





# Socioecological Determinants of Drought Impacts and Coping Strategies for Ranching Operations in the Great Plains ☆

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## Abstract

In Great Plains rangelands, drought is a recurring disturbance. Ranchers in this region expect to encounter drought but may not be adequately prepared for it. Efforts to encourage drought preparedness would benefit from a better understanding of the conditions under which managers make decisions to minimize the impacts of drought. We tested the direct and moderating roles of the drought hazard and the social-ecological context on drought impacts and response. This study was conducted with ranchers in western and central South Dakota and Nebraska following the drought that began in 2012. We surveyed ranchers regarding the effects of the drought and their responses and used multimodel analysis to explore the relationships among measures of drought preparedness, drought response, and drought impacts. Drought severity was the primary predictor of all impacts, but specific types of impacts were varied depending on the operation's enterprise mix, resources, and management. The socioecological characteristics of the ranch system predicted drought response actions taken, by either providing the necessary resources and capacity to take action or creating sensitivity in the system that required action to be taken. We conclude with recommendations for learning from current drought experiences in order to better adapt to future drought events.

## Introduction

Rangeland managers in the US Great Plains have a long history of coping with and managing drought and its impacts. Recent studies have found evidence that ranchers are adopting more proactive approaches to drought management and, following recent droughts, consider themselves better prepared for drought than they had been in the past (Coppock, 2011, Kachergis et al., 2014). At the same time, despite their preparation for drought and increased flexibility, ranchers report experiencing more severe impacts than they expected during drought (Kachergis et al., 2014). These results lead us to wonder if current expectations of drought preparedness are adequate to meet the challenge of future droughts.

The goal of ranch drought management is to minimize the risk associated specifically with climate variability (Thurow and Taylor, 1999). But drought management goals, as well as expectations of what constitutes an impact, may differ from one production system to another and from one time period to another. Drought management takes place in the context of multifaceted, dynamic, adaptive socioecological systems that encompass rangeland ecosystems, livestock production, markets, and business and family systems (Folke et al., 2002, Walker and Abel, 2002, Dunn et al., 2005, Walker et al., 2012). The management of these interconnected systems is driven by the manager's unique objectives for each, and each management decision is likely to lead to tradeoffs in system dynamics, making drought management more complex than it might appear (Birge, 2017). Adding to the uncertainty of drought management, interactions among socioecological systems may result in unexpected outcomes during drought, and variations in the severity and length of drought events may result in impacts that differ even within the same ecological system and management domain (Wilhite, 2000). All of these factors make it difficult to isolate cause and effect relationships in drought management or to predict effective strategies for future droughts. In this paper, we take a quantitative, theory-driven approach to exploring the interactions and causal relationships among the characteristics of the socioecological system, the severity of the drought, the management or response actions taken during the drought, and the resulting impacts to forage feed capacity, rangeland health, animal productivity, and financial health. The analysis informs recommendations for improving rangeland managers' preparedness for future drought events.

We frame our investigation in two bodies of literature that have emerged from the study of natural systems management and climate stressors such as drought. Climate vulnerability theory provides a useful model in which a system's exposure to a hazard, sensitivity to harm, and capacity to adapt can be measured to predict the system's vulnerability to hazards such as climate change (Yohe and Tol, 2002, Brooks, 2003, Adger et al., 2004, Eakin and Bojórquez-Tapia, 2008). The use of sensitivity and adaptive capacity in vulnerability theory are related to concepts used in socioecological resilience theory to describe a system's ability to absorb disturbance, self-organize, and adapt (Walker and Abel, 2002). Resilience theory is uniquely valuable, though, in providing frameworks for understanding systems with multiple potential stable states and the nonlinear changes that may occur in a system in response to a disturbance such as drought (Carpenter et al., 2001, Miller et al., 2010). A conceptual framework by Chapin et al. (2009) links resilience and vulnerability as complementary theoretical approaches to understanding change. In the model, interactions between socioecological systems' resources and management define what happens when an external driver (e.g., drought) affects a system. The model draws direct paths of influence among the socioecological system, its sensitivity to harm, impacts, and the learning, coping, or adaptive processes that emerge as a result of impacts (Fig. 1).

