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Coping With Historic Drought in California Rangelands: Developing a More Effective Institutional Response

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On the Ground

- Drought response is widely varied depending on both the characteristics of the drought and the ability of individual ranchers to respond.
- Assistance from institutions during drought has not typically considered preemptive, during, and post-drought response as a strategic approach, which recognizes biophysical, sociological, and economic complexities of drought.
- A USDA Southwest Climate Hub-sponsored workshop brought together a range of representatives from public and private institutions with drought response responsibilities to examine how those institutions could better support drought decision-making.
- Institutions can greatly improve their support for individual land managers by doing more systematic collecting and organizing of drought-related information as a basis for programs, and by collaborating to enhance both institutional and individual learning.

Keywords: adaptive management, C sequestration, decision support, drought policy.

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This article describes the outcomes of a workshop organized by the USDA Southwest Climate Hub in late 2015. The workshop brought together academics, agency staff, user groups, and technical advisors to examine the institutional response to the historic drought in California. Workshop participants focused on three areas of analysis: improvement of programs and policies; improvement of monitoring; and mitigation opportunities and threats. The workshop consensus was that individual ranchers have a variety of mechanisms for coping with drought, but supporting public and private institutions lacked a coherent framework for learning and communicating from individual experiences.

The multiyear drought in California is of historic proportions, both in its intensity and its effect on agriculture. Although storms of the 2015–2016 and 2016–2017 winter rainfall season have provided modest drought relief, their effects on the multiyear drought are relatively small.[i] Both short- and mid-term forecasts for precipitation are highly uncertain, but they generally predict an increase in the frequency and intensity of drought in the southwestern United States.[1]

While irrigated agriculture operations have to make decisions about crops, irrigation schedules, and so on, rangeland-based livestock operations have to make similarly difficult, but fundamentally different, decisions. Erratic and reduced forage production is a problem across the southwestern United States in general and California in particular. Currently, the only two options for an individual operator are to buy replacement forage or reduce livestock numbers. Response to short-term drought usually involves purchased feed, but the intensity and length of this drought has resulted in most operators reducing livestock numbers. The financial impact has been softened somewhat by the high live-cattle prices of 2012 to 2014, but high prices also limit post-drought restocking options. Short-term precipitation events may lead to increased forage production, but the ability of individual grazing operations to respond quickly may be limited by economic constraints.[2] Forage production on rangelands requires marketable grazers for a business to be functional, especially in the short term.

The USDA Southwest Climate Hub[ii] and the USDA California Climate Hub[iii] collaborate to develop adaptation and mitigation strategies for coping with climate change

[i] See http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php for the US Seasonal Drought outlook.

[ii] Read more on the USDA Southwest Climate Hub at http://swclimatehub.info/.

[iii] Read more on the USDA California Climate Hub at http://caclimatehub.ucdavis.edu.

effects on agricultural productivity across the southwestern United States. One of their first activities was to develop a Rangeland Vulnerability Assessment (VA) for California. The VA will be completed in 2017 and is available online.[iv] In an effort to support the implementation of the VA, we brought industry leaders together with leaders of rangeland financial and technical assistance support programs, which we collectively refer to as *institutions*, with the objective of developing strategies for post-drought actions that can assist and support individual producers in returning to sustainable grazing operations. The attendees and their affiliations can be found at the VA webpage.[iv]

The workshop objectives were to 1) distribute and discuss the California Rangeland VA; 2) involve industry and program leaders in developing response strategies; and 3) identify priorities for implementation of the VA. Specifically, we asked, "What can the institutions (state and federal agencies, commodity groups and professional organizations) do to improve adaptation and mitigation?" and "Thinking at the state or regional level, what actions can institutions take to provide support for drought affected rangelands and grazing operations?"

One of our major working assumptions is that individual ranchers are constantly adapting to a variety of ongoing changes in the operating environment. Macon et al.[2] summarized the views of individual ranchers in terms of their approach to drought and access to information. These adaptations are expressed as a range of strategies and tactics, but their correlation to outcomes as a basis for designing and implementing more effective programs are poorly quantified. Our challenge is to systematically analyze these adaptations and integrate them into a systematic support framework that can help individuals and institutions learn.

