Proceedings, Applied Reproductive Strategies in Beef Cattle
August 29-30, 2018; Ruidoso, NM

Preparing for the breeding season in a drought

E. J. Scholljegerdes
Department of Animal and Range Sciences
New Mexico State University

Introduction

Historically, droughts seem to occur infrequently but as any rancher would tell you, they are starting to become more frequent with shorter time between events, particularly, in the western United States. The challenges faced by ranchers during drought usually begin with the actual identification or acceptance that a drought is occurring (Thurow and Taylor, 1999). Although it seems intuitive that a rancher would be able to identify a drought but the lack of moisture is often interpreted as "just a dry spell" and ranchers prefer not to make a knee jerk decision. Yet in most cases when a rancher has accepted the fact that they are experiencing a drought, they are already behind. Often the best advice is to sell off cattle during a drought. This is due to the economic drivers associated with feed costs and most importantly, the damage that can occur to rangelands when over-grazed (Barker and Caradus, 2001). It has been the recommendation to sell off cattle that cost the most to maintain during drought (have the highest energy and protein demands). This is due to the concomitant increase in feed prices during times of drought. Therefore, ranchers would sell off older and less productive cows first and then would sell off younger cattle next. This was designed as an effort to reduce the feed needs for the cow herd. Unfortunately, due to the severity of recent droughts, producers have had to cull animals across all age groups due to diminishing forage supply.

The objective of this presentation is to provide information regarding the challenges ranchers face with a drought as it relates to nutritionally preparing females for the breeding season during a drought.

Forage responses to drought conditions

When precipitation deficits are short-lived (1 to 2 months), forage quality can improve due to delayed maturity and water desiccation thereby concentrating nutrients. This increase in quality has been reported in legumes (Vough and Marten, 1971) and grasses (Julander, 1945). However, this improvement is short-lived as increases in heat will often increase lignification of the plant cell wall and decreased metabolic processes (Flexas and Medrano, 2002). Inclusion of grazing further reduces forage quality during a drought (Julander, 1945). Generally speaking, yearly fluctuation in forage quality is normal. In figure 1, 18 years (1991-2009) of forage masticate crude protein (CP) concentrations are presented. Data originates from the NMSU Corona Range and Livestock Research Center. In this figure, low, high and

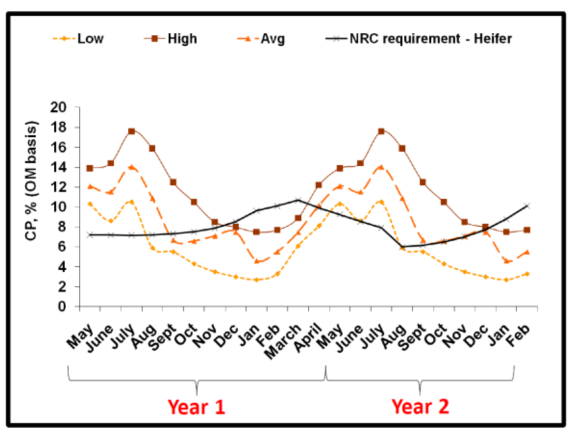

Figure 1. Forage CP concentrations in native rangeland at the NMSU Corona Range and Livestock Research Center

average CP values for rangeland during each month of the year is overlaid with the NRC (2000) requirements for beef heifers over the course of 2 years (Yr 1 = breeding in May and calving in Feb). Over the course of the 18 yr span of sampling, forage quality varied and did not always met the needs of the heifers, particularly in dry years. However, in recent years (2010-2013, data not shown) forage quality never met the requirements of heifers or mature cows. Energy values (Total Digestible Nutrients = TDN) averaged in the high 30s and low 40s (percentage) during the drought of 2010-2013, likewise, CP values were 4 to 5%. This changed as precipitation gradually increased and energy and CP levels increased to 50s and 7%, respectively.

Mineral concentrations will slightly increase as the plant matures and desiccates, but as drought continues, these values will decline (Volaire and Thomas, 1995; Volaire et al., 1998). Notable mineral changes are a reduction in Phosphorus (P), Potassium (K), Copper (Cu), Zinc (Zn), and Selenium (Se). These will be further addressed in a later section.

The reduction in forage quality and quantity are the two overarching factors that pose challenges when dealing with drought. Vigilant monitoring of forage availability and quality have been key to survival for ranchers. Little can be done to overcome forage availability aside from sale of animal units. Albeit, supplementation of sources of energy (fats and starches) can replace forage, the risk of damage to forage stands should be of major concern. In the case when forage availability is adequate, livestock nutritionists can develop supplements to meet these needs.

Water

Water is the crux of all livestock production. In this discussion, the lack of water is the issue causing the drought. However, in this section the focus is on livestock water supply and quality. As water recharge for ponds and wells becomes less and less due to sparse precipitation patterns, it has been observed that water mineral concentration will begin to increase in water. This is particularly true in ponds, were rapid evaporation will concentrate minerals. Within a well system, minerals will also concentrate as little water recharge occurs and mineral concentration may increase. Water quality then must be accounted for when developing a nutrition program during droughts. Water quality guidelines are presented in Table 1. Total dissolved solids and sulfate concentrations can increase during drought and in turn lower animal performance. This reduction in cattle performance is primarily linked to reduced water intake. A reduction in recommended water intake (Table 2) results in lower dry matter intake (Utley et al., 1970) and performance suffers. This response is further exacerbated due to the hot temperatures associated with drought and subsequent increased water requirement.

Table 1. Water quality guidelines for livestock

Item	Excellent	Very Satisfactory	Satisfactory	Marginal	High Risk
Total dissolved solids, mg/L	<1000	1000 – 2999	3000-4999	5000-6999	7000-10000
Sulfates, mg/L	<500	500-1500	1500-3000	3000-4000	>4000
Nitrate nitrogen, mg/L	<100	--	--	100 – 300	>300
Iron, mg/L	--	--	--	--	0.3
Hardness (Ca, Mg), mg/L	--	--	--	500	--
Copper, mg/L	--	--	--	--	1.0

[1]Adapted from: Runyan et al. (2009) NMSU Extension Guide M-112; Swistock, B., Penn State Water facts 12; German et al. (2008) SDSU Extension Guide C 274.

