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Drought Mitigation for Grazing Operations: Matching the Animal to the Environment

By John Derek Scasta, David L. Lalman, and Leticia Henderson

On the Ground

- With expected increases in drought frequency and severity, long-term drought management strategies that focus on cattle selection and natural resource management are essential.
- The livestock industry in general unintentionally tends to select for cattle that do not perform to their maximum potential in limited-resource environments. We discuss the implications of cattle selection based on characteristics such as genetic potential, cow size, and hide color.
- In a hypothetical model, we found that because forage requirements for smaller cows are lower than forage requirements for larger cows, using a herd of smaller cows produces a larger total calf crop if cow size and milk do not lead to greater calf production.
- Because grazed forage remains the least expensive source of nutrients to maintain the cow herd, matching cow size and milk production potential to forage resources to optimize forage utilization and reproductive efficiency should be considered a rangeland drought mitigation strategy.
- Contemporary strategies such as using EPDs and selection indexes to manage maternal traits such as mature weight and maintenance energy requirements can be integrated with conventional drought mitigation strategies that focus on resource quality management.

Keywords: beef, climate, efficiency, integrated management, rangeland, variability.

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The livestock industry has been all too familiar with drought because ranchers have always had to adapt to precipitation variability, especially on North American rangelands. Common drought management decisions have included reducing herd size and feeding harvested forage. Unfortunately, these methods have not alleviated the stress of long-term drought. According to climate forecasts, drought frequency and severity are expected to increase in coming years, posing greater challenges to livestock producers. As a result, livestock producers will have to rely on integrated and long-term management strategies. Matching animals to the environment is an effective drought management strategy. In reality though, the livestock industry has increasingly provided incentives for the selection of cattle that may not be the most suited to harsh rangeland environments. Therefore, it is important to weigh the pros and cons of animal traits, and understand how animals interact with the environment to develop integrated drought management plans.

Drought Trends and Effects on Cattle Enterprises

Climate forecasts out to 2060 suggest temperature and precipitation will change variably by region in the United States.[1] Some areas will become hotter and drier (southwestern states) and some areas will become hotter and wetter (northern mixed prairie), with a broad gradient of extremes between competing models.[1] Drought forecasts are predicting greater frequency and magnitude–forecasts that have direct implications for livestock production on rangelands.[2] First and foremost, drought reduces livestock production by reducing the amount of forage available. This reduction of forage can increase supplemental feeding costs or require herd reduction. Long-term drought patterns can cause an abnormally high volume of cattle sold at auction facilities and a subsequent short-term decrease in market animal value locally.[3] This can lead to a decrease in total cattle numbers and can cause higher market prices nationally. Consequently, these drought-driven market trends make it financially difficult to rebuild after herd reduction because a greater number of replacements are required at a greater direct opportunity cost. Secondly, drought also reduces forage quality as much as 3% of crude protein for every one-inch reduction of monthly precipitation.[4] In Wyoming, this drought-induced forage quality reduction decreased daily gain from 0.03 to 0.07 lb for each inch reduction of precipitation.[5] Thus, even if an operation was stocked to absorb the reductions in forage quantity from drought, the negative effects from lower quality may still be detrimental. Managers must also consider that even if some areas are predicted to become warmer and wetter, drought frequency and magnitude may increase and heat stress may also escalate as a stress on animals.

Cattle Industry Trends and Effects on Animal Maintenance Costs and Production

Concurrently, yet independent of climatic trends, the beef industry has promoted genetic selection trends that influence animal-environment interactions. Selection for increased calf growth has been steady since the 1970s according to most breeds' genetic trend data.[6] Similarly, milk EPDs (expected progeny differences) in most breeds (including Hereford and Angus) has consistently increased since the 1990s while a few breeds' genetic trend is negative or static.[6] Breeds with a negative or static genetic trend including Gelbvieh and Simmental had a relatively high capacity for milk yield when they entered the US beef industry. As milk production and growth potential increases, nutrient intake requirements go up and weaning weights should also increase. However, if the genetic expression for milk and growth is limited by the environment as in rangeland environments, this benefit may not be realized. Currently, no evidence exists to indicate increases in weaning weights in commercial cow/calf operations in New Mexico, Texas, or Oklahoma according to Standardized Performance Analysis (SPA).[7] This all indicates that environmental constraints in forage capacity on rangelands (such as nutrients and quality) limit the realization of genetic potential for animal performance.