Workshop Results

During the workshop, an expert panel shared the current state of knowledge of climate change impacts in the southwestern United States and California; workgroups developed response strategies on three topics: 1) enhancing adaptive capacity, 2) monitoring for decision-making, and 3) mitigation opportunities. The workgroup discussions and recommendations follow.

Overview of Climate Change Impacts on Rangelands in the Southwestern United States and California

The projected warming and uncertain precipitation will combine to decrease soil water availability and reduce both the amount and nutrient content of plant production, and alter plant community composition on rangelands in the southwestern United States.[3] This reduced water availability can be expected to reduce plant growth, shorten the growing season, and decrease the amount of forage that serves as a basis for the livestock industry. Similarly, changes in the amount and distribution of precipitation, coupled with higher temperature regimes, can be expected to alter plant phenology and reduce the reliability of forage production. In addition, the digestibility and nutritive value of plants are reduced in an elevated carbon dioxide environment due to increases in the carbon:nitrogen ratio. Lower quality forage and the ensuing reduced nutrient intake coupled with higher summer temperatures and more frequent heat stress are likely to further reduce livestock production compared to a late 20th century baseline.[4] Heat stress can also reduce forage intake and lower the reproductive efficiency of livestock, affecting herd management decisions.[3]

Increasing frequency and severity of droughts will likely change plant species composition and reduce plant cover through a combination of increased wildfire impacts and episodic plant death. The reduced availability of both soil moisture and water flowing in perennial and ephemeral streams will likely have negative impacts on the vegetation associated with riparian areas such as willows and cottonwoods, but increasing variable flows could favor invasive species such as salt cedar. As these changes in riparian vegetation become more widespread, the impacts on animal species reliant upon both the vegetation structure and water quality and quantity are likely to be more negative.[4]

Workgroup Response Strategies

Programs and Policies to Enhance Adaptive Capacity

The Adaptive Capacity Workgroup examined the problem from operational (this year), tactical (5 years), and strategic (10 years) decision-making standpoints. At the operational level, the most obvious action would be to improve accessibility and interpretation of 3- to 6-month forecasts. While improved spatial precision and forecast accuracy is always desirable, these attributes are seldom the limiting factor in drought decision-making. In particular, a better interpretation and communication of the likelihood of reaching predefined critical seasonal rainfall milestones would contribute to improved management decision-making. This timeframe allows ranchers to make decisions regarding livestock numbers and feed purchases. However, an operational decision-making tool has little use without the context of tactical and strategic support.

Enhancing tactical level drought support would include improving access to multiyear forecasts and the interpretations of impacts on forage supplies. As with operational outlooks, these forecasts are currently relatively accurate, but lack explicit connections to decision-making relative to stocking rates, destocking contingencies, and expectations of herd and individual-level animal performance.

Finally, at the strategic level, the most challenging decision for agencies revolved around being able to integrate the delivery of long-term information into a spatiotemporal framework that is relevant for producers. Much the same as management protocols in any field, a lack of explicit connections among monitoring information, model projections, and actions render most of the information useless for ranchers and land managers. What good is knowing that you are in a drought if you do not have a planned response? While

[iv] The California Vulnerability Assessment is available at http://swclimatehub.info/carange.

tactical and strategic tools are always going to have some uncertainty, it seems careless to ignore the best information available when the potential impacts are so great. Without a doubt, the overriding need for most agencies is the same as it is for individual producers: to build logical drought-contingency plans with quantitative action triggers based on specific sources of information that lead to transparent drought policy and program responses.

Improving Monitoring for Decision-Making

The Monitoring Workgroup specifically asked, "What type of data do institutions need to provide to support on-the-ground decision-making related to drought, climate change and rangeland management?"

The workgroup identified multiple data limitations that hinder the ability of state and regional level programs to provide technical and financial support to rangeland managers. Current National Agricultural Statistics Service (NASS) data are not available on a scale where decisions are made. They are both census and survey data, and the two often yield inconsistent results. While we would like to rely on census data, these data are only available with a lag of several years, rendering them useless for situations requiring rapid decision-making. In addition, some data are provided on only a 5-year time-step. Another data problem is that they are often lumped in one category (i.e., sheep and goats together). It would be more useful to provide individual categories, as a standard practice, and allow the user to combine categories as needed.

