Rangeland Ecology & Management xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Diverse Management Strategies Produce Similar Ecological Outcomes on Ranches in Western Great Plains: Social-Ecological Assessment☆

Hailey Wilmer [a,*], David J. Augustine [b], Justin D. Derner [c], María E. Fernández-Giménez [d], David D. Briske [e], Leslie M. Roche [f], Kenneth W. Tate [f], Kevin E. Miller [g]

[a] US Department of Agriculture (USDA) Northern Plains Climate Hub, Fort Collins, CO 80526, USA
[b] USDA-Agricultural Research Service (ARS) Plains Area Rangeland Resources and Systems Research Unit, Fort Collins, CO 80526, USA
[c] USDA-ARS Plains Area Rangeland Resources and Systems Research Unit, Cheyenne, WY 82009, USA
[d] Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO 80523-1472, USA
[e] Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843-2120, USA
[f] Department of Plant Sciences, University of California, Davis, CA 95616-8780, USA
[g] Croissant Red Angus, Briggsdale, CO 80611, USA

ARTICLE INFO

Article history:
Received 3 April 2017
Received in revised form 13 July 2017
Accepted 7 August 2017
Available online xxxx

Key Words:
decision making
ecological heterogeneity
grazing management
rancher
semiarid rangelands

ABSTRACT

Experiments investigating grazing systems have often excluded ranch-scale decision making, which has limited our understanding of the processes and consequences of adaptive management. We conducted interviews and vegetation monitoring on 17 ranches in eastern Colorado and eastern Wyoming to investigate rancher decision-making processes and the associated ecological consequences. Management variables investigated were grazing strategy, grazing intensity, planning style, and operation type. Ecological attributes included the relative abundance of plant functional groups and categories of ground cover. We examined the environmental and management correlates of plant species and functional group composition using nonmetric multidimensional scaling and linear mixed models. After accounting for environmental variation across the study region, species composition did not differ between grazing management strategy and planning style. Operation type was significantly correlated with plant community composition. Integrated cow-calf plus yearling operations had greater annual and less key perennial cool-season grass species cover relative to cow-calf—only operations. Integrated cow-calf plus yearling ranches were able to more rapidly restock following drought compared with cow-calf operations. Differences in types of livestock operations contributed to variability in plant species composition across the landscape that may support diverse native faunal species in these rangeland ecosystems. Three broad themes emerged from the interviews: 1) long-term goals, 2) flexibility, and 3) adaptive learning. Stocking-rate decisions appear to be slow, path-dependent choices that are shaped by broader social, economic, and political dynamics. Ranchers described having greater flexibility in altering grazing strategies than ranch-level, long-term, annual stocking rates. These results reflect the complexity of the social-ecological systems ranchers navigate in their adaptive decision-making processes. Ranch decision-making process diversity within these environments precludes development of a single "best" strategy to manage livestock grazing.

Published by Elsevier Inc. on behalf of The Society for Range Management.

Introduction

Sustainability of family ranches depends on adaptive decision making within the ranch enterprise and the broader social and ecological systems in which it is embedded (Marshall and Smajgl, 2013; Wilmer and Fernández-Giménez, 2015; Roche et al., 2015b). However, rangeland science has developed limited capacity to document, interpret, and support adaptive management because research has insufficiently considered linkages between grazing management strategies and resulting ecological outcomes at spatial and temporal scales relevant to ranch decision makers (Lubell et al., 2013; Roche et al., 2015a). Limited integration of the social and ecological components of rangeland systems in research has contributed to a large gap between scientific and management knowledge. This is clearly evident in the ongoing debate regarding the perceived benefits of different grazing management strategies (Briske et al., 2008; Teague et al., 2008; Briske et al., 2011; Provenza et al., 2013; Teague et al., 2013; Briske et al., 2014; Roche et al., 2015a).

