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On the Ground

- Adaptive management can be used to manage complexity, such as how to match forage production variability across years and within portions of a grazing season with animal demand through management flexibility.
- Adaptive management strategies should incorporate flexibility and feedback mechanisms informed by appropriate seasonal weather variables and monitoring metrics to both increase resiliency of rangeland ecosystems and reduce risk for the ranching enterprise associated with drought.
- For management flexibility, we provide four general strategies that ranchers can use to deal with drought: 1) predict it using weather and climate forecasting tools, 2) track it, 3) employ conservative stocking rates, and 4) utilize inherent spatial variability.
- Adaptive grazing management plans that seek to integrate drought prediction tools, conservative but flexible stocking, and existing and predicted spatial heterogeneity in forage quantity and quality can be incorporated into conservation practices where spatial heterogeneity in forage resources within and among allotments/pastures is often not explicitly monitored or considered when planning livestock movements.

Keywords: enterprise flexibility, grassbanking, herd structure, resiliency, risk management, risk reduction.

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Rangelands are characterized by spatial heterogeneity in soils, topography, landscape positions, historical disturbance patterns, weather, and management influences. Furthermore, rangelands often are characterized by dramatic spatiotemporal variation in precipitation[1] and temperature, and are experiencing increases in extreme droughts and deluges at multiple temporal scales under a changing climate. Adaptive management can be used to manage complexity, such as how to match forage production variability across years and within portions of a grazing season with animal demand through management flexibility. Adaptive management strategies should incorporate flexibility and feedback mechanisms informed by appropriate seasonal weather variables[2] and monitoring metrics to both increase resiliency of rangeland ecosystems and reduce risk for the ranching enterprise associated with drought. With drought having soil moisture deficits due to increased evapotranspiration at different temporal scales, reductions in forage production can markedly affect livestock weight gains and, as a result, economics for the ranching operation.[3] The movement of livestock in relation to spatial heterogeneity in forage resources can be a key strategy to mitigate the influence of extreme temporal variability in weather, especially drought.

Drought and Rangelands

Surveys of ranchers consistently showcase that most employ reactive drought management practices where herd size is reduced and feed is purchased, but fewer have well-defined proactive strategies in their drought management plans such as reserve forage supplies and varying herd numbers with forage supply[4] (Fig. 1). Moreover, there is a continued need for ranchers to engage in written drought management plans that can incorporate adaptive management and flexibility for the ranching enterprise as only 60% of surveyed ranchers in Wyoming had a current plan.[4] Droughts often are the catalyst to make ranching enterprise changes as they can be an expensive education to do something different.

Drought management plans for ranchers should encompass two primary strategies: 1) enterprise flexibility – defined as herd structure where the proportion of cow-calf pairs and yearlings (stockers) provides plasticity to match forage availability with forage demand, with advantages to economic returns[5,6] and increased resiliency of plant communities; and 2) management flexibility – defined here as adaptive management where relevant monitoring metrics provide feedback to influence subsequent decision-making processes to promote risk reduction. For management flexibility, we provide four general strategies that ranchers can use to deal with drought: 1) predict it using weather and climate forecasting tools, 2) track it, 3)