Table 2. Approximate total daily water intake of beef cattle

Weight, lb	40°F Gallons	50°F Gallons	60°F Gallons	70°F Gallons	80°F Gallons	90°F Gallons
Growing Heifers, Steers, Bulls						
400	4.0	4.3	5.0	5.8	6.7	9.5
600	5.3	5.8	6.6	7.8	8.9	12.7
800	6.3	6.8	7.9	9.2	10.6	15.0
Finishing						
600	6.0	6.5	7.4	8.7	10.0	14.3
800	7.3	7.9	9.1	10.7	12.3	17.4
1000	8.7	9.4	10.8	12.6	14.5	20.6
Wintering Cows						
900	6.7	7.2	8.3	9.7	--	--
1100	6.0	6.5	7.4	8.7	--	--
Lactating cows						
900	11.4	12.6	14.5	16.9	17.9	18.2
Bulls						
1400	8.0	8.6	9.9	11.7	13.4	19.0
1600	8.7	9.4	10.8	12.6	14.5	20.6

[1]Winchester and Morris, 1956 as published in the NRC (2000).

In table 2, recommended water intake varies depending on temperature. Water intake can further vary depending on dry matter intake and salt consumption. A more specific calculation to predict water intake was developed by Hicks et al. (1988):

$$Water\ intake\ \ L/day = -18.7 + (0.3937\ x\ MT) + (2.432\ x\ DMI) - (3.87\ x\ PP) - (4.4437\ x\ DS)$$

*Where **MT** = Maximum daily temperature, F; **DMI** = Dry matter intake, lbs.;*
***PP** = Precipitation, cm/day; and **DS** = % dietary salt*

Increased prevalence of mineral antagonisms can appear during drought. Water sulfur concentrations can increase during drought, which can cause copper antagonisms. Likewise, high iron can also antagonize copper and zinc absorption and high calcium can antagonize selenium. These antagonisms can result in not only reduced growth performance but also decreased pregnancy rates and increased morbidity. Therefore, water quality should be measured on a yearly basis and perhaps more frequently during drought conditions. From this analysis, a producer can determine total intake (water and feed) of certain minerals (e.g. sulfur) that may necessitate changes in mineral and supplementation programs. The development of a clear picture of what forages and water provide the animal will allow for efficient use of feedstuffs that can augment any deficiencies or excesses that occur in the basal diet.

Crude protein

Protein is often considered the first limiting nutrient in forage-based cattle production systems (Wallace, 1987). Forage CP deficiency generally manifests itself during the dormant season and prolonged drought conditions (> 60 days). Figure 1 illustrates that forages can provide adequate levels of CP to meet the needs of beef cattle most of the time. However, this is highly dependent on adequate precipitation and time of the year. In the case where forage CP is deficient and quantity is inadequate, supplementation is required.

Devising a protein supplement can be very complex and expensive. In ruminants, protein is not all the same. Depending on the source, supplements can be highly or lowly degraded by the ruminal microbial population. Several terms have been developed over the years to describe these and are either know as degradable intake protein (DIP) or ruminally degradable protein (RDP). These two terms can be used interchangeably as they refer to the same thing; protein that is broken down by the ruminal microbes. Good sources of this type of protein are urea, soybean meal, alfalfa, canola meal, and corn gluten feed. These are all feedstuffs that are high CP, of which, greater than 60% is readily utilized by ruminal microbes. Although at first glance it may seem that this is a waste because it only serves the bacteria. That is just not the case, as the bacteria require protein (and ammonia) to produce amino acids, which are the building blocks of enzymes used to carry out fermentation. Therefore, it is absolutely critical that nutritionists do all they can to meet the needs of the bacteria. In addition, as the rumen contracts in an effort to move nutrients down the gastrointestinal tract, bacterial naturally flow with the digesta. This ultimately supplies the animal with upwards of 60% of their daily protein supply to the small intestine. To say that another way, in the course of a 24-hour period, 60% of the cows daily protein supply to the small intestine comes from ruminal bacteria.

As stated previously, frequent sampling of forages provides information regarding protein and energy content, which combined with nutrient requirements of cows and heifers provides the information needed to balance the diet. Unfortunately, most forage analysis does not provide a value for RDP. However, we know that once forage CP drops below 7%, supplemental CP is warranted (Mathis et al., 2000). Supplemental urea is an excellent source of RDP (Köster et al., 1996), however, when forage CP is below 4%, RDP from natural sources appears to be more beneficial (Kropp et al., 1977) due in part to the provision of branched chained amino acids (Köster et al., 1997), which are needed cellulolytic enzyme production (Moharrey, 2004). Mathis et al. (2000) fed increasing levels of high RDP supplements and found that as forage quality declined, supplemental RDP increased forage intake by increasing ruminal OM digestibility. Therefore, as we provide additional CP to cattle consuming low-quality forages we are able to increase the "energy" value of the forage.

The second portion of dietary CP is known as undegradable intake protein (UIP) or ruminally undegradable protein (RUP) which are commonly known as "by-pass" protein. This portion of protein is not broken down by ruminal bacteria but is available in the small intestine. Therefore, the daily protein supply of the ruminant animal is made up of ruminal bacteria and RUP. The combination of these two sources, adjusted for absorption in the small intestine, is known as metabolizable protein (MP). The NRC (2000) reports requirements for MP for beef cattle depending on stage of production. Therefore, ruminant nutritionists must balance rations for two organisms; the ruminal microbes and the cow. Supplemental RUP not only provides amino acids needed for bodily function, they can also provide additional energy as many of the amino acids found in the diet can serve as glucose precursors. This has been demonstrated by an increase in serum insulin when RUP was fed (Wiley et al., 1991).

In regards to improving reproductive success in times of nutritional stress one must decide which type of protein to feed. Most nutritionists simply seek to balance CP requirements for cattle. However, with knowledge of the various types of CP in ruminants, Patterson et al. (2003) sought to investigate the benefit of balancing pregnant heifer diets for MP. In this experiment, supplements were fed from mid-September to late February and found that balancing diets for MP rather than CP increased pregnancy rates (91 vs. 86%, respectively). There are reports Supplementing high levels of protein in the presence of inadequate energy may have harmful effects on reproduction in dairy cattle (Elrod and Butler, 1993; Elrod et al., 1993). This is likely not a concern for beef cattle, as the diets that caused reproductive issues were above 18% CP. Kane et al. (2004) reported that supplemental RUP can increase pituitary expression of FSH as well as increased insulin-like growth factor binding proteins, which may positively influence reproduction in beef heifers. Level of RUP can increase reproductive success. Mulliniks et al. (2013) fed supplements containing 36 or 50% RUP and found that pregnancy rates increased from 67 to 80% after a 45 d breeding season. Likewise, Sletmoen-Olson et al. (2000) fed increasing levels of RUP with equal amounts of RDP across treatments and found that low-quality forage intake decreased with level of RUP in the supplement without a negative impact on cow performance when supplements were offered during late gestation through early lactation. Alderton et al. (2000) fed primiparous beef cows starting 3 d postpartum one of three dietary supplements that were balanced to provide additional RDP, RDP + RUP or RUP until 60 d postpartum. A blend of RDP and RUP was advantageous for reducing body condition score loss during the postpartum period compared to RDP or RUP alone. This, however, did not translate to an improvement in postpartum interval or pregnancy rates.