Another confounding issue to the cost of added weaning weight is the additional grazing and feed cost relative to the conversion of added milk to additional calf gain. Efficiency of conversion of added milk to additional calf gain is improved with lower-yielding cows but exacerbated with higher-yielding cows.[8] Furthermore, the positive relationship between increased genetic capacity for milk production and cow annual maintenance requirements has direct implications for feed costs and stocking rates.[9] This is especially problematic in rangeland production scenarios because efficiency of milk utilization declines as genetic potential for milk production increases in the limited nutritional environments.[8] Hence, the selection for excessive milk and growth could limit the expression of these traits by the forage system and not by the genetic capacity of the cattle.[10] Even if growth potential was maximized, the added output from added cow weight is not economical, even during periods of higher market values. For example, analysis of calf weaning weights against mature cow weights from six ranches in Oklahoma and Arkansas revealed a range of 6 to 17 lb of additional calf weaning weight for each additional 100 lb of cow weight. The benefits however, were offset by the added cost of the 100 lb of additional weight of $40 per year and a reduced calving rate of 7%.[11]

Contemporary Drought Mitigation Strategies Using Livestock Genetics

Given the recent trends in beef prices, selection for milk and growth, and drought forecasts, it is imperative that rangeland grazing enterprises minimize and control their cost of production without sacrificing reproductive efficiency. Managers should consider integrating contemporary livestock selection strategies to adapt and plan for the negative impacts of drought.

Ranchers can accomplish this by paying attention to cow size, striving to maintain moderate size cows with lower milk and moderate muscling, and neutralizing or reversing recent increasing trends in these features due to a strong selection of growth genetics and muscling.[12,13] Although frame size or mature height of popular cattle breeds has not increased since about 1987, phenotypic and genetic trends indicate that mature cow weight continues to escalate. This trend is largely due to the continued aggressive selection for rapid growth and increased muscling. These result in cattle with increased appetite, a greater proportion of their body weight in visceral organ mass, overall leaner body composition at a constant mature weight, and potentially lower overall fertility. To maintain constant or historical weaning rate, ranchers are forced to manage cows to heavier weights in order to reach the same body fat composition and therefore achieve similar reproductive performance.

Because grazed forage remains the least expensive source of nutrients to maintain the cow herd, matching cow size and milk production potential to forage resources to optimize forage utilization and reproductive efficiency should be considered a drought mitigation strategy. Given the dramatic acceleration in input costs seen in recent years and drought forecasts, downward pressure on milk yield would benefit many herds relative to their forage resources to reduce input requirements. Furthermore, larger heavier milking cows with greater maintenance requirements may have lower reproductive efficiency in constrained rangeland environments. Doye and Lalman[11] reported a reduction in cow longevity because a 1,400 lb cow would likely produce one less calf in her lifetime versus a 1,100 lb cow and have a lower calving rate.

To neutralize or reverse the trend towards larger heavier milking cows with overall greater-maintenance nutrient requirements, producers should pay attention not only to sire EPDs related to production traits such as calving, growth and muscling (i.e., birth weight, calving ease, weaning weight, milk yield, yearling weight, and muscling or yield grade EPDs), but should also pay attention to EPDs and selection indices related to maternal traits such as maternal milk, weight, height, and maintenance energy requirements.[14] These EPDs and selection indices are designed to assist in

Table 1. Hypothetical model of forage requirements, potential uniform herd sizes, pounds of weaned beef and efficiency assuming there is no difference in calf for a 210-day grazing season weaning weight relative to cow size across the drought gradient[16]

