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Assessing Drought Vulnerability Using a Socioecological Framework

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On the Ground

- Drought is a persistent problem on rangelands and adjusting management to respond appropriately is critical to both preserving natural resources and to maintaining financial viability.
- We explore the value of using a structured assessment approach to determining both social and ecological vulnerability.
- This approach allows for the identification of vulnerable ecosystems and business operations at regional and local scales as a basis for developing effective policies and programs.

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Drought (an extended period of relatively low precipitation) is a natural part of the environment and is inevitable in rangeland ecosystems.[1] It is an important ecological filter that shapes species, communities, landscapes, and regions. And, it is one of the most important factors defining rangelands and makes rangeland ecosystems unique.

Unfortunately, it also presents a major challenge to rangeland managers in their quest for sustainability, both ecological and economic. From a manager's perspective, drought tends to be a creeping and insidious natural hazard that is experienced by degrees, usually over an extended period of time. It can be difficult to determine when a drought begins or ends, and impacts can extend over a larger geographical area compared to other natural hazards, such as fire, flood, or disease.

Traditionally, the response to drought in rangeland-based livestock grazing systems has been based on maintaining financial viability while retaining as many reproductive units (cows, ewes) as possible for post-drought recovery.[2] However, changes in the economics of ranch management and an enhanced understanding of the impacts of drought on ecosystem function have forced a reevaluation of these principles. With increasingly frequent and intense drought forecast in most rangeland ecosystems due to a changing climate, responsible stewardship demands that we develop a more systematic approach to anticipating and responding to drought.

Joyce et al[3] suggested that a more structured, systematic approach to assessing the vulnerability of individual rangeland socioecological systems could help policy makers and managers develop more realistic approaches to climate change. A socioecological system is defined as a complex bio-geo-physical unit and associated social actors and institutions, all interacting in an adaptive manner to produce outcomes.[4] Importantly, a socioecological system approach not only examines the impacts of a stressor, like drought, on a system, but also takes into account what tools are available to respond. While an understanding and an ability to predict drought intensity is a valuable component, it is only relevant within the context of the specific socioecological system. A meaningful drought response approach will include policies, programs, and management developed with knowledge of the social, economic, and ecological impacts of drought and a thorough understanding of the ability of individuals and institutions at a local level.

Assessing the Vulnerability of Rangeland Socioecological Systems to Drought

The diversity of rangeland ecosystems and livestock production systems requires an approach that includes a wide range of environmental, social, and economic impacts of drought. This broad range of socioecological conditions precludes a one-size-fits-all approach to both management and policy. Vulnerability is commonly expressed as f (impact [exposure, sensitivity], adaptive capacity) (Fig. 1). Determining the potential impact of drought requires developing realistic estimates of both the exposure and the sensitivity, and integrating those two factors.

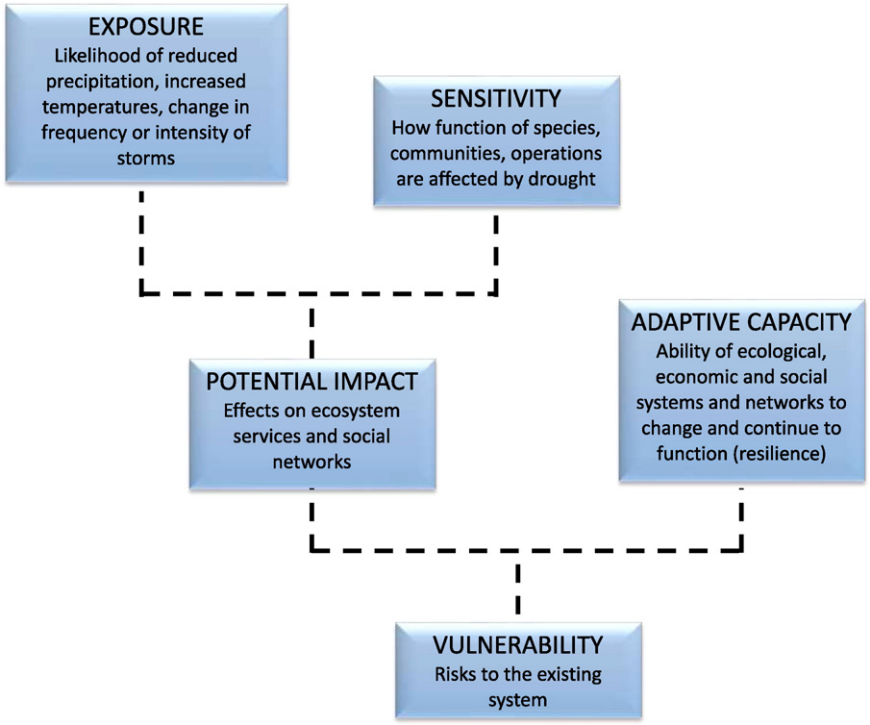

Figure 1. A vulnerability assessment framework for rangeland drought following Joyce et al.[3]

While an improved understanding of the impact of drought can be helpful in responding during a drought or post-drought recovery, a similarly rigorous estimate of the adaptive capacity is necessary to improve preparation for coming drought. Any credible vulnerability assessment requires attention to all of the components.

Exposure is the likelihood of an event occurring: how often and how severe is the drought? The vast majority of work in the research community has focused on improving the ability to predict the frequency and severity of drought. Unfortunately, accurate long-term (beyond a few weeks) prediction of precipitation is a difficult challenge. Temperature forecasts have more skill and have seen improvement but numerous gaps in monitoring, model refinement, and basic understanding of user needs across time and geographical scales make long-term drought prediction quite a difficult proposition. The National Oceanic and Atmospheric Agency Climate Prediction Center routinely issues both monthly and seasonal drought outlooks for the United States but their accuracy is limited. Seasonal forecast skill is markedly improved during strong climate events (i.e., El Nino Southern Oscillation); however, even during these rare events a particular outcome is not guaranteed.[i] National scale prediction is often not of great utility to local and regional users.

Current and antecedent data, along with the seasonal predictions, can be employed to provide an estimate of the level of drought risk *exposure*. These tools, collectively referred to as drought early warning systems show promise.[5] Where model predictive skill is lacking, engaging partners and other proven local and regional information sources to determine explicit needs (decision points) can increase the value of information and improve utility. The National Integrated Drought Information System has developed such a drought early warning system in several regions of the country. In the Missouri Basin, for example, a broad partnership of climate, agriculture, water resources, and other professionals issue a regional three-month summary of climate conditions and potential impacts of those events, including sector-specific outlook sections. In addition, there is a monthly webinar for the north-central United States to consolidate and interpret the large amount of information from state, federal, and academic sources.

Sensitivity is the term that defines how a particular organism, community, or system (economic or ecological) will respond to a particular event. A realistic sensitivity analysis requires a well-developed understanding of how the individual, community, or operation functions, particularly inputs, outputs, and feedback processes. For instance, a substantial amount of effort has been devoted to developing 'bioclimatic envelopes' for individual species to predict the impact of changing climatic variables on species distributions, and the make-up of plant communities via quantitative changes in ecological processes.[6] Climate scientists and ecologists have collaborated to make predictions of the effects of changes in temperature and rainfall on establishment, growth, reproduction, and recruitment of individuals and how those lifecycle

[i] For example, see https://www.climate.gov/news-features/blogs/enso/what-expect-winter-noaa%E2%80%99s-outlook-reveals-what-conditions-are-favored.