Climate Change and Rangelands: Responding Rationally to Uncertainty

By Joel R. Brown and Jim Thorpe

According to most estimates, rangeland ecosystems occupy about 50% of the earth's terrestrial surface. By itself, this estimate implies rangelands are important to humans, but their importance extends far beyond their global dominance. Globally, rangelands provide about 70% of the forage for domestic livestock. For many societies, livestock are critical to survival. Rangelands also provide a host of ecosystem services technology or other land types cannot provide. Among the most important of these services is climate regulation, or the ability to sequester and store greenhouse gases such as carbon dioxide.

The ability of any rangeland to provide any ecosystem service is dependent, primarily, upon the rangeland's condition. Degraded rangelands are poor providers of ecosystem services, regardless of the commodity. In crop or forest ecosystems, managers can overcome inherent biophysical limitations with additions of water, fertilizer, cultivation, or new plant species. Rangeland managers typically lack those options. In general, management is concentrated on affecting changes in soils and vegetation through the application of disturbances, such as fire or grazing. The primary input for rangeland managers is intellectual capital, whether it is in the form of livestock management practices based on research conducted at a nearby experiment station, experience handed down across generations, or other forms of local knowledge. Because rangeland managers have a limited ability to manage inputs, they are more dependent on environmental conditions. In particular, rainfall (amount and timing) governs rangelands, and managers' success or failure is determined by their ability to respond to, rather than create, conditions. Any change to the environment affecting rainfall, or how soils and plants process water, will have a dominant influence on productivity, stability, and profitability.

The interaction between scientists and managers is critical to understanding and managing the relationships critical to healthy rangeland ecosystems. While scientists uncover new relationships governing ecosystem behavior, managers are ultimately responsible for implementing practices to ensure continued heath of the systems they manage. One of the most important scientific contributions of the past decade is an enhanced understanding of earth's climate system and human impacts on climate. Through a collaborative effort, scientists have communicated the links between humans and climate. Policy makers and the public are generally aware that humans have an influence on climate—an influence that is likely to increase in the immediate future. There is a recent consensus on the need for humans to mitigate their effects on climate and adapt to likely climatic shifts.

Rangeland managers are certainly not strangers to the vagaries of changing climate; if not aware of long-term, human-induced climatic change, then, certainly they are aware of short-term weather variability. Weather events influence and profoundly change entire societies. Historians often point to the North American winter of 1886–1887, when extremely harsh weather marked an end to the era of open ranges, and caused reorganization of the livestock industry. Widespread losses of livestock to low temperatures and heavy snow crippled the industry, with effects cascading into a larger financial disaster ultimately affecting the entire country.

The effects of climate change are still making history. Media reports of famine and political strife, due to regional droughts in developing countries, are becoming more frequent, and more disturbing. However, news reports seldom convey the complex relationship between human societies and their environment. The drought of 2000 in Mongolia, close on the heels of a harsh winter, resulted in widespread livestock deaths, rising meat prices, and devastated rural economies. The combination of harsh winter and drought, called "dzuds" by Mongolians, is often cited as a major factor in power shifts among dominant political parties. The sequence of drought–famine–social unrest–political upheaval is currently being played out in eastern Africa and is affecting millions of people and destabilizing entire regions. Furthermore, these destabilizing droughts could encompass multiple decades. Once this sequence of events is underway, droughts are often forgotten, yet whole societies are forever changed.

Even in developed countries with established political systems and stabilizing infrastructure, climatic change can be devastating. Australian range scientists and pastoralists are familiar with drought, and have an enviable history of coping with its effects. In the past, droughts impacted agricultural economic sectors while having minimal effects on the larger economy. However, a current decade-long drought, which qualifies as the worst drought in a century, is affecting other economic sectors and causing considerable political consternation. Some groups are proposing that Australia's population might already exceed the carrying capacity needed to maintain their desired quality of life given the prospect of a drought-plagued future.