The basic accessibility and utility of data supporting decisions is also paramount. In order to make sound decisions, users must be able to access information in a format that includes complete metadata. The lack of supporting information (for instance, soils, weather, and historic vegetation dynamics) that can provide more complete context diminishes the value and utility of drought-specific recommendations. Data should be available in the public domain, such as the Data.gov effort, to enable and support decision-making. In addition, decisions made by ranchers are primarily related to the economics of the farm operation, so collecting data directly or indirectly related to economic factors or linking collected data with economic factors will support landowner decision-making.

Participants identified the development of sound and consistent monitoring protocols as an essential factor for decision-making during drought. Rangeland monitoring requires funding and staff, so clear goals for the use of the data are needed to justify the allocation of additional resources. This is especially true when multiple agencies or organizations are all contributing information to a common portal. Data and interpretations need to be curated and presented with a focus on specific user questions and placed in specific spatial and temporal contexts.

To illustrate the importance of temporally relevant information, long-term forage production and livestock numbers could contribute to the development of strategic drought planning and response, but an understanding of growing conditions delivered weekly would be of greater value than very precise season-long averages to a rancher trying to determine an optimal destocking action. Conversely, trying to make tactical and strategic stocking rate decisions based on short-term fluctuations in within-season rainfall is unnecessarily complex and time-consuming. Thus, standardized monitoring protocols could be helpful, but could also leave critical gaps depending on specific user needs. Different agencies monitor with different objectives. The Risk Management Agency (RMA), responsible for providing insurance products, collects the history of each county and each area. The RMA goes directly to a commodity group to collect information. That historical information can be essential in developing actuarial tables for estimating the probabilities of different drought events in a strategic timeframe, but is a poor source of information when trying to decide operational stocking rate reductions. On the other hand, agencies such as the Natural Resources Conservation Service or University of California Cooperative Extension are looked to by producers for information more relevant to within-season rainfall deficits and corresponding short-term stocking rate adjustments.

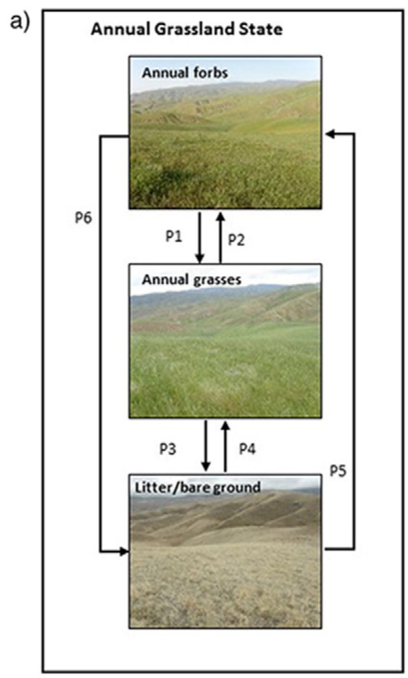
Spatially, an ecological site (ES) is probably the most useful unit for study, monitoring, and management of rangelands.[5] ESs and their associated state-and-transition models (STMs) are useful tools for describing and predicting dynamics on spatially and temporally complex rangelands.[6] An ES is a conceptual grouping of land units, or "sites," that have similar biophysical characteristics and ecological dynamics. Ecological sites differ with respect to geology, topography, and soils, and are thus relatively predictable at a ranch scale, providing a practical and accessible way to organize information Temporal change within an ES is typically depicted with an STM.[7] STM developers customarily portray states as stable, resilient regimes separated by threshold-based transitions. Transitions describe causes of change, provide warning signals of imminent catastrophic change, and clearly demonstrate (via hysteresis) that recovery would be impossible or expensive to achieve. Within-state dynamics, conversely, are attributable to minor fluctuations in climate or management, and recommended responses are typically minor management adjustments.[8] The Box illustrates how an STM can provide drought response information to individual ranch management. Because the land units characterized by ES share similar potentials and behaviors, understanding dynamics of a few key examples can allow managers or agency technical staffs to develop quantitative estimates of the impacts of drought across entire regions. The US Department of the Interior Bureau of Land Management, USDA Forest Service, and USDA Natural Resources Conservation Service, supported by research agencies such as the US Department of the Interior US Geological Survey and USDA Agricultural Research Service, have officially agreed to use ESs as tools for organizing information relevant to rangeland management, but the value of these tools has been limited by inconsistent application and interpretation.[5]