Overall, meeting the RDP needs of the ruminal bacteria is critical for optimal fermentation of forages. Lardy et al. (1999) determined that RDP was the first limiting nutrient on fall winter range for cows that calved in the summer. Therefore, supplemental RDP ensures that adequate microbial protein reaches the small intestine but excessive amounts may hinder reproductive success. Although it would appear that supplements that contain above 30% RUP have beneficial effects on heifer and cow reproductive performance, a definitive level of RUP has not been established to date due to equivocal responses observed in the published literature. Nonetheless, it remains that RUP is beneficial to the animal in regards to improving growth performance and in some cases reproduction.

Energy

It is often said that in rangeland bound production systems all the energy cattle need is present in the forage. However, that energy is not always readily available to the ruminal bacteria. In most cases, supplemental CP, as described earlier, can provide the additional nutrients needed by the microbes to harvest this energy. There is a vast amount of literature that describes the importance of energy on reproduction therefore, the focus of this discussion will be on the challenges faced with meeting energy demands when cattle consume low-quality forages.

In New Mexico, multiple year droughts have reduced the energy content (TDN) of forages to 40% or below. It has been our observation that supplemental CP fed to meet protein needs is still inadequate to provide ample energy. Again, this supports the need for forage sampling and proper supplement balance. Like protein, energy can come in various forms. The three main forms in the context of ruminants is nonstructural carbohydrates (NSC), structural carbohydrates (SC), and fat. Examples of NSC are cereal grains such as corn, wheat, sorghum, barley, and oats. Structural carbohydrates are from co-products such as soyhulls, wheat middlings, distiller's grains and beet pulp and can include high quality hay (e.g. alfalfa). Fats can be in the form of tallow, oilseeds, or vegetable oil.

In a drought situation, adequate forage availability is key to maintaining animal units. Therefore, it would seem advantageous to utilize an energy source that will reduce forage intake without having detrimental effects on animal performance. Supplemental NSC will generally replace a portion of forage. However, there is inherent risk in providing these in a pasture supplementation scenario. This is due to the fact that over consumption can lead to acidosis or bloat and reduced forage utilization. However, proper feed management can overcome this issue.

Specifically, feeding every day can lessen the amount delivered disallowing aggressive eaters from over consumption. In the case when supplementation occurs infrequently (e.g. three days a week), addition of white salt to the diet to limit intake can be a useful tool. To calculate how much salt should be added to a supplement to limit to a specified intake the following equation can be used:

$$\%\ salt\ needed\ in\ supplement = \frac{(BW\ x\ 0.001)}{((BW\ x\ 0.001) + Desired\ intake)}$$

*Where **BW** = body weight; **Desired intake** = how much supplement is required*

If salt is going to be used for an intake limiter, it is critical that ample water is available as cattle will increase intake. Likewise, if TDS concentration is high in water caution should be exercised (for more info see Berger and Rasby, 2011). Processing of cereal grains can an important consideration for cattle on pasture or fed roughages. Cost associated with processing may be avoided in forage situations as extensive mastication and rumination with roughage diets will increase break up of grains. However, processing prior to feeding can increase utilization of these grains.

Supplemental corn at 0.2% BW has been shown to increase forage intake yet at 0.4 and 0.6% of body weight (BW) forage intake was decreased (Pordomingo et al., 1991). In agreement, Chase and Hibberd (1987) fed increasing amounts of corn to steers consuming low quality hay and found that digestibility increased at 0.1% BW but declined up to 0.7% BW. Therefore, at 0.2% BW, forage intake and overall energy status can be improved in cattle consuming low quality forage, however, above 0.5% BW forage intake declines and energy status may not be improved.

In the case where pasture availability is limited and roughage prices are high, placing females in a dry-lot has its advantages. Loerch (1996) limit-fed beef cows and heifers a corn-based supplement plus hay to provide similar energy intake as ad libitum hay alone and found that feed costs could be reduced by 50% and pregnancy rates could be improved. This was investigated further by providing fat as an additional energy source (Small et al., 2004). Although there were no differences in animal performance, passive transfer of immunoglobulins was greater for fat supplemented cows. Therefore, the careful use of grains as an alternative source of energy when pastures are limited in quantity or when hay is expensive is a viable option to survive a drought.

Supplemental SC provides highly digestible fiber that lessens the risk of digestive upsets. Structural carbohydrates are often the energy substrate of choice in manufactured feeds due to the structure of the carbohydrate which can have less negative impacts on the rumen environment compared to NSC. These supplements generally stimulate forage intake and overall energy status (Chan et al., 1991). Simply supplying supplemental alfalfa to grazing animals can improve performance. Vanzant and Cochran (1994) offered 0.48, 0.72, and 0.96% BW to cows (in last trimester) and steers consuming dormant, tallgrass-prairie forage (2.1% CP and 50.7% ADF). As expected, alfalfa hay slightly decreased forage intake but increased total dietary intake up to 0.7% BW, after which no differences in total intake were observed. In this study, provision of alfalfa at 0.72 % BW or more increased conception rates during the first 20 d of the breeding season by 35% (61 vs 86%) but did not change total pregnancy rates. This improvement was due to the greater energy balance going into calving as demonstrated by lower body condition score losses during late gestation and early lactation.

Sources of SC from co-products (e.g. wheat middlings, soyhulls, or beet pulp) are desirable feedstuffs as they have moderate levels of protein and are high in energy. Therefore, they can be an effective supplement for cows consuming low-quality forages. Cox et al. (1989) reported that prepartum cow BW gain improved as wheat middlings increased in the supplement. Marston et al. (1995) offered supplements that varied in mixture of soybean meal and soybean hulls to spring calving cows either pre or postpartum when consuming prairie grass hay (4.5% CP). Conception rates were greater in cows fed supplements with more soybean hulls (energy) before calving over that of protein supplements (90 vs 80%, respectively). Supplements were formulated and fed at a level to provide equal amounts of protein per day. Pre-partum supplementation had a greater impact on reproduction that postpartum supplementation.

