational opportunities that appear to be "handed down" from nonranching experts, especially government actors. Policy and management actions must be context specific and informed by diverse ranching stakeholders. Ranchers in the western United States consistently indicated greater trust in other ranchers or people working in the ranching industry than government agencies or experts (Wilmer et al. 2016; Davis et al. 2017; Stasiewicz & Paveglio 2018), suggesting that climate change action may be most effective when co-developed and encouraged by trusted local ranchers and other respected community members. A menu of strategies that ranchers could evaluate for applicability and efficacy on their operation could, for example, be a useful tool for ranchers and ranch advisors.

As the climate continues to change, natural resource-dependent livelihoods like ranching will become increasingly difficult. Simultaneously, the services that working range landscapes, and the ranchers who manage them, provide, like clearing fuel in fire-prone landscapes and sequestering carbon in soils, will become increasingly crucial to humanity. As academics, our role in supporting ranchers in a more volatile climate future starts with meaningfully including ranchers' experiences of climate change in academic discourse.

[6] Just 100 firms are responsible for 71% of global emissions, and none of these firms are ranches (Griffin 2017).

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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