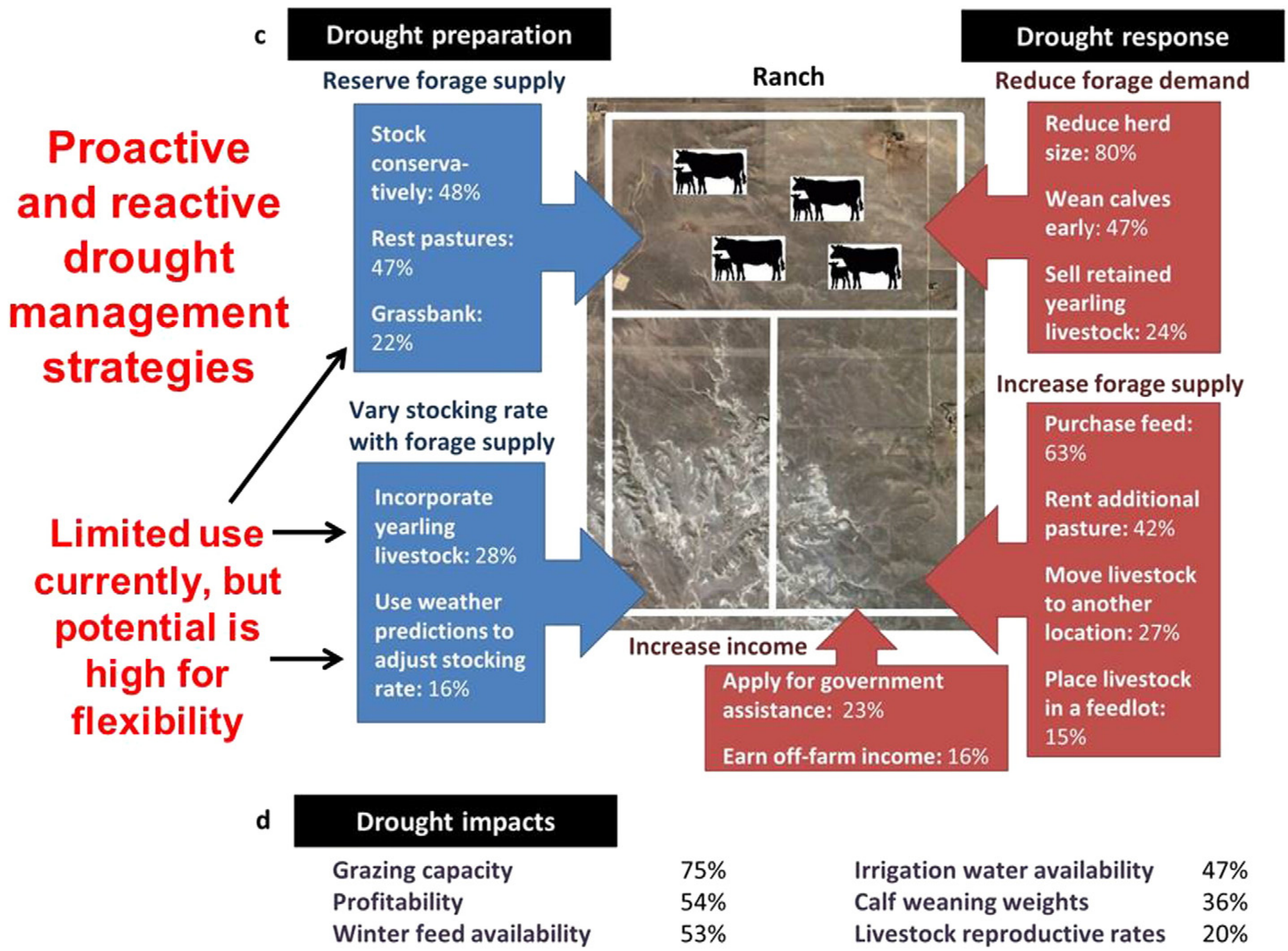

Figure 1. Proactive (drought preparation) and reactive (drought response) drought management strategies employed by Wyoming ranchers (adapted from Kachergis et al. 2014[4]).

employ conservative stocking rates, and 4) utilize inherent spatial variability. Ranchers typically utilize a combination of all these strategies, as each involves inherent limitations or costs.

Predicting Droughts

Increased understanding of the complexity of climatological influences on drought provides a foundation for the spatial and temporal aspects of drought frequency, and illustrates the need for adaptive management to provide flexibility for the ranching enterprise. For example, over half of the spatial and temporal variance in multidecadal drought frequency in the United States is attributed to the influences of the Pacific and Atlantic Ocean oscillations.[7] The combinations of positive (warm) and negative (cool) regimes for the Pacific Decadal Oscillation (PDO) and the Atlantic Multi-decadal Oscillation (AMO) lead to contrasting spatial configurations of drought frequency across the United States (see Fig. 2).[7]

The Dust Bowl years of the 1930s drought occurred when both the PDO and AMO were positive (panel C, Fig. 2).[7] The 1950s drought had a similar positive AMO but a negative PDO (panel D), and this combination has also been prevalent over the 2000s. With the PDO currently entering a warm phase (+PDO), and the AMO beginning to enter a negative phase (-AMO), the historical relationships suggest that drought frequency across most of the rangelands of the United States will be low (panel A, Fig. 2), with the exception of the West Coast, and the northern tier of western states (most of Idaho, Montana, Wyoming, and North Dakota). Our rapidly improving understanding of how these decadal-scale oscillations influence drought risk in North American rangelands provides a context in which to assess the magnitude of drought risk.