Engel et al. (2008) sought to compare the effects of dried distiller's grains plus solubles (DDGS) with soybean hulls on cow reproductive performance. Although DDGS has highly digestible fiber, it is also high in CP that contains a large proportion of RUP and contains 10% fat. Therefore, it is not surprising that the DDGS were superior to soybean hulls in this comparison. As discussed earlier RUP has beneficial effects on reproduction, moreover, fat also has been shown to have beneficial impacts on reproduction in certain scenarios (see review by Funston, 2004; Hess et al., 2008). The use of fats in drought situations can be beneficial. Fat can decrease overall dietary intake, which could be used to reduce pressure on forage reserves during drought. Fat should not be provided in a forage-based diets at levels greater than 3% added fat to obtain the greatest response (Hess et al., 2008). In most cases forages contain between 0.5 to 3% fat.

Scholljegerdes and Kronberg (2008) fed 1.82 kg of whole flaxseed (26.5% total fatty acids, DM basis) to cattle consuming native grass hay (9.6% CP and 77.6% NDF, DM basis), which equated to 7% dietary fat and reported not deleterious impact on ruminal digestibility of fiber or protein. Authors reported a substitution rate of 1 kg of flaxseed replaced 0.65 kg of forage. This would suggest that oilseeds, such as flaxseed, soybeans, canola, or whole cottonseed could be used to provide energy to ruminants. Scholljegerdes et al. (2014) offered whole soybeans or whole flaxseed to beef cows grazing summer native range (6% CP and 69% NDF, DM basis) during the breeding season. Although reproductive performance did not differ due in part to relatively low number of animals per treatment, growth performance was 0.83 and 1.10 kg/d for soybean and flaxseed fed cows, respectively. In cases where drought has lowered the quality of forage, supplemental fat can be an attractive way to increase energy density of the diet. The fact that fat is 2.25 times higher in energy than carbohydrates is advantageous to the producer because less feed must be delivered to provide comparable energy to carbohydrates. Likewise, most oilseeds contain greater than 25% CP, which provides additional benefits, however they can be expensive.

Overall, energy supplementation is an important consideration when it comes to drought management. Energy balance going into calving or up to breeding can have a profound impact on reproductive success. Although protein supplementation can liberate more energy from drought stricken forages (see discussion above), during extensive drought supplemental energy is often needed and must be considered as part of a drought supplementation strategy.

Minerals

Mineral concentrations in drought stricken forages are likely to cause a mineral and vitamin deficiency in the basal diet. Although this has direct effects on cows and heifers, it can also have an impact on the calf and has been shown to reduce a calf's ability to respond to vaccination (Bagley et al., 2003). This information suggests that although offspring may seem to be well-fed, it is possible that acute nutritional deficiencies experienced during gestation or as neonates may negatively impact the offspring's ability to mount an immune response later in life.

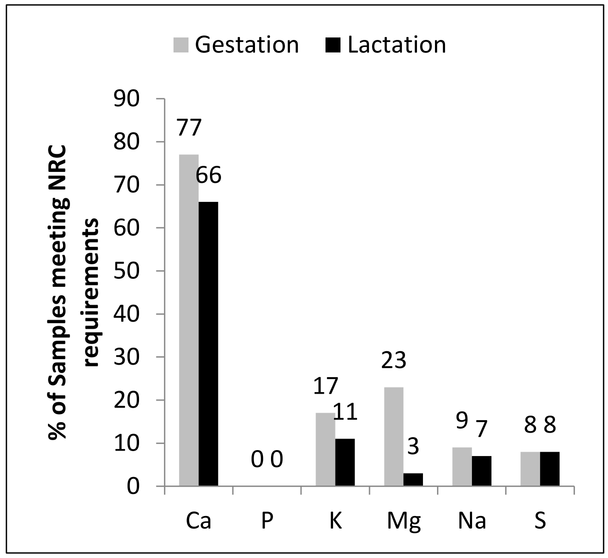

Figure 2. Percentage of samples collected in 2001 and 2002 that meet the NRC macromineral requirements for a gestating and lactating beef cow across the state of New Mexico. (Adapted from Mathis and Sawyer, 2004)

Minerals hold a paramount role in bodily function. In particular, the immune system relies on specific minerals to maintain proper function. Proper mineral nutrition at the ranch can have long-lasting impact on reproductive success of the cow and her ability to raise a calf each year.

In order to accurately assess what minerals are needed, one must assess the basal value of the forage to be grazed. Mathis and Sawyer (2004) conducted forage mineral survey across New Mexico from various regions of the state during the fall (mid-October through mid-December) and late winter (February through early March) of 2001 and 2002. Samples were analyzed for calcium, phosphorus, magnesium, potassium, sodium, sulfur, aluminum, cobalt, copper, iron, manganese, molybdenum, selenium, and zinc. These times were selected to represent samples at the end of the growing season and around the time of complete dormancy. In Figure 2, we observe that the overall state average macromineral concentration in forages rarely meets the National Research Council (NRC, 2000) recommended mineral levels for gestating and lactating beef cows. In other words, only 77% of the samples collected by Mathis and Sawyer (2004) had a calcium concentration great enough to meet the cow's requirements provided she was able to eat recommended levels of forage. None of the samples collected were able to meet the phosphorus requirements. This of course is not surprising to most cattlemen, as phosphorus is often our first mineral deficiency observed in dormant native pasture. The authors did point out that the phosphorus content of fall forage was much greater than that of winter. In Figure 3, Iron and Cobalt were adequate the majority of the time, with copper, selenium, and zinc being deficient close to 50% of the time. Interestingly, iron was extremely high in a large number of samples. The authors point out that 32% of the samples collected were at a value high enough to cause a copper deficiency due to the antagonistic influence iron can have with copper when the ratio of iron:copper ratio is greater than 100:1. This high level of iron may also decrease zinc absorption. This brings up a very important point in that considerable variation existed across the state and timely forage analysis is warranted in order to accurately develop a mineral program that fits the needs of the cattle.

Apart from forages, water mineral content can have a tremendous impact on mineral status of livestock. The water quality in New Mexico can negatively influence the animal's ability to utilize certain minerals. These are called "antagonisms" and they can have profound effects on animal performance. The most noteworthy antagonism resulting from water in New Mexico is sulfur and copper. With the recent drought, sulfur content of well water has likely increased as wells are not being diluted with rainfall recharge. If total dietary sulfur intake, which includes feed and water, reaches upwards of 0.2 - 0.3% of total dietary intake, copper availability is reduced (Underwood and Suttle, 1999). Likewise, water hardness and calcium levels are often very high in many of the wells throughout New Mexico. Therefore, testing of water and forages will provide an accurate picture of what the beef cow and her calf consumes and deficiencies can be overcome with mineral supplementation.