Cow weight (lb)	Daily forage intake (lb)*	Total season intake (lb)	Herd Size	Pounds of weaned beef†	Efficiency ratio‡
1,000	22.0	4,620	100 hd	50,000	0.50
1,100	24.2	5,082	91 hd	45,500	0.46
1,200	26.4	5,544	83 hd	41,500	0.42
1,300	28.6	6,006	77 hd	38,500	0.39
1,400	30.8	6,468	71 hd	35,500	0.36

* Based on 2.2% of body weight forage DMI of low quality forage for lactating cows.[17]
† Assuming an average 500 lb weaned calf across all cow sizes and across the drought gradient.[16]
‡ Calculated as calf weight:cow weight with a common target of a cow weaning 50% of her body weight or an efficiency ratio of 0.5.

maintaining performance (calf weaning weight for example) and fertility while controlling nutrient requirements of the cow herd. If a ranch is large enough, managers may consider selecting growth bulls to produce market calves and maternal bulls selected for the best possible environmental match to produce heifer replacements.

Stocking rates ideally should be based on the forage intake requirements relative to the forage supply, an adjustment that may have not been made due to the slow temporal trend affecting size and milk of cows. Because forage intake requirements are a function of animal size and forage quality, as average cow size in the herd increases, the additional forage requirement per cow increases, and therefore the number of cows should be adjusted down accordingly. Although accounting for body size in stocking rates calculations may not be a new concept, the continued escalation of the cow size problem, primary recognition in animal centric disciplines, and ability to put this trend in the context of research conducted in different environments continues to rely on new data. For example, a recent study on fertilized small pastures (~8 ac) in southwestern Arkansas showed larger cows (1,258 lb) did wean ~45 lb heavier calves than small cows (1,020 lb).[15] Contradictory results from a semi-arid rangeland environment in Wyoming recently indicated however that smaller cows weaned calves as heavy as the largest cows and may have an advantage over large cows due to their ability to reduce forage inputs while simultaneously increasing total output measured in annual total weaned weight of calves.[16]

Using this general result for the cow size*rangeland environment interaction, we developed a hypothetical modeling scenario presented in Table 1 that we suggest for western rangelands. We used a formula assuming that forage dry matter intake (DMI) is 2.2% of a lactating cow's body weight on low quality forage[17] for five cow sizes (Table 1, Fig. 1). Consequently, daily forage intake and total season intake increases as cow size increases. For example, 1,400 lb cows need 8.8 lb of forage more per day and 1,848 lb of forage more for the 210-day grazing season than 1,000 lb cows (Table 1). Subsequently, the stocking rate would need to be prorated as cows get larger (Fig. 1). The total pounds weaned ranges from 50,000 lb for 1,000 lb cows to 35,500 lb for 1,400 lb cows if larger cows offer no advantage in calf weaning weight (Table 1). Finally, the only cow size capable of weaning 50% of her body weight would be the smallest 1,000 lb cows; a result that is also supported by ranch level data in Scasta et al.[16] (Table 1). Thus, because smaller cows require less forage, more individual cows can be placed on the same pasture and more total calf crop weight produced if the growth potential of larger cows is constrained by the environment. Furthermore, a larger herd comprised of more small cows could be an advantage because overhead costs can be spread across more animals and smaller cows have lower maintenance costs.[11] This approach is also relevant to EPDs associated with feed intake and efficiency as a recent study has concluded that bigger Angus cows ate more (i.e., DMI was 4.8% higher) but their feed efficiency was not different (i.e., residual feed intake) than small cows.[18] Moreover, as of late 2015, two major breed associations had started to use a DMI EPD because of the recent genetic trends in the cattle industry that have produced cattle with greater dry matter/nutrient requirements of which increasing body size is one of the characteristics driving that trend (see American Angus Association https://www.angus.org/AGI/GenomicEnhancedEPDs.pdf and American Hereford Association http://www.hereford.org/static/files/1215_PerformanceMatters.pdf). Understanding these discrepancies between intake, efficiency, and production relative to body size is important when considering reports suggesting that breeding for *larger* animals is a drought adaptation strategy (see the recommendation for southern Australia's 12-42 inch precipitation zone in Moore and Ghahramani[19]). Here the authors explicitly state that breeding for larger body size was the most effective adaptation option for the SRES A2 global change scenario predicting decreasing precipitation and forage production.[19] In reality though, the authors are suggesting breeding for greater 'forage conversion efficiency' because that is the assumption used in modeling–a trait that is not necessarily correlated with cow size.[18,19]