The effects of climate change must be considered across multiple scales. The examples above generally describe how the effect of climate change extends beyond local or regional boundaries to contribute to change at national scales. As technical sophistication improves our ability to observe our world, and observations encompass longer time frames, the global nature of climate change becomes more obvious. Local effects (reduced precipitation, increased temperatures) can lead to overgrazing, which can cascade into regional desertification. We now know that regional desertification can cause increased wind erosion and dust that can be transported by upper atmospheric winds where it can affect global weather patterns and impact human health.

Although numerous examples of the impacts of climate change can be informative upon post hoc analysis, the real challenge that remains is developing tools that predict climate changes and aid us in developing adaptive responses to impending change. The increasing sophistication of global climate models is allowing scientists to make reasonable inferences about potential changes in regional and local climates. The work of the Intergovernmental Panel on Climate Change (IPCC), through the Assessment Reports, and the United States Global Change Research Program (USGCPR), through the National Assessment Report, provide relevant projections of changes in climate and offer interpretations of how those changes might affect human activities. An explanation of the terminology used to describe the likelihood of projected changes is explained in the sidebar. Some of the general changes in ecosystems globally are as follows:

Explanation of the terminology used in Intergovernmental Panel on Climate Change reports

Terminology	Probability
Virtually certain	>99%
Extremely likely	>95%
Very likely	>90%
Likely	>66%
More likely than not	>50%
About as likely as not	33–66%
Unlikely	<33%

- Warming will be greatest over land, and at high northern latitudes; it will be least over the southern oceans and parts of the North Atlantic
- Contraction of snow cover, increases in thaw depth over permafrost regions, and decrease in sea ice extent
- Very likely increase in frequency of hot extremes, heat waves, and heavy precipitation events
- Likely increase in tropical cyclone intensity
- Poleward shift in extra tropical storm tracks
- Very likely precipitation increases in high latitudes and likely decreases in most subtropical regions
- High confidence that river runoff and water availability will increase at high latitudes and decrease in dry regions in midlatitudes and tropics
- High confidence that many semiarid regions (Mediterranean basin, western United States, southern Africa, and northeast Brazil) will see decreases in water resource availability

Although these projections are informative and provide valuable insights into important potential changes and their effects on ecosystem behavior, more detailed projections are necessary to formulate regionally and locally appropriate responses. Both the IPCC and the USGCRP have devoted significant effort to predict likely climate scenarios that can be used by policy makers and land mangers. Some of those predictions are as follows:

Africa

- By 2020, between 75 and 250 million people could be affected by diminishing availability of water
- By 2020, yields from rain-fed agriculture could be reduced by up to 50%, greatly affecting food security
- By the end of the 21st century, sea-level rise is projected to affect low-lying coastal areas; adaptation costs could amount to 5–10% of Gross Domestic Product
- By 2080, an increase of 5–8% of arid and semiarid conditions

Asia

- By 2050, freshwater availability throughout most of Asia is projected to decrease
- Climate change, associated with rapid urbanization, industrialization, and economic development will compound pressure on natural resources
- Changes in the hydrologic cycle are projected to increase human morbidity and mortality due to diarrheal diseases

Australia

- By 2020, significant loss of biodiversity in coastal and near coastal tropical environments
- By 2030, water supply and security problems will intensify in southern and eastern Australia
- By 2030, agricultural productivity is projected to decline over southern and eastern Australia due to increased incidence of drought

Latin and South America

- Increases in temperature and decreases in soil water availability are projected to lead to replacement of tropical forest by savannas in eastern Amazonia. There will be a likely shift from semiarid to arid vegetation
- Risk of significant biodiversity loss throughout the tropics
- Decreases in crop yields in some areas, with soybean yields projected to increase in temperate areas
- Loss of glaciers is projected to significantly affect water availability for food production

North American rangelands, because they are among the most studied on the planet, could have the most certainty with regard to predicted responses to climate change. The USGCRP Assessment used two common and reliable models (Hadley Model and Canadian Model) to predict climatic changes during the 21st Century. Although the models differ slightly in their predictions, general trends were similar. The USGCRP then conducted a series of workshops in the late 1990s to analyze the potential effects of climate changes and develop response scenarios. We slightly altered the definitions of regions used by USGCRP to better reflect rangeland ecosystems and their use and management patterns.