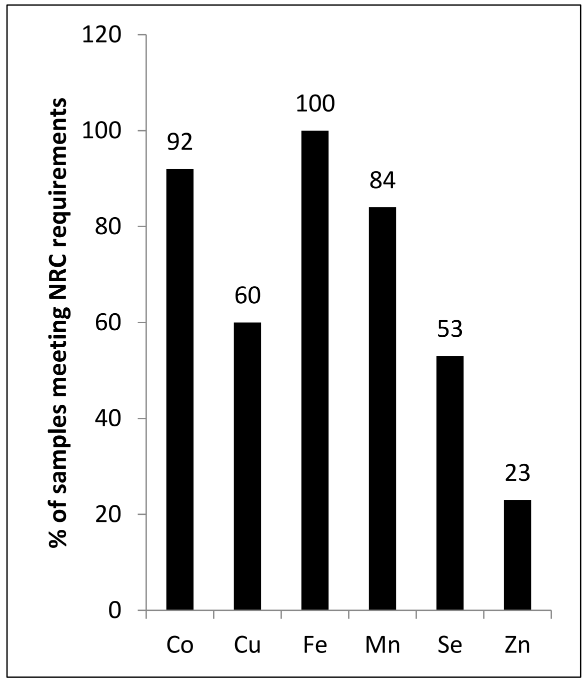

Figure 3. Percentage of samples collected in 2001 and 2002 that meet the NRC micromineral requirements for a gestating and lactating beef cow across the state of New Mexico. Adapted from Mathis and Sawyer, 2004

The following responses to mineral supplementation are by no means all-inclusive and many if not all the focus is on the microminerals, in particular copper and zinc. This is not to suggest that the others are of little importance but simply reflects the focus of recent research in this area. The need for proper balance for the macrominerals, calcium, phosphorus, magnesium, and potassium seems to be well accepted in the ranching community, therefore, this section will focus on recent finding regarding growth, health, and reproduction in cattle supplemented microminerals.

Proper mineral intake is critical for adequate immune system function and energy and protein metabolism. This is particularly true for young nursing calves. However, we often take for granted that the cow is going to provide the calf what it needs to grow properly. Because, it is difficult to determine actual calf mineral intake, data do exist that suggest that calves nursing cow's supplemented mineral can exhibit improved growth performance. Specifically, Stanton et al. (2000) reported that calves nursing dams offered a high level of organic trace minerals gained more body weight from birth to weaning than calves nursing dams consuming low and high levels of inorganic minerals. Ahola et al. (2004) reported that kilograms of calf weaned per cow exposed were greater for cows supplemented inorganic versus organic minerals but overall performance did not differ based on source of mineral supplementation. This variation between experiments is not uncommon in the mineral research arena, but the take home point would be that adequate mineral supplementation is warranted considering the improvement in nursing calf performance.
Although high levels of supplemental micro minerals rarely exhibit an improvement in cow body weight gain, improvement in reproductive success is most often reported. Total luteinizing hormone (LH) release after gonadotropin releasing hormone administration was greater for heifers receiving Cu supplementation (Ahola et al., 2005), which is of great benefit to reproductive success

in heifers and cows. This can be supported by the research that has shown that supplemental minerals can improve reproductive performance. Specifically, Stanton et al. (2000) reported that cows conceiving to artificial insemination were improved by 15% when offered a high level of organic minerals compared to low and high levels of inorganic minerals; however, overall pregnancy did not differ across treatments. This agrees with Ahola et al. (2004) who reported cows fed organic versus inorganic mineral sources had 15% greater conception rates to artificial insemination, yet overall pregnancy rates were not different across mineral source but were numerically higher (5%) compared to controls fed marginal levels of minerals. It should be pointed out that the organic sources of minerals are more biologically available than inorganic sources, so many of these responses could likely be achieved if inorganic sources were provided at a higher level.

Although the published experiments reported above appear to draw a strong conclusion towards the advantages of mineral supplementation, the relative treatment differences (control treatments versus mineral treatments) can, in some cases, be small. In many instances, the experiments were designed to observe differences between animals that were deficient and those that were well fed. However, in experiments where differences were not observed the controls were in adequate mineral status.

The high cost of mineral and variation in intake often causes concern to livestock producers. If one were to assess the total cost of mineral supplementation based on an average cost of mineral being $880/ton with an intake of 3 oz per head per day (0.19 lbs/hd/d) this would come out to be $0.08/hd/d ($880/ton = $0.44/lb; $0.44 * 0.19 lbs of intake/hd/d = $0.08/hd/d) or $30.51 per year per cow. For the rancher to justify this added cost, one can consider any of the above improvements in performance (calf growth, reproduction, immune function). For example, let's start with calf weaning weight. Stanton et al. (2000) reported that calves nursing dam's supplemented organic minerals had an 11 lb weaning weight advantage (460 versus 471 lbs). If that calf were sold at weaning with a current market price being $2.15/lb that additional weight would garner an additional $23.65, which is close to covering the cost of supplementing the cow for the year, now combine that with the improvement in conception to artificial insemination, which would mean that those calves would be born earlier in the season as compared to those bred naturally and would wean at a higher body weight. Specifically, the calves born earlier in the season would only have to wean 3.1 lbs heavier than later born calves to cover the cost of the mineral program for the year.

The high cost of mineral can be a scary purchase but considering all the benefits it seems that year-round mineral supplementation is relatively cheap insurance.

