Making Research Relevant: Sharing Climate Change Research with Rangeland Advisors to Transform Results into Drought Resilience

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Research Paper

Making research relevant: Sharing climate change research with rangeland advisors to transform results into drought resilience

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On the Ground

- Public programs, strategies, and incentives to implement rangeland climate adaptation are more effective if they are tailored to local drought exposures, sensitivities, and adaptation opportunities. As such, local rangeland advisers who aid in climate adaptation are pivotal to the development of these resources.
- We hosted a virtual workshop with rangeland advisors to share results from our climate vulnerability assessment, gain their insight on finding usability, and discuss visions for resource creation.
- Climate adaptation resources should not follow a one-size-fits-all approach. Accommodating variety in resource development and outreach must consider multiple factors: variation in the ranching community, instability in the environment beyond climate, and rancher/manager identified variables in climate vulnerability assessment analyses.

Keywords: Climate change, co-ideation, engagement, rangelands, workshop.

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Introduction

Drought and climate change are central themes investigated in past rangeland research, modeling, and extension activities.[1] This effort is critical to the longevity of ranching and food production, as drought and climate change decrease water supplies and stress forage growth, while exacerbating other issues (e.g., human health, financial strains). For instance, between 1980 and 2019, 26 major drought events occurred in the United States, with impact costs exceeding $1B each. In total, these events cost the nation at least $249B.[2] Recent droughts have reached record intensity in some regions of the United States, such as the Texas-Oklahoma drought of 2012[3] and the California drought of 2012 to 2014.[4] Although the word "drought" indicates abnormally dry conditions, there are different classes of drought, including meteorological, hydrologic, agricultural, and ecological. While classification adds complexity to drought evaluation and discussion,[5] classification helps us better understand the linkages between drought and climate change, human impact, and projecting future drought. How ecological drought (i.e., periods of water deficits that drive ecosystems beyond thresholds of vulnerability) differentially impacts rangelands, livestock, and human communities across various regions remains largely unexplored. As such, the development of resources to accommodate unique regional experiences has yet to reach its full potential.

We report the findings from a virtual workshop with rangeland advisors designed to share the initial climate change vulnerability assessment results from our research project, "Rangelands, Ranching, and Resilience: Ensuring Adaptive Capacity in a Variable Climate" (R3). Through the workshop format, we sought to collect rangeland advisors' thoughts on the usability of our findings and their visions for creating effective information resources and outreach opportunities.

The overall R3 project itself builds upon prior climate modeling efforts by acknowledging regional differences in climate impacts and the environment's (natural and human) ability to respond to these impacts. The research approach, which includes regional analyses, is needed to develop and evaluate regional strategies to cope with differential changes

in exposure and sensitivity to climate change and accommodate various adaptation capacities. We ground the project premise in the following four guiding principles.

R3's guiding principles

1. Different geographic regions within the western United States have distinctive backdrops on which to assess impacts of climate change. These backdrops include the biophysical environment, as well as the socio-economic and cultural environment, that influence how climate change manifests on the ground. Climate has influenced natural and grazing evolutionary histories, and the culture of land management.[6-8] Regions also differ in their exposure to increases in future climate variability.[9]
2. The coupling of social and natural components in rangelands determines sensitivities and effective adaptation strategies.[10] For instance, vulnerability in livestock production can be strongly influenced by sensitivities in forage production to climate variability.[11,12] By examining vulnerability through a social-ecological lens, we can best capture the available potential management strategies.
3. Coping with uncertainty is a challenge in both human decision-making and natural environments. Just as some individual plants and animals adapt to a changing environment to survive, eventually changing the characteristics of the species,[13,14] uncertainty in weather conditions has forced ranchers to adopt a variety of flexible and conservative management strategies that ultimately may become common practice.[15-17]
4. The experience and knowledge of local actors are necessary to understand specific sensitivities and existing local capacity to adapt to climate events.[18] Thus, we embed our extension efforts with local managers and ranchers throughout the project framework, first to understand on-going adaptations to recent climate variability by the innovators and early adopters and then to explore how those early adaptations may need to be modified under future climate scenarios.