A drought management framework informed by this model allows managers, researchers, and advisors to more effectively examine the effects of their predrought management and resources on the response options they are likely to use and the impacts they experience, as well as to learn and plan to adapt their systems for future drought events. In order to specify the model in the context of rangeland drought management, we evaluate the model's core theoretical pathways, as well as alternative causal pathways, using a survey of individual ranch operations following a recent drought event. Specifically, we explore the effect of the system's resources and management characteristics on impacts managers experienced and the response actions they took, at distinct drought severity levels. We also propose that grouping coping actions conceptually with learning, innovating, and adapting may conceal potential feedback relationships between actions and impacts, and explore alternative models that predict causal relationships from coping action to impact (e.g., Feola and Binder, 2010). Our research questions include the following:

1. To what degree does the socioecological system predict drought impacts under various drought severity scenarios by defining the system's sensitivity to harm?
2. To what degree does the socioecological system predict rangeland manager's drought responses under various drought severity scenarios by defining a) the sensitivity of the system (i.e., the need to take action), and/or b) the adaptive capacity of the system?
3. Is the nature of the relationship between range managers' drought response actions and impacts unidirectional from one variable to the other, or reciprocal?

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## Section snippets

### Methods and Descriptive Summary of Variables

Our study focuses on range-based livestock producers in western and central South Dakota and Nebraska. The study area is part of the US Great Plains region, dominated by grasslands, row crops, and small grains agriculture. The area is semiarid, with average annual precipitation ranging from 381 to 610 mm (USDA NRCS, 2006).

The study focuses on the drought event beginning in 2012. That year was the third warmest on record for the continental United States (NOAA-NCEI, 2012) and the driest on...

### Description of Respondents/Operations

At the time of the survey, the average age of respondents was 60 yr, similar to the national average of 58 yr (USDA NASS, 2012). A little over half of respondents described their rangelands as primarily native mixed grass, and the rest reported mostly a mixture of native and introduced grasses or native shortgrass. Survey respondents operated cattle grazing operations with an average of 349 owned cattle, with a range of 0 to > 7 500. Almost all (90%) of the surveyed operations included cow-calf ...

## Discussion

This study clarifies key relationships in the Chapin et al. (2009) model as related to rangeland management during drought, including the roles of the socioecological system and the drought hazard in predicting response and impact. With regard to impacts, drought severity plays the role of primary predictor, but the predictive ability of each model improves through the addition of socioecological characteristics measuring the sensitivity of the system. The specific mix of socioecological...

## Implications

With regard to the question, "What can be done to better prepare rangeland managers for future drought events?" this study makes clear that "it depends" on the priorities of the manager and characteristics of the rangeland management system. Managers are likely to have preferences as to the types of impacts they most want to avoid, as well as drought response actions that are the most aligned with their management goals. Understanding the complex causal relationships of drought management...

## Acknowledgments

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...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...

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...The impacts of these negative consequences for ranching operations increase with increasing drought severity (Haigh *et al.* 2019). Delays in drought-related destocking influence economic returns and negatively impact rangeland productivity, health, and diversity (Haigh *et al.* 2019). The cumulative financial losses and mental stress from decision-making conundrums with drought impact emotional and social dynamics of ranching families and communities (Wilmer and Fernández-Giménez 2016)....

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...These results are consistent with past descriptive research finding that drought contingency plans tend to be primarily focused on destocking actions (Knutson and Haigh 2013). As described in Haigh *et al.* (2019), among those who took each type of drought response action in 2016, the timing of beginning to

act varied from early summer to late fall. Purchases of supplemental feed began most frequently in July 2016, but many waited until September or October to begin making these purchases....

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