Higher temperatures and heat stress alone can reduce cattle production by reducing feed intake, feed efficiency, and causing mortality.[20] The provision of shade and water offers

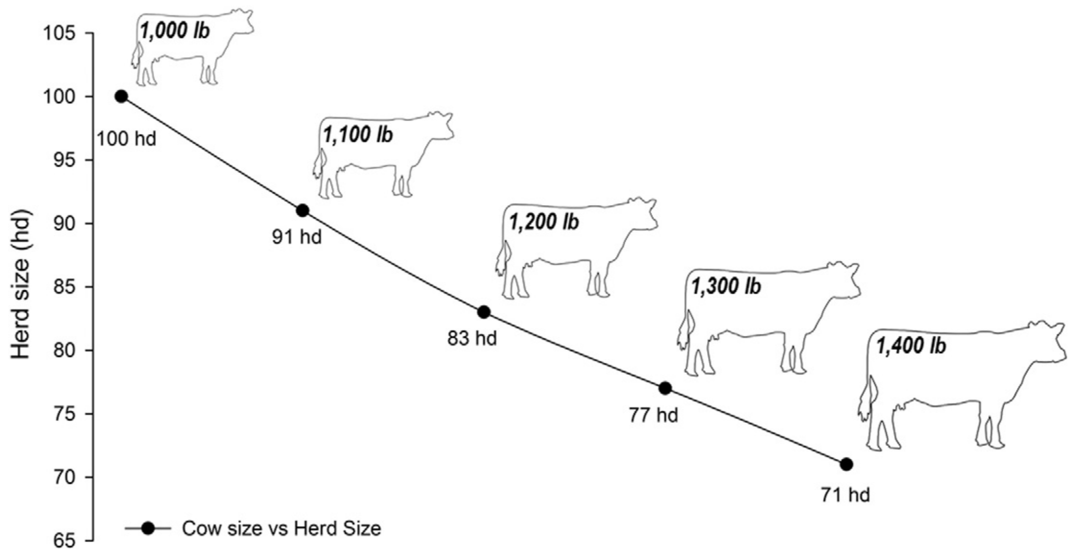

Figure 1. Tradeoff between cow size and potential herd size. Model assumes a uniform cow size within each potential herd and prorating stocking rate to equitably balance animal demand with forage supply.

production benefits, especially for *Bos taurus* cattle.[21] If higher temperatures prevail, ranchers should consider that *Bos indicus* cattle have greater heat stress tolerance than *Bos taurus* cattle because of differences in metabolic rate, resource consumption, rate of sweating, and hide characteristics.[21] Brown-Brandl et al.[20] conducted an assessment of heat tolerance of Angus, MARCIII (crossbreed consisting of Pinzgauer, Red Poll, Hereford, and Angus breeds), Gelbvieh, and Charolais breeds with varying hide color (black, dark red, tan, white, respectively). Black hided cattle had the greatest respiration rates, panting scores, and surface temperatures followed by dark red, then tan, and then white cattle. The development of heat stress increased drinking and standing, decreased eating, lying, and physical activity. Darker cattle made more behavioral adjustments than lighter cattle. These heat tolerance results are driven by cattle with lighter hair coats having lower solar absorption.[22] Scientists are also evaluating DNA markers in dairy cattle to identify chromosomes associated with productivity relative to temperature-humidity indices.[23] A similar approach for beef cattle has been used to assess heat-tolerant (Romosinuano breed) and heat-susceptible (Angus breed) cattle and indicates that prolactin (an endocrine marker) influences cow heat tolerance.[24] Thus, advances in capitalizing on heat tolerance could be advantageous for all areas forecasted to become warmer and regardless of disagreement between precipitation forecasts. Most simply, managers should consider hide color and breed composition to better cope with heat stress, especially in open rangelands that do not have readily available shade resources. However, only focusing on heat tolerance may be overly simplistic, especially in northern areas that experience cold winters because traits that dissipate heat well may decrease cold tolerance and challenge thermal regulation in the winter–a major concern for maintaining body condition.