Given the prevalence of diverse, locally dependent climate change experiences, and the ample local expertise of rangeland advisors working for Cooperative Extension Service (CES) and USDA technical assistance agencies, we designed R3 to continuously incorporate advisor knowledge and feedback. Ideally, these discussions with rangeland advisors would inform the project's trajectory and, ultimately, suggestions for effective adaptation strategies and recommendations. This effort extends beyond a one-time event, but represents an iterative process between advisors and researchers, working together to develop knowledge and outputs (Fig. 1). As such, R3's history involved creating trusted relationships with rangeland advisors, using qualitative research efforts aimed to understand personal experiences, and now this workshop to relay new and transformed information back to people on the ground with the hope of developing effective drought adaptation information and resources together.

Workshop background

Increasingly, western ranchers experience and anticipate the impacts of a changing climate. Many ranchers report feeling moderate to severe levels of anxiety over the need to identify and employ climate change adaptation strategies.[19] To help them adapt, the scientists who forecast climate change impacts for western rangelands must work collaboratively with rangeland advisors to ensure that the best scientific information is made available to ranchers in an accessible and relevant form.

Climate vulnerability assessments aid in identifying risks from climate change impacts of different magnitudes and provide information for adaptation planning processes. Results from assessments must therefore maintain relevance to, and usability by, rangeland advisors who guide adaptation strategies in their communities. The goal of this workshop was to convene rangeland advisors for their assessment of R3 preliminary findings and collect their ideas about how best to share information with their rancher clientele. This step of the iterative engagement process ensures research efforts meet the informational needs of communities combating drought and other climate impacts.

We invited leading rangeland advisors from six states across the western United States within the R3 study site (Fig. 2) to participate in a 3-hour virtual workshop to assess usability of and dissemination options for findings from R3. We targeted rangeland advisors from the R3 study site so that knowledge and experience of place remained consistent with all of the R3 efforts. We define "rangeland advisors" as range or natural resource professionals who provide guidance to ranchers on relevant research, resources, or tools that will improve the sustainable longevity and success of rancher operations. Working closely with ranchers, advisors have clear ideas of their clienteles' needs as well as influence in rancher decision-making. They would have an understanding of how, and if, our results can be useful to their rancher communities. These individuals include staff from CES, USDA Farm Service Agency (FSA), and USDA NRCS. We collected names and contacts of relevant rangeland agents and specialists from each organization's offices within our study site. We also included advisors who have previously participated or informed other aspects of the R3 project. We sent these individuals an email invitation that included a workshop agenda, informational flyer (Fig. S5), registration link, and Zoom details. Individuals from Arizona, California, Colorado, Nevada, New Mexico, and Utah participated; of the 14 participants, eight were from CES, one from FSA, and five from NRCS.

We structured the workshop to include two main segments: 1) sharing R3's goals, methods, and findings to date through presentations, and 2) gaining feedback from participants through discussion. In a series of 10-minute presentations, we provided a high-level overview of the project's guiding questions, methods, and results to date that illustrate drought exposure, sensitivity, and adaptive capacity across various rangeland types in the western United States (Fig. 2).