While we are currently fortunate to be in an oscillation pattern associated with reduced drought risk in the Great Plains and Great Basin, predictions of weather 3 to 12 months out still involve substantial uncertainty. For example, the seasonal precipitation patterns predicted in mid-May 2012 for summer (June, July, and August) 2012, showcased only below average precipitation for the Pacific Northwest; yet the summer 2012 across the Great Plains rivaled the 1930s Dust Bowl in terms of spatial extent and had devastating economic consequences for ranchers. This uncertainty in predicting precipitation for critical forage growths period for many rangelands is problematic for ranchers in grazing

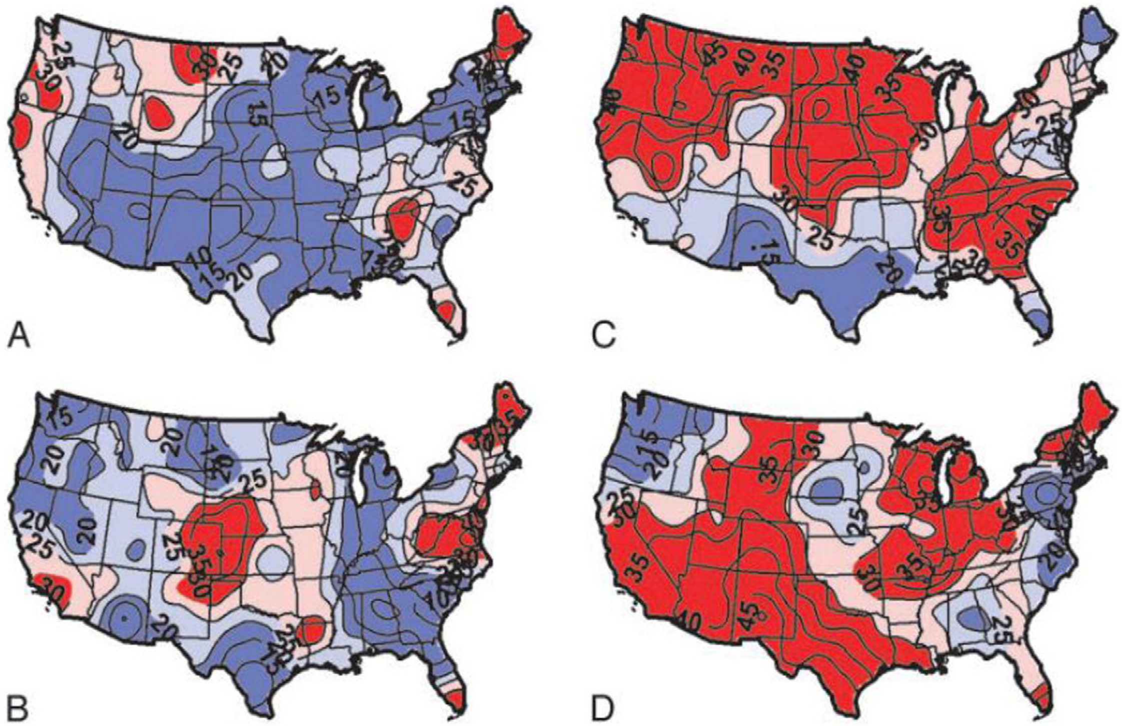

Figure 2. Drought frequency in the United States as influenced by Pacific Decadal Oscillations (PDO) and Atlantic Multi-decadal Oscillations (AMO) (from McCabe et al. 2004[5]).

management decision-making. Further advances in the reliability and accuracy of the robustness of future seasonal precipitation forecasts are critical for risk reduction, resiliency of rangelands, and robustness of rural economies and communities that can be markedly impacted by drought.