Prepartum nutrition

Use of body condition scoring (BCS) is a useful tool for assessing the nutrient status of your cow herd. In beef cattle, BCS is commonly on a 9-point scale and ascribes a number depending on body fatness and muscling (Wagner et al., 1988). This becomes a valuable tool as one begins to consider the need for more or less concern about animal condition going into key production periods. In a spring calving system, assessing BCS at the beginning of the third trimmester is a very useful time to collect this data. At the beginning of the third trimester or 90 days prepartum provides ample time to change nutrition programs to increase cow condition. The NRC (2000) states that a body condition is worth approximately 80 to 120 lbs depending on mature size of your cow herd. For example, in a 90 d period, to increase one BCS, smaller sized cattle would need to gain 0.88 lb/day and larger cattle would need to gain 1.3 lb/day. Although possible, it may be difficult and expensive to expect this much gain on a pregnant cow consuming drought stricken pastures. DeRouen et al. (1994) assessed BCS on 476 pregnant heifers prior to calving (90d prepartum). Heifers were classified to have a BCS of 4 to 7 then were randomly assigned to one of three diets formulated to provide low, recommended, or high energy levels (based on TDN requirements; NRC 2000) until calving within each BCS. Afterwards, all cows and calves were managed the same until weaning. Body weight and BCS changes were monitored throughout. After conclusion of the study, authors classified the animals based on BCS loss or gain. Specifically, animals were classified as decreasing, maintaining, or increasing BCS. There were no differences amongst these classifications for pregnancy rate with an average of 78.4%. However, when they analyzed pregnancy rates within BCS they reported lower rates when losing weight. Body condition score 4 and 5 cows did not differ (64.9 and 71.4%, respectively) and BCS 5 and 6 did not differ (87.0 and 90.7%, respectively). Practically speaking, these lack of differences suggests that pushing cows from a 4 to a 5 may not matter but going from a 5 to 6 or 7 would be beneficial in first calf heifers. Similar work out of Louisiana by Richards et al. (1986) in older cows, shows less of a difference when cows BCS varies provided they are fed to meet or exceed requirements. It is important to note, that absolute BCS is likely not the reason for beneficial response, rather it is the growth trajectory. Work from New Mexico (Mulliniks et al., 2012) demonstrated that the pregnancy rates for the cow herd at Corona Range and Livestock Research Center varied little when cows calved at either a BCS 4, 5, or 6. In particular, pregnancy % for BCS 4, 5, and 6 were 92, 91, and 90%, respectively. Probably more telling is the fact that the days to first postpartum ovulation also did not differ for the three BCS classifications (84, 82, and 80 d, respectively). In other words, the lower prepartum BCS did not necessarily increase postpartum interval.

The use of supplements to provide animals with a positive plane of nutrition prior to calving appears to the have the most significant impact on subsequent pregnancy success. Assuring cattle calve in a reasonable BCS is likely the best management strategy.

Postpartum nutrition

Nutritional management of beef females during pregnancy is absolutely critical in order to achieve a yearly calving interval. Granted, it is often thought that nutrition going into breeding is the key driver to maintain this interval. Yet, the challenges of improving nutritional status of beef females, postpartum, is often very difficult. This is particularly true in the desert Southwest as forage quality often does not start to improve until after the breeding season starts. This is especially true during times of drought. In general, cattle will lose BW and BCS after calving due to the initiation of lactation and the associated increased energy demands. The challenge for beef producers is to plan for this inevitable weight loss. In general, postpartum BW nadir (point where cows switch from losing weight to gaining weight after calving) in New Mexico cows is around 53 d. This BW loss can extend the time of resumption of estrus. However, this can be mitigated through proper supplementation. Perry et al. (1991) reported that cows fed varying energy levels during the pre- and postpartum periods. Specifically, cows were either fed a high (150% of NRC; H) or low (70% of NRC; L) level of energy in a factorial design (L-L, H-L, L-H, H-H). Cows fed the H in the postpartum period had greater LH pulse frequency and amplitude than those fed L.

This is not particularly surprising, but if you look further into this study, they actually showed that cows fed the high treatment during the prepartum period and then switched to the low during the postpartum period, they had a similar response for LH pulse amplitude and pulse frequency was intermediate to cows fed the high level energy throughout. Cows fed the high level during the prepartum period irrespective of postpartum treatment had a shorter interval to ovulation than the other treatments and cows fed the low treatment throughout failed to ovulate during the study. Heifers entering the calving season in a BCS of 4 had a shorter postpartum interval if they could increase BCS by 1 unit (Lalman et al., 1997). It was reported that a 1.8-unit change was maximal for shortening postpartum interval, but the difference between 1.0 and 1.8 unit change was negligible.

During a drought, it may be very costly to significantly increase body weight and condition, however, it appears that ensuring cattle are on a positive plane of nutrition will ensure the best opportunity for a successful breeding season.

New Mexico Case Study

In most of the literature regarding supplementation, it is difficult to pinpoint the ideal program for drought management. This is due to the fact that droughts are not consistent. The overall goal of drought management is maintaining animal units and ensuring proper nutrition throughout the year. It has been shown that any nutritional perturbation during gestation can have long-term impacts on offspring performance (Funston et al., 2010). As an example, at the NMSU Corona Range and Livestock Research Center our supplementation programs are minimalistic. We seek to keep feed costs low by supplying maintenance requirements and allow body condition to slip during certain times knowing that we could gain it back in other times of the year. This often came at the cost of pregnancy rates (high 80s to low 90s), but economically we made it pencil out. However, during the drought of 2010-2013 we observed that previous supplementation programs were not working based on much lower pregnancy rates (averaged 70%). We also observed that during the drought we had certain groups of cows (grouped by year of birth) that did not fare as well as others when forage quality was very poor, yet when forage quality was adequate there seemed to be little difference between groups. As time progressed and forage quality declined, we see this same group of females, now older, have lower pregnancy rates. We are currently analyzing historical ranch data to see if the year in which these females were gestated was a drought year. The hypothesis is that the age groups that do not seem to be able to cope with poor forage quality were likely gestated during times of drought and therefore had improper fetal development.

With that in mind, we had to revisit our nutrition program and incorporate unique feedstuffs that had not been utilized on the ranch before. Due to the extensive nature of the ranch we could not simply feed more supplement as labor and equipment maintenance become cost prohibitive. Therefore, we sought supplements that contained more energy in the form of fat. At that time, manufacture feeds were in the \$450/ton and above and high quality alfalfa hay was priced at \$350/ton delivered to the ranch so we simply could not afford to feed those supplements. Therefore, we investigated the use of DDGS, which is not widely used in New Mexico because we could purchase DDGS and have it delivered to the ranch for \$100 less per ton than a comparable manufactured supplement.

This seems like a "no brainer" but DDGS has a high concentration of sulfur (S) and we have high S water (SO_4 = 2080 mg/L). Therefore, we had to be very cautious as to how much DDGS we could feed. The NRC (2000) indicates that 0.41% S is the maximal tolerable level that can be provided a beef cow before health problems start to manifest. Therefore, we had to test each load of DDGS for S content and adjust the amount fed to stay below this level. In addition, water sampling became a regular part of our nutrition program because we had to include water S content in our nutrition program. With these constraints, we were able to economically feed DDGS and improved our pregnancy rates up to the low 90s. We also included DDGS in the heifer development programs. We sought to increase growth performance in these heifers up to breeding using programmed feeding (high level of growth followed by moderate or vice versa). It appears that as long as we can achieve a minimum of 53% of mature BW by breeding our heifer conception rates to timed artificial insemination are 60% and total pregnancy rates are 90%, irrespective of timing of growth.