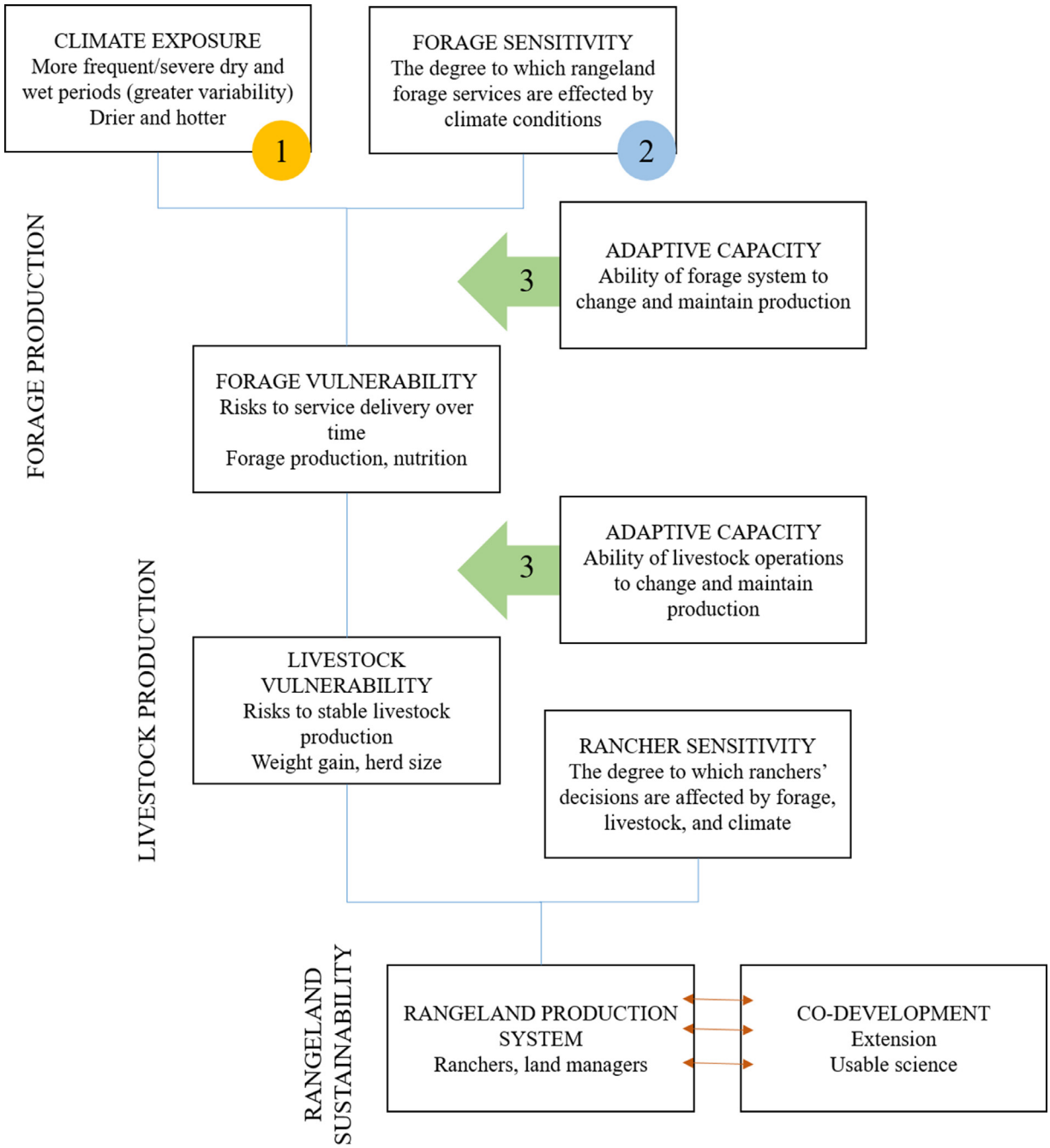

Figure 1. Conceptual model illustrating integration of science, rangeland advisors, and ranchers (adapted from Suding and colleagues' 2018 grant proposal[31]).

Through this first step, we sought to ground the participants in the R3 efforts to date so that we can move forward from a shared understanding together. We also hoped to clarify the limitations of the data and research team capacities. For instance, providing the timeline of the research grant will inform what is possible in terms of resource creation for the duration of the project or prompt other avenues for moving forward beyond the lifetime of the grant. Lastly, we wanted to illuminate the importance of the participants' insight and expertise to these efforts. We recognize our work cannot be used to its fullest potential without the input from the people who work directly with, and understand the needs of, the audiences we hope to support.

Following these short presentations, we divided participants into multiple groups of three to four individuals to discuss the presentations. We assigned a discussion leader from the research team to each group to guide conversation with a set of discussion questions (Table 1). Additionally, we assigned a note-taker from the research team to each group to document their discussion highlights. Groups reconvened to share discussion highlights in plenary with the goal to identify common themes (Fig. 3).

