



Research Paper

Principles for successful livestock grazing management on western US rangelands

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On the Ground

- In recent decades rangeland science has moved from a “command and control” framework to one that values heterogeneity, recognizes rangelands as social-ecological systems, and seeks to integrate complexity.
- This new framework recognizes management as fundamentally site-specific, but rangeland science has not provided clear principles for successful livestock grazing management for use by producers and other stakeholders. This reticence has created a void often filled by prescriptive solutions that contradict our best understanding of rangeland systems.
- We engaged hundreds of livestock grazing management experts in an iterative conversation to distill a set of evidence-based, adaptable principles for successful livestock grazing management in the semiarid and arid rangelands of the western United States.
- The seven principles are: Practice adaptive management; Optimize stocking rate; Use a grazing plan; Prioritize ecological health; Evaluate distribution; Welfare begets performance; and Think beyond the range. The full versions of these principles contain paragraph length descriptions highlighting key considerations for each.
- We envision these principles as a first draft to be improved with discussion and additional research. Further development can include definitions, suggested applications, and checklists for assessment for use in teaching, extension, and industry evaluation efforts.

Keywords: Grazing management, Livestock, Principles, Rangelands.

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Introduction

Livestock grazing management on the diverse rangelands of the western United States is enormously complex.^{1,2} Environmental heterogeneity, grazing livestock, and human goals interact to generate endless permutations of potential management strategies.³ In the face of this complexity, rangeland science seeks to provide usable information to improve ecological, economic, and social outcomes for livestock producers and rangeland stakeholders.⁴

In previous eras, the recommendations of rangeland science were often situated in the “command and control” framework common to agricultural science.⁵ Recommendations encouraged livestock grazing managers to “manage to the middle” and limit diversity in pursuit of predictability. However, in recent decades a new framework has emerged from the science, one that values environmental heterogeneity, recognizes rangelands as social-ecological systems, and seeks to integrate rather than ignore complexity.⁶

Perhaps the dominant idea guiding this new framework is that livestock grazing management is highly site-specific and thus management strategies are context-dependent.⁷ Put simply, “it depends” has become the (first) answer to nearly every question. In most situations, and as the start of a lengthier conversation, “it depends” is the correct answer. There is no single best approach to grazing management for all situations, and multiple approaches can produce similar outcomes.⁸

However, the lack of a clear answer on the question of principles for successful livestock grazing management has created a challenge for rangeland scientists. Our reticence has left a void that is increasingly filled by simplistic explanations and prescriptive solutions that contradict our best understanding of rangeland systems.

Here we aim to step into that void and start a meaningful conversation. This effort began with casual discussions, asking each other “well, what do we know,” and grew into a year-long effort engaging hundreds of livestock grazing management

Table 1

List of advisory team members.

Name	Institution	State
Aaron Lien	University of Arizona	AZ
Leslie Roche	University of California, Davis	CA
Justin Derner	USDA Agricultural Research Service	CO
Karen Launchbaugh	University of Idaho	ID
Lance Vermeire	USDA Agricultural Research Service	MT
Derek Bailey	New Mexico State University	NM
Paul Meiman	University of Nevada, Reno	NV
Kirk Davies	USDA Agricultural Research Service	OR
Eric Thacker	Utah State University	UT

experts from across the western United States. Throughout this process, we endeavored to distill a set of evidence-based and adaptable principles that capture the rangeland science community's collective knowledge about successful livestock grazing management in the semiarid and arid rangelands of the West.

As with similar efforts in other disciplines,⁹ we believe these principles can help establish a shared vision of successful livestock grazing management and the research needed to support it. However, we do not think these principles are definitive but rather a first iteration that should evolve with debate and discussion. More important than the conclusions of any single project or group of people is the ongoing process of thoughtful and inclusive construction and dissemination of usable knowledge that is rangeland science at its best.^{2,10,11}

Methods

Our project was conceived as an iterative conversation among a small group of rangeland scientists from across the western United States and a larger community of livestock grazing management experts from the same region. We used a five-step process to develop a set of principles for successful livestock grazing management: 1) recruit a geographically representative advisory team (Table 1); 2) design a grazing management survey and distribute to experts across the western United States; 3) analyze survey results and delineate draft principles; 4) gather feedback on draft principles from survey respondents and at the 2023 Society for Range Management Annual Meeting; and 5) integrate feedback and refine principles.

Geographic and system boundaries

We focused the geographic scope of our work on the semiarid and arid rangelands of 11 western US states (Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming). For system boundaries, we limited the principles to those that apply to the interactions among managers, livestock, and the land. We recognize our boundary drawing is subjective and did not encompass some relevant issues like financial man-

agement; however, these boundaries were necessary to manage the project effectively.