From our experiences in New Mexico it seems that in order to survive drought one must be vigilant in monitoring nutrient supply (forage and water) and be willing to change management and nutrition programs. We monitor our water and rangeland and reformulate mineral supplements every year. We seek alternatives for heifer development, which include irrigated annual forages native pasture with supplement and in worst case scenario, drylots. Mulliniks et al. (2013) demonstrated that heifers developed on New Mexico dormant rangeland with supplemental RUP had greater in-herd retention rate than those developed in a drylot. In the past year, we have received some rain and grew some grass, however, we were not optimistic that we were out of the drought, so we brought in some yearling heifers to graze extra grass and bred them and sold as bred heifers, which was very profitable. However, we do not make any decision without placing pencil to paper first to ensure it makes economic sense and has no long-term ramifications.

Conclusions

A lot of discussion has been put forth on energy, protein, and mineral supplementation. However, little has been provided regarding specific facts on what works best in a drought situation. Furthermore, no specific examples have been given in regards to how to ensure proper development of heifers. The reason behind this is because there is no one way that works better than another. Cattle prices are at a level that feeding through a drought is a viable financial option. Therefore, one needs to assess the following to determine the best plan. If forage quality is below 7% CP, supplemental RDP is needed to gain more energy out of the forage. If forage energy values are below 45% TDN, additional energy may be needed in the form of non-structural or structural carbohydrates. Addition of structural carbohydrates at 0.2% BW can increase forage utilization and up to 0.4% will reduce forage intake but caloric intake should be sufficient to meet performance needs. Structural carbohydrates will stimulate forage intake, which means cattle will perform at a higher level but consume more forage. Supplements containing high levels of fat can be beneficial for growth in young heifers and in the prepartum period for cows. Growth rates do not need to be extreme as long as we attain an adequate % of BW. Mineral content of forages and water need to be monitored such that the use of co-products can be done safely and mineral formulations can change to account for any deficiencies. Drought is an unfortunate event that sadly puts a lot of producers out of business, but being proactive in range and nutritional management will ensure survival.

References

Ahola, J. K., D. S. Baker, P. D. Burns, R. G. Mortimer, R. M. Enns, J. C. Whittier, T. W. Geary, and T. E. Engle. 2004. Effect of copper, zinc, and manganese supplementation and source on reproduction, mineral status, and performance in grazing beef cattle over a two-year period. J. Anim. Sci. 82:2375-2383.

Ahola, J. K., T. E. Engle, and P. D. Burns. 2005. Effect of copper status, supplementation, and source on pituitary responsiveness to exogenous gonadotropin-releasing hormone in ovariectomized beef cows. J. Anim. Sci. 83:1812-1823.

Alderton, B. W., D. L. Hixon, B. W. Hess, L. F. Woodward, D. M. Hallford, and G. E. Moss. 2000. Effects of supplemental protein type on productivity of primiparous beef cows. J. Anim. Sci. 78:3027-3035.

Bagley, C. V., H. R. Bingham, and J. O. Hall. 2003. The association between serum mineral and vitamin A and E concentrations and respiratory disease in beef calves entering backgrounding lots. Bov. Pract. 37:68-73.

Barker, D. J., and J. R. Caradus. 2001. Adaptation of forage species to drought. XIX Proc. International Grassl. Congr. Sao Paulo, Brazil.

Berger, A. L., and R. J. Rasby. 2011. Limiting feed intake with salt in beef cattle diets. NebGuide G2046, Univ. Nebraska Extension, http://ianrpubs.unl.edu/live/g2046/build/g2046.pdf .

Chase, C. C., and C. A. Hibberd. 1987. Utilization of low-quality native grass hay by beef cows fed increasing quantities of corn grain. J. Anim. Sci. 65:557-566.

Cox, D. A., K. H. Ovenell, K. S. Lusby, and R. P. Wettemann. 1989. Wheat middlings versus soybean meal and two wheat middlings/soybean meal supplements for wintering spring calving beef cows. In: Oklahoma Agric. Exp. Sta. MP-127. Oklahoma State University, Stillwater. p. 41-45.

DeRouen, S. M., D. E. Franke, D. G. Morrison, W. E. Wyatt, D. F. Coombs, T. W. White, P. E. Humes, and B. B. Green. 1994. Prepartum body condition and weight influences on reproductive performance of first-calf beef cows. J. Anim. Sci. 72:1119-1125.

Elrod, C. C., and W. R. Butler. 1993. Reduction of fertility and alteration of uterine pH in heifers fed excess ruminally degradable protein. J. Anim. Sci. 71:694-701.

Elrod, C. C. M. Van Amburgh, and W. R. Butler. 1993. Alterations of pH in response to increased dietary protein in cattle are unique to the uterus. J. Anim. Sci. 71:702-706.

Engel, C. L., H. H. Patterson, and G. A. Perry. 2008. Effect of dried corn distiller's grains plus solubles compared with soybean hulls, in late gestation heifer dies on animal and reproductive performance. J. Anim. Sci. 86:1697-1708.

Flexas, J., and H. Medrano. 2002. Drought-inhibition of photosynthesis in C3 plants: Stomatal and non-stomatal limitations revisited. Annals Botany 89:183-189.

Funston, R. N. 2004. Fat supplementation and reproduction in beef females. J. Anim. Sci. 82(E. Suppl.):E154-E161.

Funston, R. N., D. M. Larson, K. A. Vonnahme. 2010. Effects of maternal nutrition on conceptus growth and offspring performance: Implication for beef cattle production. J. Anim. Sci. 88:E205-E215.

Hess, B. W., G. E. Moss, and D. C. Rule. 2008. A decade of developments in the area of fat supplementation research with beef cattle and sheep. J. Anim. Sci. (E. Suppl.):E188-E204.

Hicks, R. B., F. N. Owens, D. R. Gill, J. J. Martin, and C. A. Strasia. 1988. Water intake by feedlot steers. Okla. Anim. Sci. Rpt. Mp-125:208.

Julander, O. 1945. Drought resistance in range and pasture grasses. Plant Physiol. 20:573-599.