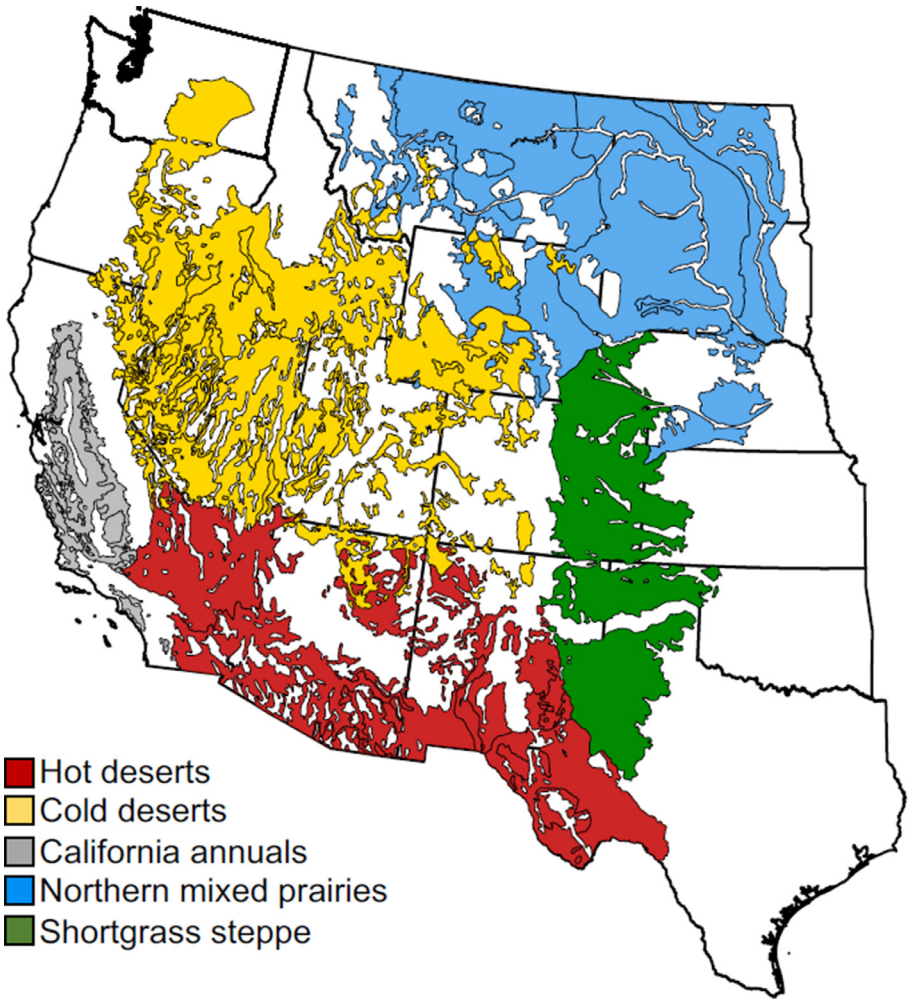

Figure 2. Extent of the *Ranching, Rangelands, and Resilience: Ensuring adaptive capacity in a variable climate* (R3) study site. Additionally, figure demonstrates rangeland type diversity.

Table 1
Small-group discussion questions used by discussion leaders to guide conversation

Discussion Questions
1. What information and tools do your clientele currently use to make decisions, what gaps or barriers remain, and what might be needed in the future?
2. What information and outputs from our research project might be most useful to you and your clientele?
3. How should we, as a research team, package and distribute information identified in the previous point to be most useful and accessible?
4. What is the most logical next step to achieve these outputs?

Workshop presentations: R3's goals, methods, and findings

Presentation One: R3 background

In this presentation (Fig. S1), we shared R3's purpose, which aims to identify regions where climate change will pose a high priority threat to rangeland production systems. We explained that answering this question will help ranchers and managers identify where to prioritize climate threats over other rangeland problems and vice versa. The following presentations expand upon the three components of the climate vulnerability assessment we performed to answer our research question.

Presentation Two: Exposure - ecological drought approach and regional summaries

In this presentation (Fig. S2), we described our efforts to understand how drought will change throughout the 21st century in terms of soil moisture, precipitation, and temper-

Figure 3. Group discussion captured by graphic illustrator present at the workshop (Karina Branson, ConverSketch).

ature. We walked through the methods for this step, which included examining an inclusive suite of different climate projections,[20-22] as well as quantifying the degree and duration (i.e., exposure) of past and future drought.[23-25] We then presented our results by region to highlight the diversity in drought manifestation. We explained that while temperature is likely to increase across all regions, precipitation and soil moisture display more variability. For instance, we described the northern mixed prairies and cold deserts of the western United States (Fig. 2) will experience an increase in winter and spring soil moisture, although relatively unchanged summer and fall soil moisture. In California's annual rangeland region, we suggested more frequent extreme drought during the winter, but slightly wetter average spring and summer conditions. We explained that spring soil moisture is likely to decline in the hot deserts region, but differ in projections for soil moisture change for other seasons in both the hot deserts and shortgrass steppe.