Characteristics of principles

To ensure applicability across a wide range of climates, ecosystems, and management approaches, we first sought principles that are adaptable rather than prescriptive. Second, we sought outcome-oriented principles rather than practice-oriented principles, assuming a correlation between adaptability and orientation toward outcomes. Third, we sought to identify principles that are practical to assess, which is particularly important for users aiming to support effective grazing management (e.g., industry, certifiers, and producer support organizations). Finally, and most importantly, we sought principles supported by scientific evidence.

Survey

We described this background and the expectations in a survey (Supplemental Fig. S1) that was distributed digitally across the western United States via each advisory team member's network as well as broad channels such as producer association list-servs and Extension networks. We requested responses from any who self-identified as livestock grazing management "experts," with an emphasis on hearing from people with "all types of backgrounds in livestock grazing management." All who responded to the survey were included in the analysis. The main section of the survey was a request for thoughts on successful livestock grazing management within seven categories identified by the advisory team through lengthy discussion. We felt the first six categories were comprehensive within our system bounds but included an "other or uncategorizable" category to both solicit uncategorizable input and check the comprehensiveness of the other six.

We placed no limits on response length and emphasized the survey was largely a "brainstorming" session to further encourage responses. We also collected optional demographic data from respondents. Names, emails, and other contact information were not requested, though respondents could volunteer that information in a separate unlinked form if they wanted to provide future feedback and receive project updates.

Analysis

We used thematic analysis to encode survey responses in NVivo 1.7, translating lengthy responses into multiple summary "codes" aimed to capture the essence of the information provided.¹² For those unfamiliar with qualitative methods, it is important to note we did not aim to be objectively detached but rather to find information relevant to our project goals without straying from what we perceived to be the respondent's intent.^{13,14} The codes were developed and refined across multiple readings, with the initial coding done by the first author and then reviewed and re-coded by 1 to 2 advisory team members for each category.

Table 2
Demographic information for survey respondents (65 out of 80 total respondents).

Demographic question	Number of respondents	Proportion of respondents
In which states do you have experience doing work related to livestock grazing management?*		
Arizona	12	18.5%
California	10	15.4%
Colorado	34	52.3%
Idaho	7	10.8%
Montana	11	16.9%
New Mexico	17	26.2%
Nevada	10	15.4%
Oregon	10	15.4%
Utah	10	15.4%
Washington	3	4.6%
Wyoming	11	16.9%
Which statement characterizes your work with livestock grazing management? You can select more than one.*		
I make day-to-day decisions about the management of grazing livestock.	35	53.8%
I assist grazing managers with technical or other support (e.g., extension, NRCS, nonprofit, etc.)	30	46.1%
I conduct research on livestock grazing management.	14	21.5%
I regulate or oversee livestock grazing managers (e.g. work for a grazing association or public land management agency)	17	26.2%
Do you have a bachelor's degree or higher in Range Management or a closely related field like Natural Resource Management?		
Yes	42	64.6%
No	23	35.4%
How many years of experience do you have working in livestock grazing management?		
<5 years	1	1.5%
5-10 years	7	10.8%
10-20 years	10	15.4%
>20 years	47	72.3%

* More than one selection was permitted.

The most commonly recurring codes provided the foundation for the draft principles. The advisory team reviewed and discussed the draft, leading to significant revisions. We sent this revised draft set of principles to the survey respondents who had provided contact information.

Additionally, we sought feedback on the draft principles from attendees of the Society for Range Management (SRM) Annual Meeting in Boise, Idaho in February 2023 via a “campfire conversation,” a world-café-style session.¹⁵ This session consisted of facilitated rotating 20-minute discussions of individual draft principles at three tables. We captured feedback in this campfire conversation via a written feedback form given to attendees as well as facilitator notes. We summarized the input from these feedback rounds and used it to revise the principles, which were further reviewed and revised by the advisory team.

Results

We received a total of 80 responses to the survey, with representation from across the 11 western states. Of the 80 responses, 65 supplied the optional demographic information (Table 2). Colorado was the most represented state, with

52.3% of respondents having experience working in Colorado, and Washington was the least represented state, with 4.6% of respondents having experience there. The average respondent had experience working in more than two states. Notable among the demographic data was that the majority (53.8%) of respondents were making day-to-day decisions about the management of grazing livestock, roughly two-thirds had a bachelor's degree or higher in rangeland management or a closely related field, and a remarkable 72.3% of respondents had more than 20 years of experience in livestock grazing management.