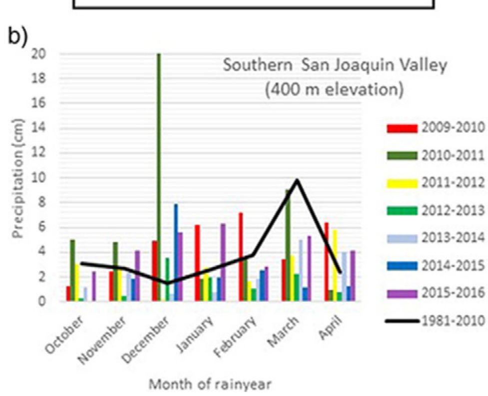
The monitoring workgroup also identified the existing value and potential for remote-sensing technologies for improving drought response. Remote sensing has an important place in systematic drought monitoring on rangelands

Box

To illustrate the importance of ES information in making drought response decisions, we chose an STM from the Miocene Hills site (a). It consists of shale and sandstone hills that dot the edges of the southern San Joaquin Valley. Elevation ranges from 300 to 750 m and slopes from 20% to 30%. Soils are sandy clay loams. Annual rainfall is 250 mm, but is highly erratic (b). Information in this illustration is drawn from Spiegal et al. 2015.[15]
In the Mediterranean annual grassland ecosystem, where state changes occur infrequently, community phases (CP) are the most dynamic and responsive components and provide the most relevant information for drought decision-making. Pathways (P) provide guidance managers can employ to shift species composition and achieve management objectives. This model was developed using existing literature, field data from Tejon Ranch, and expert knowledge.
Annual grassland composition and production depends largely on the conditions at germination the previous fall and winter. Grazing generally has a weaker influence than amount and timing of rainfall. Although these vegetation dynamics are ubiquitous across the entire annual grassland ecosystem, this STM provides some important site-specific insights:

i. The Annual Grasses CP is generally associated with highest levels of animal performance. The clay dominant soils can retain early winter rainfall, which may be sufficient for grass growth even in dry years. December rainfall can inform mid-season livestock acquisition decisions.
ii. In the Litter/Bare ground CP, managing residual dry matter (RDM) levels is critical to recovery to the Annual Grasses CP (P4). RDM levels should be maintained at >700 kg/ha, which may require stocking rate reductions.
iii. The Annual Forbs CP has higher potential for native biodiversity goals (native forbs *Plantago erecta*, *Plantago ovata*, and *Plagiobothrys canescens)*, but may require more flexible stocking rate adjustments to maintain RDM levels below 500 kg/ha.





because it can be used over large areas and the availability of satellite records from the mid-1970s. In addition to direct estimates of vegetation properties (production, standing crop, seasonality, phenology, life form relationships) that may be deployed by ranchers to make on-the-ground decisions, technical advisors and policymakers can use the same information at larger scales to identify early warning signs of drought and opportunities to intervene to avoid damage to resources.[9] As in-field monitoring, remote sensing does not offer a universal metric for drought response; rather, a multitude of information sources and tools should be combined into a wide array of products to answer specific questions.

The knowledge gaps and needs with regard to monitoring for decision-making relate to a lack of collected data, as well as technical challenges and remote-sensing knowledge gaps. There is large variability in spatial and annual precipitation in California. Local precipitation measurements would help ranchers make management decisions and could be collected as simply as installing rain gauges on individual properties, ultimately linking management decisions to precipitation by a rain gauge network.[10] However, merely tracking precipitation (or lack of it) is a relatively poor basis for effective drought management and policy. Past precipitation patterns, current rainfall, and projected changes in seasonal precipitation by mid- century[v] are all necessary pieces that allow a variety of users to conceptualize changes and relate those changes in rainfall and temperatures to short-, medium-, and long-term sustainability goals.