Figure 2. Breeds of cattle such as Corrientes that are adapted to arid and semi-arid conditions have been integrated into grazing operations for hardiness and to capture an alternative market for rodeo stock. Picture from west of Bill, WY in 2015.

Another strategy to mitigate drought effects could be adopting drought-adapted cattle breeds or crossbreeds. Frisch[25] assessed performance of purebred *Bos taurus* cattle and crossbred *Bos taurus* x *Bos indicus* cattle under drought in Australia. Crossbred cattle had lower gains in wet years but had fewer debilitating losses in drought years. Researchers in New Mexico have also been assessing Criollo cattle, a breed from Mexico that is adapted to arid environments, and a few ranchers in Wyoming have integrated Corriente cattle (Fig. 2).[26]

Conventional Drought Mitigation Strategies Altering Resource Availability

Managers should therefore, consider integrating the contemporary livestock selection strategies (Fig. 3, Table 2) with conventional resource management strategies. For example, when forage quantity is predicted to be reduced by drought, adjusting stocking rates and resting pastures to maintain a forage reserve is prudent When forage quality is predicted to be reduced by drought, it may be effective to provide a protein supplement to enhance DMI and forage digestibility to avoid performance losses.[27] Furthermore, because drought can also cause a shift in diet composition towards greater selection of shrubs, an inventory of alternative forages is practical.[27] Researchers also suggest adjusting stocking rates relative to precipitation in the current growth season, adopting more liquid livestock classes such as stocker cattle, and/or adopting more drought tolerant livestock species such as sheep or goats.[28]

As drought escalates, stock water quantity and quality can deteriorate, especially in stock ponds. As water quantity is reduced, the concentration of feces and urine in the remaining water source can increase proportionally and have a negative effect on animal performance. Willms et al.[29] reported that calves on cows and heifers drinking clean water delivered to a trough from a well gained 9% and 23% more weight, respectively, than animals drinking from a tank or pond. Thus, as drought escalates, ranchers should not only assess water quantity, but water quality as well.

Conclusions

The threat of drought-induced losses has been a struggle for as long as humans have herded animals on rangelands. Given the forecasts of future drought cycles, it is imperative that producers and technical advisors consider a suite of integrated adaptation strategies including matching the animal to the environment (Table 2). Because rangeland forage resources are extensive and subject to precipitation variability, the primary adaptations strategies should optimize the plant-livestock interaction and incorporate long-range planning.