☆ This work was supported by the USDA-ARS; AFRI awards 2009-04442 and 2012-38415-20328, Colorado Agricultural Experiment Station project COLO0698; Western Sustainable Agriculture, Research, and Education program (Project Number SW10-073); and the Center for Collaborative Conservation Fellows Program at Colorado State University.

* Correspondence: Hailey Wilmer, USDA Northern Plains Climate Hub, 1701 Center Ave, Fort Collins, CO 80526, USA.
E-mail address: hailey.wilmer@ars.usda.gov (H. Wilmer).

https://doi.org/10.1016/j.rama.2017.08.001
1550-7424/Published by Elsevier Inc. on behalf of The Society for Range Management.

Social scientists recognize that grazing management is not driven entirely by vegetation and livestock production variables commonly examined in grazing experiments (Roche et al., 2015a). Instead, rancher decision-making takes into account complex, context-specific social-ecological interactions, often addressing both financial and ecological objectives, and relies upon multiple forms of rangeland management knowledge at broad spatial and temporal scales (Brunson and Burritt, 2009; Budd and Thorpe, 2009; Ellis, 2013; Hruska et al., 2017; Roche et al., 2015a; Roche et al., 2015b; Wilmer and Fernández-Giménez, 2015). Stocking rate decisions are particularly complex, and are expected to pose continued economic challenges for ranchers adapting to increasingly variable climatic conditions across the Great Plains of North America (Hamilton et al., 2016; Mu et al., 2013; Joyce et al., 2013; Polley et al., 2013; Ritten et al., 2010; Torell, 2010). Although considerable research exists on the financial and ecological implications of stocking rate and grazing intensity (Bement, 1969; Derner et al., 2008; Dunn et al., 2010; Hart et al., 1988; Holechek, 1988; Mu et al., 2013; Reeves et al., 2015) our understanding of on-ranch grazing decision-making is less well developed (Rowe et al., 2001; Grissom and Steffens, 2013; Kachergis et al., 2014). Additionally, rangeland scientists recognize that the ecological outcomes of livestock grazing often manifest over time scales of one to several decades, though traditional grazing management experiments rarely occur at these time scales (Milchunas et al., 1994; Porensky et al., 2016; Sanderson et al., 2016; Augustine et al., 2017).

Lubell et al. (2013) proposed a theoretical framework to link social and ecological relationships in rangeland systems. It theorizes that adaptive feedbacks between social and ecological processes across multiple spatial and temporal scales are influenced by a rancher decision maker's goals, capacity, values, beliefs, and access to information through social networks while he or she learns and adapts to both social and ecological dynamics (Fig. 1). However, the hypothesized relationships in this framework, particularly between grazing management strategies and the resultant ecological outcomes, remain to be tested on working ranches (Roche et al., 2015a).

Here, we evaluate and refine the Lubell et al. (2013) conceptual framework for ranch-scale social-ecological interactions. Specifically, we 1) test the links between rancher decision making and ecological outcomes (Holling and Gunderson, 2002; Marshall and Smajgl, 2013); 2) elucidate ranch adaptive decision-making processes through qualitative interviews (Sayre, 2004); and 3) discuss the implications of the identified decision-making processes to the larger grazing systems debate (see earlier). We evaluated the conceptual framework using a combination of rancher interviews and vegetation monitoring (plant species and functional group composition) for 17 ranches in eastern Colorado and eastern Wyoming.

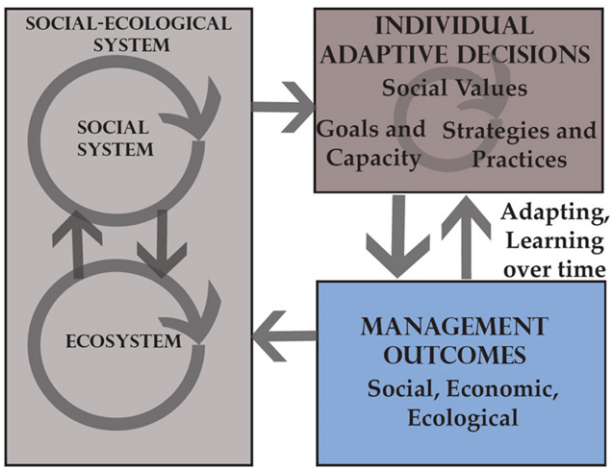

Figure 1. Conceptual framework. Lubell et al.'s (2013) theoretical framework for ranch decision-making hypothesizes links between individual ranch management decisions, management outcomes and broader social-ecological dynamics.