Presentation Three: Sensitivity - mid-century forage projections regional summaries

For this presentation (Fig. S3), we explained how forage will be impacted by the aforementioned changes in soil moisture, precipitation, and temperature. We walked through the methods we used to create these forage projections, which included analyzing past relationships between weather and remotely sensed forage production and creating models unique to each region.[26] We explained that climate change is likely to impact forage production variably across western US rangelands by mid-century (2020-2059). We shared that mid-century changes to both average forage production, and the probability of years with low forage production (defined as annual production <75% of the historical mean for a site), are modest across most western US rangelands. We described that the Southern Plains and Southwest present an exception to these findings. Further, we explained that large reductions in forage are projected by mid-century, supporting other findings that the southwestern United States is where climate change will most impact forage production by mid-century across western US rangelands.[27,28]

Presentation Four: Human dimensions of range resilience

In this final presentation (Fig. S4), we walked through our efforts to understand what "resilience" means for ranchers, what they identify as threats to the future of ranching, and how they are adapting to these threats. We presented the methods and results of our focus groups and interviews conducted with ranchers in California, Nevada, Utah, Arizona, Colorado, and Nebraska. We explained how four resilience themes emerged, with each theme representing a set of challenges and adaptations: 1) resilience to changing ecological conditions such as drought and invasive weeds; 2) economic resilience in face of challenging markets; 3) resilience in the face of a changing ranching community and succession; and 4) resilience to competing priorities for how rangeland should be used. We further discussed how, on both private and public rangeland, ranchers are trying to adapt to each of these themes simultaneously, with each theme providing both constraints and opportunities to ranch resilience. Lastly, we described how participating ranchers in the focus groups and interviews expressed higher levels of agency and capacity in

the face of ecological challenges than they did for the other three thematic areas.

Workshop discussions: Participants' response to R3 efforts

A diversity of drought tools and resources exist, but participants expressed that knowing what tool to use and when to use it is a daunting challenge. For the participants, most of these tools are left unused by their clientele, as ranchers often turn to reactive and financial backing strategies. While temporarily helpful, these steps lack the long-term, whole-ranch perspective and may be maladaptive as drought and other climactic challenges persist and evolve. Constrained by finances, time, valued or traditional ways of operating, environmental conditions, etc., ranchers often lack the flexibility to invest in exploring or implementing new tools or changes in their operations.

The participants discussed a few factors that make current tools inaccessible given these constraints. Certain project variables, as well as timescales that exceed decade lengths, might not translate well into actionable information, at least for the decision-making calendars ranchers are currently using. For example, relying on precipitation totals or averages leaves blind spots for ranchers who need to know when precipitation is occurring (seasonality and shifts therein) or how precipitation will influence forage growth.

Participants discussed a few factors presented in the research analysis and data that might challenge the accessibility and usability of project outputs. The mid-century projections we presented reveal intriguing information but can be hard to conceptualize into drought plans. This facet is especially true for those who must operate on shorter, day-to-day timeframes. Participants suggested incorporating shorter time scales, narrower confidence intervals, and historical trends to increase reliability and user interest.

Participants suggested that surface water availability, in addition to precipitation, could serve as an additional factor in determining management scenarios in drought. Recognizing other variables that would better illustrate local climate scenarios and inform decisions, participants wondered how well this data and its outputs can accommodate the intra-county variability that is a reality across most of the western states. For instance, what would applying this information look like within a county where cattle graze both range and forest land? Participants also recognized the predicament in incorporating a multitude of variables that better reflect the complexity of actual ecosystems versus maintaining simplicity for the desired user. They suggested examining the prioritization of challenges, with a heightened focus on sustaining rancher livelihoods and well-being, to envision win-win scenarios.