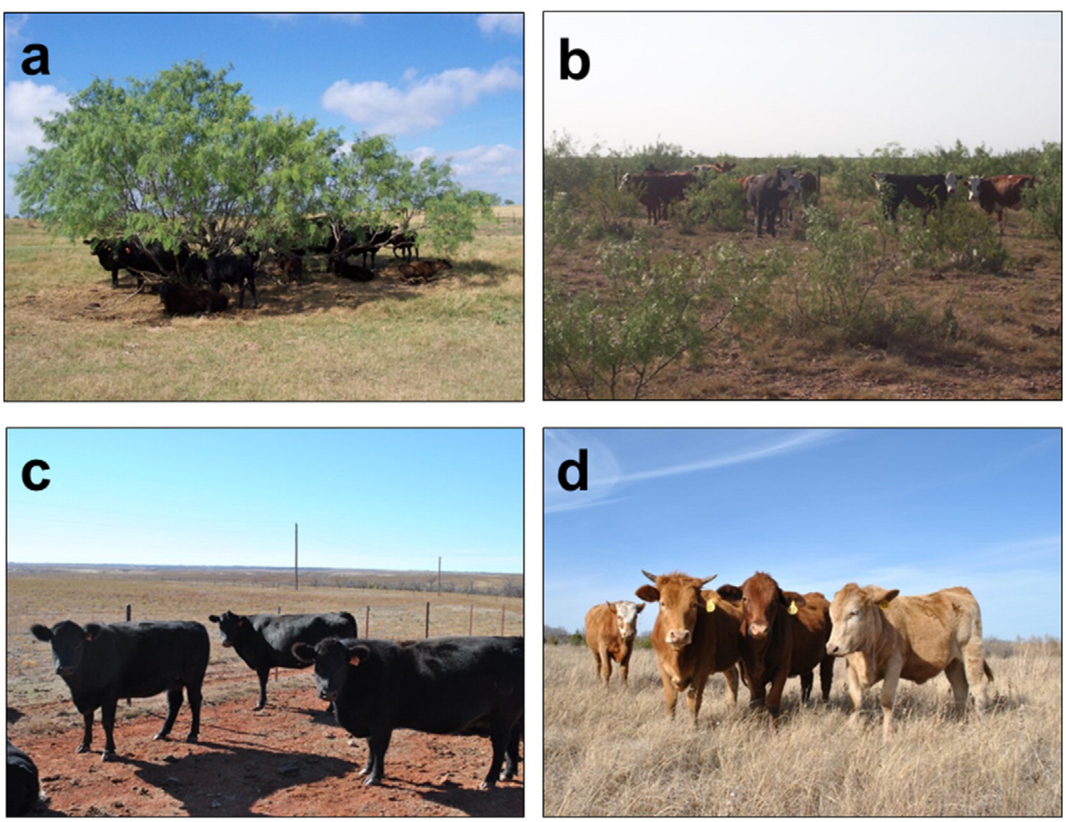

Figure 3. Drought mitigation strategies for grazing operations that match the animal to the environment should: a) consider heat stress risk and performance losses relative to cattle hide color and breed; b) consider classes of livestock that are more liquid than cows or crossbred animals such as these stocker cattle and inventory alternative forages such as shrubs like mesquite (*Prosopis glandulosa*) in the southwest United States; c) balance animal demand to forage supply relative to drought such as these cows in 2012 during the drought in western Oklahoma; and d) rest pastures to stockpile forage and consider crossbred replacements of lighter hide color such as these heifers from late 2012 in central Texas.

Table 2. Drought issues and mitigation strategies that could be integrated to minimize the negative effects of drought on rangeland grazing operations

Related Issue	Strategy
Livestock industry trends	- Consider that breed and hide color influence animal thermal regulation and heat stress; if possible consider providing shade and water for more susceptible animals
	- Assess cow size and your genetic selection trend relative to forage supply
	- Consider selecting for smaller cows that are more moderate in milk production
	- Consider the influence of cow size and maintenance requirements on animal longevity and conception/calving rates
Animal adaptation	- Consider cattle breeds that are more adapted to semi-arid conditions similar to drought
	- Consider integrating a cross-breeding program to include a more hardy breed and take advantage of heterosis
	- Consider adopting more liquid livestock classes as a proportion of the total inventory such as stocker cattle
	- Consider adopting more drought-adapted livestock species such as sheep or goats
Reduced forage supply	- Re-assess stocking rate, especially relative to the long-term trend and cow size
	- Integrate rest into the grazing management plan to stockpile forage and enhance flexibility during drought
	- Manage stocking rates adaptively relative to precipitation in the current growing season
Reduced forage quality	- Assess forage quality metrics such as crude protein and digestibility; consider an economical protein supplement to enhance digestibility of lower quality forage
	- Consider alternative sources of forage such as shrubs that livestock will utilize as environmental stress increases
Reduced water quantity and quality	- Consider offering clean water in a trough to avoid reduced animal performance due to fecal and urine contamination

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