Climate/Weather Tools

To assist ranchers with reducing enterprise risk and increasing resiliency of rangelands, several weather/climate forecasting tools are available. The US Drought Monitor[i], released weekly, provides the spatial extent of abnormally dry to extreme and exceptional drought conditions. Further, monthly drought outlooks[ii] and seasonal drought outlooks[iii] provide maps with probabilities of spatial aspects of drought persisting, improvement from drought, and where drought development is likely. These resources, combined with one-month temperature[iv] and precipitation[v], and three-month temperature[vi] and precipitation[vii] probability outlooks from the National Weather Service Climate Prediction Center can be used in an adaptive management framework to adjust cattle numbers to expected forage conditions.

Though there are several weather/climate tools available for ranchers, the effectiveness of these tools merit further advancement for increased robustness and predictability. The value in these tools is that they do provide ranchers more information now than ever before, and at a fingertip with accessibility via smartphones and other mobile devices. Yet, ranchers should continue to cautiously use these tools and recognize that the provided information is imperfect and has a high degree of uncertainty. In addition, most rangeland systems (particularly semiarid to arid) are inevitably associated with a high level of unpredictability at temporal scales of months to the full year. Moreover, the lack of sufficient soil moisture monitoring efforts limits application of many of these climate/weather tools to the granularity of ranch-scale decision-making associated with drought planning.

Employ Conservative Stocking Rate, but Track Forage Variability Too

Ranchers manage livestock enterprises within the constraints of spatial heterogeneity of their operations and the temporal variability of environmental/climatological factors. One of the simplest means to match forage availability with demand is to take a conservative approach to setting stocking rates. For example, many ranchers in the western Great Plains employ an overall conservative stocking rate across the entire ranch property such that 10% to 33% of the ranch is planned

[i] Access the US Drought Monitor at http://droughtmonitor.unl.edu/

[ii] Access NOAA's monthly drought outlook at http://www.cpc.ncep.noaa.gov/products/expert_assessment/month_drought.png

[iii] Access NOAA's seasonal drought outlook at http://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.png

[iv] View one-month temperature probability outlooks at http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead14/off14_temp.gif

[v] View one-month precipitation probability outlooks at http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead14/off14_prcp.gif

[vi] View three-month temperature probability outlooks at http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead01/off01_temp.gif

[vii] View three-month precipitation probability outlooks at http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead01/off01_prcp.gif

to be rested (no use) each growing season to provide "forage insurance". Setting stocking rates based on expected forage supply during dry or drought years may increase resilience of the rangeland plant-soil community and will reduce the chance of having to sell cows during periods of unfavorable prices, but leads to the inevitable question of how extra forage produced in above-average precipitation years could be more effectively utilized.

Critical dates for ranchers in terms of enterprise decisions for retaining yearling steers (stockers), replacement heifers, culling dry cows, and early weaning need to be an essential component of drought management plans for ranchers. These critical dates are increasing in importance given the marked increase in pasture rent values[viii], which further drives economic considerations of appropriately matching forage availability with forage demand. As variability increases in key seasonal precipitation that influences forage production, the importance of critical dates also increases.

To track temporal variation in forage production in an effort to match cattle numbers with forage availability, ranchers can 1) reduce cattle numbers progressively with increasing severity and duration of drought, which is why having established critical dates for enterprise decisions is essential; 2) add forage quickly through leasing land, purchasing feed or moving cattle to alternate locations where forage is available, perhaps in other states (as was the case with the recent Southern Plains drought as cattle moved to the Northern Plains states); and 3) substantially increase enterprise flexibility by splitting forage between cow-calf and yearling enterprises to adapt to weather/climatic variability. To the extent that ranchers can obtain quality precipitation forecasts, economic models of ranching enterprises have shown that the combination of a mixed yearling and cow-calf enterprise can generate approximately twice the economic returns of purely cow-calf enterprises, due to the capacity for the mixed enterprise to minimizing selling of cattle at low prices during drought and purchasing high-priced animals following drought.[6]