Understanding the complex realities and decision space of ranchers may resolve broader research and communications challenges. The participants suggested that the long-term forage production estimates may be less actionable and relevant than near-term information on forage or information on other threats. In response, we wonder if end-of-century projections are relevant to ranchers and if beginning with a knowledge co-production process would help focus on the most pressing questions.[29,30] Long-term projections cannot inform decisions made at the margin (e.g., "What do I need to do next year in order to continue production?"), but this does not mean such projections are not valuable. Some ranchers may very much like to know longer-term climate and forage projections, if only as one additional piece of evidence to weigh in succession planning or in deciding whether to sell or significantly alter their operations. More broadly, when conceptualizing the impacts of climate change, rangeland advisors and managers may need to be encouraged to consider a longer planning horizon to adequately prepare for changing conditions. Ultimately, participants expressed that exposure and sensitivity information were only one piece of the complexity in the factors entering into and defining the decision space.

It is vital to build and maintain ongoing partnerships between researchers and technology transfer professionals. Participants explained that climate change researchers rarely understand the pressures that ranchers face daily, and ranchers are unlikely to teach them. The gap between scientists and stakeholders is spanned by professionals in CES, NRCS, and other state and federal agencies whose programs exist to help ranchers succeed. As scientists work to translate research into actionable products for ranchers, the quality of engagement with these boundary-spanning professionals will define how effectively research is integrated into decisions that matter for people and the land.

Key lessons learned from participant feedback

For the community at large

Participants acknowledged that certain factors in their day-to-day experiences will affect how resources and tools, like the results and subsequent outputs created from R3, are absorbed and used. We synthesize this input into general suggestions for our communities, not specific to our project, to mobilize knowledge transfer from research to actions on the ground. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Climate communication professional. A local expert trained in climate communication who serves as a one-stop-shop for climate information and resources would alleviate some of the barriers ranchers and their rangeland advisors face when incorporating climate data and tools into their operations. CES in Arizona and Utah employ climate specialists in similar capacities, serving as models for CES in other states to evaluate and replicate.

New "old" ways of doing things. Time is a scarce resource for ranchers. Presenting information in time-accessible ways to ranchers is of high priority to disrupt patterns of reactive (e.g., destocking, supplement feeding) strategies and implement

more sustainable options. In coordination with the aforementioned climate communication professional, options like radio programs, newspaper blurbs, and conversations at kitchen tables could offer effective solutions to current drought adaptation barriers. One-on-one conversations via house visits would also restore the social component lost in group settings or research outputs. The social component is critical to developing trusting relationships that encourage interest and participation in other drought adaptation opportunities. These efforts strengthen the alignment between the social and natural components of the world around us, further advancing a more holistic view of climate change and validation of a social-ecological approach. Moreover, the individualized approach would aid in transferring generalized drought tools and information to ranch-specific scenarios.

For the project

Additionally, we synthesize priority participant suggestions that relate directly to R3's methods and future trajectory.

Values-based approach. R3 results demonstrate that drought, and more broadly climate change, will impact rangelands differently across the West, with the southwest and southern plains rangelands significantly more threatened by drought impacts. However, despite this potential threat, participants explained people may not accept certain information on drought under climate change given their beliefs toward climate change in general. While ranking or prioritization of threats and values offers a method of targeting audiences for this information, a variable that remains important across most audiences is lifestyle. Ranching as a lifestyle implies that motivations to ranch extend beyond economic considerations, but include enjoyment of the outdoors, scenic views, and family involvement, to name a few. Including these factors when assessing drought impact might make drought more relatable across a diversity of operations and influence adoption of adaptation strategies. Determining ways to convey research information that improves the well-being of ranchers and sustains their operations is critical. Means of doing so may include tools that quantify decisions for ranchers, or a list of options from which ranchers can choose depending on their values, circumstance, and/or ranch-level needs.