Responses were well distributed across the seven grazing management categories (Table 3), with >60 responses in all but the “other or uncategorizable” category. Responses averaged 340 words, totaling 27,276 words of text. For context, this is about the length of “The Old Man and the Sea” by Ernest Hemingway. After iterative team coding, we encoded 98 unique codes to these responses.

Of the 38 initial respondents supplying contact information, 12 responded to the request for feedback on the draft principles and provided 1,996 words of comments and suggested edits. At the 2023 SRM Annual Meeting, we received 81 written responses via the feedback forms while taking notes to capture the input of 30 to 40 additional conversation

Table 3

Response counts and length by category.

Survey category	Response count	Total words
Stocking rate and timing/intensity/frequency/duration of grazing	68	6,069
Livestock performance and health	61	3,188
Livestock distribution	63	3,066
Ecological health of rangelands	65	3,962
Goal setting, planning, and adaptation	61	3,760
Wildlife conflict and interactions with the public	60	3,272
Other or uncategorizable	33	3,959
Total	80	27,276

attendees who did not supply written feedback. We summarized the written and oral feedback into 161 distinct suggestions. We used this feedback to further edit and improve the principles in content and clarity of presentation. Note that there may have been overlap between survey respondents and respondents at the SRM Annual Meeting, as the need to preserve anonymity meant we did not ask the SRM respondents if they had previously participated.

After multiple rounds of drafting, feedback, discussion, and edits, we determined we had achieved “data saturation,” as additional responses repeated previously received input without providing significant new information.¹⁶ This does not necessarily mean the principles are in any way final or not worthy of debate, but rather that we had reached a point where starting a new phase of principle development was necessary.

The format of the principles was an important consideration of the advisory group and a subject of feedback from respondents. Although some respondents felt strongly that the principles need to be short and easily memorized, our advisory group and many respondents suggested that some length was required to provide proper detail and context. We compromised to arrive at a format consisting of short memorable statements followed by paragraph-length principles, with key items in bold.

Ultimately, we delineated seven principles for successful livestock grazing management in the semiarid and arid rangelands of the western United States (Fig. 1). These principles mostly align with the categories from our survey, with the input from the rangeland science community constituting the bulk of the body of each principle. Note that we split the “stocking rate and timing, intensity, frequency, and duration of grazing” category into two principles and used the data from the “other or uncategorizable” category to inform other principles, which was a good indication that the six categories we selected were comprehensive. The principle developed from the “wildlife conflict and interactions with the public” category expanded beyond our expectations, growing into a principle we named “Think beyond the range,” which is further explored below.

A point of emphasis among survey respondents and the advisory team was that the principles are nonhierarchical, with goal setting fundamental to all. Many indicated they should



Figure 1. The seven principles for successful livestock grazing management on semiarid and arid rangelands of the western United States.

be seen as dependent upon and overlapping with one another and unable to be applied in isolation.

The seven principles for successful livestock grazing management on semiarid and arid rangelands of the western United States

Practice adaptive management. Successful grazing management relies on **adaptive management** and **flexibility**. This begins with **collaborative goal setting**, including **identification of challenges, opportunities, and tradeoffs** in advance. **Monitoring of outcomes** along with the use of **checkpoints and triggers** enable **timely adjustments** of plans and strategies. **Regular formal meetings** with **team members and appropriate stakeholders** to **share and integrate lessons learned** further enhance the likelihood of success.

Optimize stocking rate. Setting an optimal **stocking rate is the key decision** for successful grazing management. For most operations, working from a **well-considered base stocking rate** and making **year-to-year adjustments** to **strategically match livestock to forage** will support achievement of

goals. **Enterprise flexibility** and attention to **climatic indicators** can enable **timely growth or reduction** in the livestock herd.

Use a grazing plan. Grazing managers should have a **written grazing plan** that uses **strategic triggers** and aligns with management goals. The grazing plan should **address timing, intensity, duration, and frequency** of access to rangeland, ensuring **sufficient plant rest** while remaining **drought-ready** at all times. **Record keeping** is essential, and don't forget to **include ecological goals in planning**. Throughout, **integrate data, technical support, and experience** into decision-making.

Prioritize ecological health. Successful **grazing management prioritizes ecological health**. Maintenance of **heterogeneity in the plant community** via planned grazing confers **resilience** while **supporting biodiversity, soil health, and critical ecosystem services**. Make use of both **local knowledge and technical information and support to understand site potential and ecological processes**. Identification and **regular monitoring of goal-relevant metrics** enables timely adjustments. Throughout, **keep in mind a broad-scale view** of the ecological effects of grazing management.

Evaluate distribution. The **distribution of livestock** can be as impactful to outcomes as the number of livestock. Examine **pasture-specific context** and manage livestock distribution via the **strategic location of attractants** alongside **well-planned, site-specific fencing**. Breeding of **locally adapted livestock and herding** can further assist in achieving desired distribution. Pay **attention to herd dynamics and grouping tendencies**.