Mitigation Opportunities and Threats

The Mitigation Workgroup attempted to identify implications, both intended and unintended, associated with ongoing efforts to develop rangeland-based greenhouse gas (GHG) mitigation projects and how drought might complicate those efforts. In California, rangelands are the largest land cover by area, covering over one half of the state. Forty-three percent of California rangelands are privately owned; however, in California's Central Valley and surrounding foothills, where rangelands are dominated by annual grassland and hardwood woodlands, this percentage exceeds 80%.[11]

The proportion of lands in private ownership and tendency for lower profits compared with other land uses make rangelands subject to conversion. Between 1984 and 2008, over 195,000 hectares of rangeland within a 13.5 M ha study area in California were converted to residential development or more intensive agriculture.[12] The Central Valley region and surrounding foothills contain approximately 34,350 km^2 of grassland; a scenario analysis of future land use change in this region found that 23% to 37% of grassland could be converted to development or more intensive agriculture by 2100.[13] In this region, the total baseline soil organic carbon stock in the top 20 cm for grasslands is estimated at 100 Tg C. Based on land use change scenarios, 23% to 39% of the organic soil carbon in grasslands is potentially subject to disturbance (such as conversion to development) by 2100.[13]

[v] Seasonal precipitation data are available at http://swclimatehub.info/data/county-temp-precip-maps/precipitation.

Due to the high risk of conversion on rangelands, and due to the large soil carbon pool that exists on these lands, avoided loss of soil carbon is considered a significant GHG mitigation opportunity in California. The potential for new carbon offset projects to mitigate GHGs has grown with emerging carbon markets. The Climate Action Reserve has recently implemented the Grassland Project Protocol to provide guidance on how to quantify, monitor, report, and verify GHG emission reductions associated with the avoided conversion of grassland to cropland[vi]. This protocol provides a mechanism for avoided loss of soil carbon on California grasslands.

Similarly, the California Department of Conservation's Sustainable Agricultural Lands Conservation program supports the protection and management of California's agricultural lands. The goal of this program is to prevent increases in land use change-based GHG emissions through planning and permanent protection of farm and ranch lands via agricultural easements and by limiting opportunities for expansive, vehicle dependent forms of development in favor of more focused, compact, and transit oriented development within discrete growth boundaries.[vii]

There is a high demand for rangeland conservation programs in California by landowners. According to the California Rangeland Trust, 100,000 ha could be protected via conservation easement if sufficient funds were available to purchase easements, however there is a tipping point driven by land value and demand for conversion to residential development or high-value crops like grapes and almonds that could lead to conversion of rangeland to another land use.

One approach to assess threats and opportunities for grassland avoided loss is to conduct a sensitivity analysis to understand how the area and distribution of land set aside for open rangeland can influence the effectiveness of climate change mitigation. Knowing that land area reserved for carbon sequestration and enhancement is limited by competing demands for agriculture, development, and other uses, scientists can develop multiple avoided loss scenarios that assign incremental areal and spatial allocation of land for grassland carbon avoided loss. Alternate scenarios can be used to assess tradeoffs between land value, risk of conversion, and prevention of GHG emissions.[14] This workgroup strongly felt that the highest priority for land-based mitigation in California rangelands was the protection of existing land use and avoidance of emissions due to land use change.

Summary

Two major points emerged from the workshop. First, ranchers are constantly adapting and have always done so. These adaptations are expressed as a range of strategies and tactics, but their correlation to specific outcomes as a way to

[vi] The Grassland Project protocol is available at http://www.climateactionreserve.org/how/protocols/grassland/.

[vii] For more on the Sustainable Agricultural Lands Conservation (SALC) program see http://www.sgc.ca.gov/Grant-Programs/SALC-Program.html.

improve information transfer is poorly quantified. More importantly, there is not an agreed-upon framework for systematic analysis upon which agencies and institutions charged with providing technical and financial assistance can synthesize those individual activities and build them into a learning environment. Second, change in the future will likely accelerate and increase in magnitude, and a more realistic and better-defined context that integrated the complex interactions among climate, livestock, managers, and policy could greatly aid in developing responses. The future will not merely be a repeat of the past, but the past certainly holds important clues as to how to deal with the future. The challenge to the institutions is to find a way to communicate both the individual successes and failures in a logical and coherent manner that will support land managers.

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