Northwestern United States Rangelands

- Average temperatures will likely increase about 2°F by the 2030s and 5°F by the 2050s, with increases occurring both in the summer and winter
- Average precipitation could increase in California and the southern Great Basin, primarily in the winter, with no change or decreases in summer
- California's Mediterranean climatic patterns are unlikely to change
- Increasing temperatures will likely raise stream temperatures
- Higher winter temperatures will very likely reduce snowpack and peak runoff and shift peak flows earlier in spring in both the Rocky and Sierra Nevada Mountains
- Water management for flood control, fish runs, and irrigation will become more complicated
- Increased chances of summer drought will likely increase wildfire frequency and intensity on both range and forest lands
- Invasive species could be favored by changes in wildfire regimes and precipitation and temperature changes

Southwestern United States Deserts and Rangelands

- Increases of about 3–4° F by the 2030s and 8–11° F by the 2090s
- Rainfall for the region is likely to become more highly variable and with increases occurring primarily during the winter
- Reduced snowpack and increased peak flows during late winter and spring
- An increase in the number of extremely wet or dry years, increasing the chance of multiyear drought or more frequent and intense wildfires
- Increases in the amount of grasslands, shrublands, and forests at the expense of desert vegetation

Great Plains of the United States

- Temperatures are forecast to increase 5–12°F over the next century, with the greatest increase in the western portion of the region
- A greater number of heat events (>3 consecutive days over 90°F), increasing stress on humans and livestock
- Although increases in precipitation are forecast, greater increases in evapotranspiration are likely to result in reduced soil moisture availability
- Increased CO_2 content in the atmosphere could favor shrubs (C_3) over grasses (C_4)
- Increased climate variability will favor invasive and weedy species

Given the benefit of history, combined with our expanding understanding of the effects of climate change and climate variability on rangelands, and subsequently human societies, we can make inferences on how to manage rangelands in the future. We asked authors from around the world to address how rangelands might respond to a changing climate and discuss possible management options. Management options might be in the form of mitigation or adaptation. Mitigation refers to how rangelands can be managed to reduce the effects of human activity on climate through carbon sequestration. Sequestration is the increased storage of carbon in the soil and vegetation through the management of naturally occurring processes: photosynthesis, humification, and aggregation. Adaptation, on the other hand, assumes that climate change will occur and focuses primarily on how rangeland management can change to reduce the impact of those changes. This issue of *Rangelands* contains a series of eight articles addressing different aspects of rangelands and climate change. The first (de Steiguer et al.) examines how rangelands can be managed to mitigate, or lessen the impact of, climate change. The remaining articles provide insights into how climate change might affect rangeland ecosystems on a regional scales and how current management can respond to maintain the flow of ecosystem services and the integrity of these valuable lands. In organizing this special issue, we felt publishing only one article on mitigation is appropriate, given the limited capacity of managed rangelands to mitigate climate change and the potentially large impact of climate change on rangeland ecological processes and management.

We have taken pains to ensure that the articles are readable and relevant. In order to improve the readability of the articles, we have limited citations within the text. However, because the field of climate change and predictions about impact are fraught with uncertainty, it is important that interested readers have access to the full range of literature upon which the authors have relied to make their conclusions. The articles with full citations are posted at http://www.rangelands.org/climatechange.shtml. All of the articles in this special issue were peer-reviewed and we thank the reviewers for their efforts. We sincerely hope this issue stimulates some thought within the rangeland management community (managers, technical advisors, policy makers) about the numerous possibilities for responding to what is clearly the most important issue of this century…climate change.

Additional Reading

Gore, A. 2006. An inconvenient truth: the planetary emergency of global warming and what we can do about it. New York, NY, USA: Rodale Books. 327 p.

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National Assessment Synthesis Team, US Global Change Research Program. 2000. Climate change impacts on the United States: the potential consequences of climate variability and change. New York, NY, USA: Cambridge University Press. 155 p.

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