Methods

Study Area

We conducted our study in the western North American Great Plains, where plant species and functional group composition are important indicators of rangeland biodiversity, hydrologic function, and productivity and are influenced by grazing management, environmental variability, and evolutionary history of grazing (Milchunas et al., 1989). Furthermore, vegetation composition influences livestock weight gains (Derner et al., 2008) and economic returns for ranchers (Manley et al., 1997; Hart and Ashby, 1998; Dunn et al., 2010). Biophysical drivers of plant species composition include spring precipitation (Lauenroth and Sala, 1992), catena position, soil texture, and temperature (Epstein et al., 1997). Within this biophysical setting, stocking rate experiments have clearly shown that season-long heavy-grazing intensity induces slow, continuous, and directional changes in vegetation composition via replacement of cool-season perennial grasses with less productive warm-season perennial grass species (Milchunas et al., 1994; Hart and Ashby, 1998; Derner and Hart, 2007; Porensky et al., 2016) and moderate increases in bare ground (Augustine et al., 2012). Also, heavy grazing reduces the ability of cool-season perennial grasses to respond to precipitation variability (Irisarri et al., 2016).

The study area is characterized by a north-south gradient in mean annual temperature (7 − 11°C) and a west-east gradient in mean annual precipitation (339 − 460 mm) (Fig. 2). Native plant communities within this region are dominated by warm-season shortgrasses (primarily *Bouteloua gracilis* and *Bouteloua dactyloides*), cool-season midgrasses *(Pascopyrum smithii, Hesperostipa comata),* and cool-season sedges (*Carex* spp.), with increasing dominance of cool-season gramminoids in the northern, cooler portion of the study area and dominance of warm-season shortgrasses in the southern, warmer portion (Lauenroth et al., 1999; Lauenroth and Burke, 2008).

Our sampling approach identified individual ranches in our study area and then categorized ranches on the basis of an analysis of their self-reported, ranch-scale management practices of all land they managed in some manner (deeded, leased, and government permits). Ranches with similar management practices were grouped together, and ecological monitoring data were statistically compared across groups of ranches. We studied 17 beef cattle ranches distributed across a latitudinal gradient ranging from approximately 39.882 to 42.821°N and from − 102.150 to − 105.217°W, with seven ranches in Wyoming and 10 in Colorado. All were family-owned cow-calf or cow-calf plus yearling ranches. Potential ranch participants were identified through network sampling from the ranching community known to the research team and their agricultural networks (Noy, 2008). This case selection technique follows replicate, not sampling, logic and seeks to identify groups of ranchers with similar qualities, not to sample across a distribution of a specific population. Network sampling is often used in case study and qualitative social research to identify multiple cases that will provide insight into a specific phenomenon and to aid in theory development, and it is not meant to provide a random sample of cases for statistical generalization across a population (Yin, 2013).

Social and Management Data Collection

We used repeated, semistructured ethnographic interviews to identify themes in rancher decision-making processes at time scales that encompass ranchers' lifetimes and multigenerational planning horizons. These data also allowed us to identify specific management practices in place for 10 yr or more that we could use to compare ecological conditions across groups of ranches that shared the same practices. Figure 3 provides a summary of the methods, including data collection and

Please cite this article as: Wilmer, H., et al., Diverse Management Strategies Produce Similar Ecological Outcomes on Ranches in Western Great Plains: Social-Ecological Assessment, Rangeland Ecology & Management (2017), https://doi.org/10.1016/j.rama.2017.08.001