Welfare begets performance. Optimize livestock welfare and performance by providing timely access to **nutritious forage, high-quality water, and appropriate minerals and supplements** while **minimizing environmental stressors**. Use a **written herd health plan** and **track quantitative performance data** to examine tradeoffs. **Regular monitoring** of livestock will ensure **timely medical treatment**. Breeding of **range- and climate-adapted livestock** will enhance the likelihood of success.

Think beyond the range. Successful grazing management must **recognize and integrate external factors**, including the interests of external stakeholders. In all cases **proactive planning and effective management** will increase the likelihood of success and minimize conflict. At the same time, it is important to **engage in honest dialogue with external stakeholders** and **participate in public education efforts**, using your experience and data to **demonstrate the benefits of successful grazing management** and **provide place-based context**. Throughout, recognize that **win-win solutions are possible** and **share lessons learned**.

Discussion

We focused on delineating principles relevant to the interaction among manager, livestock, and land. However, the survey responses indicated this boundary is arbitrary and fac-

tors outside that interaction inevitably influence it. This is, of course, a core tenet of our understanding of livestock grazing management as a social-ecological system.¹⁷ The “Think beyond the range” principle is therefore aimed at straddling this boundary, with a focus on engaging external stakeholders. While there is a wealth of information available to livestock producers on other “beyond the range” factors such as business planning, there is a dearth of guidance for external engagement, despite its importance.¹⁸

We acknowledge some key terms used in the principles may need definition or raise questions. What is “flexibility”? What does “well-considered” mean in relation to stocking rate? How can we know if fencing is “site-specific,” and does that include virtual fencing? While we have extensively discussed the language used in the principles, these questions raise a more important question, namely “who owns these principles?”

As noted, our intention is that these principles be seen as a first draft to be improved through debate, revision, and adaptation. Additionally, even if they remain as written, they can be applied to different uses via the development of appropriate supporting materials. Though these materials would vary depending on the situation, items such as definitions of key terms, discussion of key points, suggestions for application, checklists for assessment, and bibliographies should be considered for inclusion. By leaving these items to be developed by others, we believe the principles can be more effectively applied to the great diversity of situations in which they will be useful while improving on any limitations of our effort.

Ultimately, one of the key assets of the principles is their adaptability. However, we think we have had mixed success in making them outcome oriented. This is interesting because we expected adaptability and orientation to outcomes to be correlated. Instead, the principles largely contain practices that are generalized and thus more adaptable, but they are still practices, nonetheless. This may be inevitable—rangeland science is an applied discipline and connecting practices to ultimate outcomes in complex systems is difficult. A key lesson is connecting grazing management practices to social, economic, and ecological outcomes is essential.¹⁹ On the other hand, an orientation toward practices makes the principles easier to assess—another noteworthy tension. While some elements in the principles may be more difficult to verify than others, reading through the bolded items one can see that most of the items can be readily assessed.

Finally, an assessment of how well the principles are grounded in scientific evidence yields some interesting considerations. Early in the project we decided to develop the principles with surveys and discussions with the rangeland science community rather than conduct a literature review and write the principles ourselves, heavily citing every statement. This moved us from the top-down approach typical of such efforts to a bottom-up orientation.

Therefore, not every statement is backed by scientific literature that directly validates it. Although most statements are supported by scientific evidence, others are supported

by our community's collective intelligence and experiential knowledge. This was the great benefit of allowing the principles to emerge from the collective wisdom of the people who know the science and the art of livestock grazing management.²⁰

Conclusions

We set out to start a meaningful conversation on grazing management to fill a void in rangeland science. To accomplish this task, we worked with experts from across the western United States to identify seven grazing management principles for successful livestock grazing management. These principles continually emphasize the importance of planning, goal setting, adaptation, flexibility, and local context. It is noteworthy that each of these is essential to moving beyond outdated “command-and-control” management; it is clear from our survey results that many managers have already done so.

We expect these principles may be applicable to areas outside of the semiarid and arid rangelands of the western United States, and we encourage others to expand on and refine our principles both within and outside that region. We hope they will initiate a conversation that will continue to improve livestock grazing management. These principles also serve as a base from which new information can be sought and assimilated. In this spirit, our next step is to develop supporting materials for use in various projects that can make use of these principles, including informing industry sustainability efforts.

For more information, and to join the conversation, visit <https://agnext.colostate.edu/>.

Declarations 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

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.rala.2023.11.001](https://doi.org/10.1016/j.rala.2023.11.001).

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