Use Spatial Heterogeneity

In dealing with temporal variation in forage production, ranchers can take advantage of spatial variability in precipitation, soils, and topography by understanding sources and scales of local variability. For example, precipitation can be highly variable spatially within a single growing season and this can vary across years on the same landscape.[1] Measuring this spatial variation at scales of individual ranches or collections of adjacent properties, and adjusting livestock distribution in response, can substantially increase the temporal stability of available forage. "Next generation innovators"[8] are establishing networks through local neighbors and various entities to provide security of alternative forage sources for drought, as well as sharing information related to decision-making in an effort to deal with temporal variation of forage production. Adjusting livestock distribution in response to spatial variation in precipitation can be important not only as forage resources decline in dry periods, but also during wet cycles when intense grazing in areas with high quality, ephemeral forages can allow for grassbanking in portions of the landscape with more productive but lower quality forages. Ranchers can also reserve more productive lowland pastures for dormant (winter) grazing or for possible haying if economic conditions warrant.

Adaptive Management Strategies

Integrating the previously described four strategies can be accomplished though adaptive management where specific goals and objectives are set for individual ranching operations. Filtering these goals and objectives through the lens of weather/climatic variability assists ranchers in determining options for adaptive management strategies addressing drought. A suite of proactive strategies are currently being employed by ranchers, with these including: grassbanking, conservative overall ranch stocking rate, incorporating yearling livestock to match forage availability with forage demand, and using seasonal outlook weather/climate predictions to adjust stocking rates.[4]

The strategy of grassbanking and intentionally resting pastures is being experimentally evaluated in the western Great Plains for multiple objectives of vegetation, profitability of ranching operations, and wildlife habitat in the Adaptive Grazing Management experiment, a stakeholder-driven effort including ranchers, conservation/environmental organizations, and state/federal land mangers[ix]. What is novel here is the explicit incorporation of seasonal outlook weather/climate predictions, rotation of year-long rest among pastures across years, and relevant monitoring metrics for each of the primary and secondary objectives, which provides key data for feedback, both within and between grazing seasons, to complete the loop in terms of adaptive decision making. For example, favorable weather conditions during the grazing season in 2014 allowed livestock to graze longer in a fewer number of the total available set of pastures, thereby providing the opportunity for adaptive management decision-making by the stakeholder group when planning for the subsequent grazing season. This included incorporating patch burn management (or pyric-herbivory[9]) to address multiple objectives, and planning to increase stocking rates by 5% due to grassbanked forage reserves, winter soil moisture status, and the three-month drought outlook. A small area of the rested pastures (25%) was burned to create breeding habitat for a grassland bird of conservation concern, reduce densities of prickly-pear cactus, and enhance forage quality for livestock early in the subsequent grazing season.[10,11] The latter can be particularly important in the event of above-average precipitation in the subsequent spring. At the same time, most

[viii] To review South Dakota Agricultural Land Market Trends from 1991 to 2015, see https://igrow.org/up/resources/03-7008-2015.pdf.

[ix] For more on the USDA ARS Adaptive Grazing Management Experiment, see http://www.ars.usda.gov/Research/docs.htm?docid=25733

(75%) of the rested pastures remained unburned, providing standing forage reserves in the event of below-average spring precipitation in the subsequent grazing season.

Inclusion of Adaptive Management for Grazing Decision-Making on Private and Public Rangelands

Adaptive grazing management plans that seek to integrate drought prediction tools, conservative but flexible stocking, and existing and predicted spatial heterogeneity in forage quantity and quality can be incorporated into conservation practices such as the USDA Natural Resource Conservation Service (NRCS) Conservation Practice Standard 528 - Prescribed grazing[x] for implementation on private lands. Similarly, such integration could enhance allotment management plans by the Forest Service and Bureau of Land Management where spatial heterogeneity in forage resources within and among allotments is often not explicitly monitored or considered when planning livestock movements. The Adaptive Grazing Management experiment is one example of collaborative, adaptive grazing management efforts in rangelands worldwide that can provide a learning environment for rangeland stakeholders to integrate multiple proactive drought planning strategies into grazing management of both private and public lands in a manner that enhances rangeland resilience and reduces risk for ranching enterprises.

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[x] See the NRCS Prescribed Grazing standard at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_025729.pdf