Stakeholder advisory board. No matter the trajectory of R3, we must retain close communication with stakeholders to ensure our outputs remain accessible and effectively meet the needs of their communities. Creating a representative advisory board of interested stakeholders would support the consistent and efficient feedback systems between the research team and stakeholders. To achieve representation of the variety of perspectives and experiences, the board should also include ranchers, in addition to rangeland advisors, with deep consideration of the diversity of ranch operations (e.g., size, land base, management practices) and environments (e.g., rangeland types). Involvement in an advisory board will demand additional time and energy from stakeholders, so ensuring their involvement is meaningful and worthwhile is critical. This intentionality requires thoughtful planning by the research team, balancing proactive advisory board development with the lack of complete certainty in research results and timelines. Developing a board prematurely, for example, without a clear vision for an integrated research product, might result in inviting people with expertise, expectations, etc., that do not align with the project goals, potentially misusing stakeholders' time. The suggestion for a stakeholder advisory board aligned well with the original intentions detailed in the project's premise. However, development of an advisory board was delayed to account for the feedback obtained at this workshop.

Key lessons learned from workshop format

The workshop format proved to be a valuable, efficient tactic to engage with rangeland advisors for sharing and gaining feedback on project results. We learned valuable input from participants that we believe will help us best translate research findings into practical outputs. Although each region and situation is different, we believe our lessons can be applicable to other efforts to incorporate rangeland advisors' guidance into products of research endeavors. We provide the following lessons learned to inform future stakeholder engagement efforts.

Timing and length of workshop

Running a total of 3 hours, the workshop proved too long for some participants, evidenced by a decrease in attendance toward the end of the event. We held the workshop in a period of heightened virtual communication due to the COVID-19 pandemic. Requesting the time, energy, and attention of others during this time entails a more critical consideration of people's emotional and mental capacities. For future events, offering a series of workshops could potentially assist in breaking up the agenda and potentially leave more time for questions, discussion, and information sharing. Simultaneously, a series of workshops would build familiarity among participants over time, creating a network of involved technical and service providers. Those benefits would need to be balanced, however, against the likelihood that some participants would not be able to attend more than one workshop due to other time commitments. The event also occurred during livestock fair and showing season, limiting the availability of our targeted audience. We recorded the workshop and shared relevant materials after the workshop for those who were unable to attend for the entirety or at all.

Preworkshop communication

Gentle reminders sent a week, 2 days, and the morning before the workshop ensured the event was not forgotten among busy calendars. Reminder emails included the date, time, Zoom access details, and the most recent agenda. Providing a detailed agenda before the meeting demonstrated respect for participants' time, structured the meeting, and rein-

forced the meeting goals and objectives. Additionally, we provided the discussion prompts before the workshop and again at the workshop break so that participants would have time to reflect and formulate their answers.

Conclusions

We argue that public programs, strategies, and incentives to implement climate adaptation are more effective if they are tailored to the local diversity in exposures, sensitivities and adaptation opportunities faced by ranchers and land managers. Thus, perhaps the most important result of the workshop was a reinforcement of the notion that "one size does not fit all." Accommodating variety in resource development and outreach must consider multiple factors: variation in the ranching community, instability in the environment beyond climate, and what variables are chosen in the types of analyses we performed for R3.

For full-time ranchers, attending a workshop conducted in collaboration by climate, beef, crop, range, and economic CES educators and scientists might be the best way to learn about options for adaptation. For those ranchers who must maintain a second job, asynchronous communication channels may be the only accessible ways to learn. There remain differences in rural internet access and capacity that will make web-based tools more useful in some locations than in others. Because time is limited, the methods used to help ranchers adapt to climate change must be designed so that even small investments in time can lead to real improvements in resilience. When developing the messaging of these outputs, remembering that sustaining rancher livelihoods provides a universal avenue to reaching diverse audiences.

Although forage availability is a critical factor in climate change adaptation for ranchers, it is far from the only consideration. This emerging workshop idea reinforces the initial project guiding principle that both social and natural components determine effective adaptive strategies.[6] Adaptation must include tracking and responding not only to a changing climate, but also to changes in markets, rangeland plant communities, and the human communities in which ranchers reside.

Lastly, ranchers and their rangeland advisors will have key insight to the variables, geographic scales, and timeframes to include in climate assessments that would produce actionable results. Involving these folks early and throughout the research development and execution is vital. However, researchers must remain transparent to the uncertainty of their models and invest in other methods to complement gaps in model shortcomings.

Declaration of Competing Interest

The authors declare the following personal relationships which may be considered as potential competing interests: M.B. is a former member of the Rangelands Steering Committee but had no input on the review or decision process of this manuscript.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.rala.2021.08.004.

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