Kane, K. K., D. E. Hawkins, G. D. Pulsipher, D. J. Denniston, C. R. Krehbiel, M. G. Thomas, M. K. Petersen, D. M. Hallford, M. D. Remmenga, A. J. Roberts, and D. H. Keisler. 2004. Effect of increasing levels of undegraded intake protein on metabolic and endocrine factors in estrous cycling beef heifers. J. Anim. Sci. 82:283-291.

Köster, H. H., R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant, I. Abdelgadir, and G. St.-Jean. 1996. Effect of increasing degradable intake protein on intake and digestion of low-quality, tallgrass-prairie forage by beef cows. J. Anim. Sci. 74:2473-2481.

Köster, H. H., R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant, T. G. Nagaraja, K. K. Kreikemeier, and G. St. Jean. 1997. Effect of increasing proportion of supplemental nitrogen from urea on intake and utilization of low-quality, tallgrass0prairie forage by beef steers. J. Anim. Sci. 75:1393-1399.

Kropp, J. R., R. R. Johnson, J. R. Males, and F. N. Owens. 1977. Microbial protein synthesis with low quality roughage rations: Isonitrogenous substitution of urea for soybean meal. J. Anim. Sci. 46:837-843.

Lalman, D. L., D. H. Keisler, J. E. Williams, E. J. Scholljegerdes, and D. M. Mallett. 1997. Influence of postpartum weight and body condition change on duration of anestrus by undernourished suckled beef heifers. J. Anim. Sci. 75:2003-2008.

Lardy, G. P., D. C. Adams, T. J. Klopfenstein, and R. T. Clark. 1999. First limiting nutrient for summer calving cows grazing autumn-winter range. J. Range Manage. 52:317-326.

Loerch, S. C. 1996. Limit-feeding corn as an alternative to hay for gestating beef cows. J. Anim. Sci. 74:1211-1216.

Marston, T. T., K. S. Lusby, R. P. Wettemann, and H. T. Purvis. 1995. Effects of feeding energy or protein supplements before or after calving on performance of spring-calving cows grazing native range. J. Anim. Sci. 73:657-664.

Mathis, C. P., and J. E. Sawyer. 2004. New Mexico forage survey. Proc. West. Sec. Am. Soc. Anim. Sci. 55:182-184.

Mathis, C. P., R. C. Cochran, J. S. Heldt, B. C. Woods, I. E. O. Abdelgadir, K. C. Olson, E. C. Titgemeyer, and E. S. Vanzant. 2000. Effects of supplemental degradable intake protein on utilization of medium- to low-quality forages. J. Anim. Sci. 78:224-232.

Moharrey, A. 2004. Effect of isoacids on some rumen enzymes. J. Anim. Feed Sci. 13(Suppl. 1):159-162.

Mulliniks, J. T., S. H. Cox, M. E. Kemp, R. L. Endecott, R. C. Waterman, D. M. VanLeeuwen, and M. K. Petersen. 2012. Relationship between body condition score at calving and reproductive performance in young postpartum cows grazing native range. J. Anim. Sci. 90:2811-2817.

Mulliniks, J. T., D. E. Hawkins, K. K. Kane, S. H. Cox, L. A. Torell, E. J. Scholljegerdes, and M. K. Petersen. 2013. Metabolizable protein supply while grazing dormant winter forage during development alters pregnancy and subsequent in-herd retention rate. J. Anim. Sci. 91:1409-1416.

NRC. 2000. The nutrient requirements for beef cattle. 7th rev. ed. Natl. Acad. Press, Washington DC.

Patterson, H. H., D. C. Adams, T. J. Klopfenstein, R. T. Clark, and B. Teichert. 2003. Supplementation to meet metabolizable protein requirements of primiparous beef heifers: II. Pregnancy and economics. J. Anim. Sci. 81:563-570.

Perry, R. C., L. R. Corah, R. C. Cochran, W. E. Beal, J. S. Stevenson, J. E. Minton, D. D. Simms, and J. R. Brethour. 1991. Influence of dietary energy on follicular development, serum gonadotropins, and first postpartum ovulation in suckled beef cows. J. Anim. Sci. 69:3762-3773.

Pordomingo, A. J., J. D. Wallace, A. S. Freeman, and M. L. Galyean. 1991. Supplemental corn grain for steers grazing native rangeland during summer. J. Anim. Sci. 69:1678-1687.

FRichards, M. W., J. C. Spitzer, and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300-306.

Scholljegerdes, E. J. 2014. Role of mineral nutrition on performance of NM ranch calves. Proc. Southwest Beef Symposium. Clayton, NM.

Scholljegerdes, E. J., and S. L. Kronberg. 2008. Influence of level of supplemental whole flaxseed on forage intake and site and extent of digestion in beef heifers consuming native grass hay. J. Anim. Sci. 86:2310-2320.

Scholljegerdes, E. J., L. A. Lekatz, and K. A. Vonnahme. 2014. Effects of short-term oilseed supplementation on plasma fatty acid composition, progesterone and prostaglandin F metabolite in lactating beef cows. Animal. 8:777-785.

Sletmoen-Olson, K. E., J. S. Caton, K. C. Olson, and L. P. Reynolds. 2000. Undegraded intake protein supplementation: I. Effects of forage utilization and performance of periparturent beef cows fed low-quality hay. J. Anim. Sci. 78:449-455.

Small, W. T., S. I Paisley, B. W. Hess, S. L. Lake, E. J. Scholljegerdes, T. A. Reed, E. L. Belden, and S. Bartle. 2004. Supplemental fat in limit-fed, high grain prepartum diets of beef cows: Effects on cow weight gain, reproduction, and calf health, immunity, and performance. Proc. West. Sec. Am. Soc. Anim. Sci. 55:45-52.

Stanton, T. L., J. C Whittier, T. W. Geary, C. V. Kimberling, and A. B. Johnson. 2000. Effects of trace mineral supplementation on cow-calf performance, reproduction, and immune function. Prof. Anim. Sci. 16:121-127.

Thurow, T. L., and C. A. Taylor, Jr. 1999. Viewpoint: The role of drought in range management. J. Range Manage. 52:413-419.

Underwood, E. J., and N. F. Suttle. 1999. The mineral nutrition of livestock. 3rd rev. ed. CABI Publishing, New York.

Utley, P. R., N. W. Bradley, and J. A. Boling. 1970. Effect of restricting water intake on feed intake, nutrient digestibility and nitrogen metabolism in steers. J. Anim. Sci. 31:130-135.

Volaire, F., and H. Thomas. 1995. Effects of drought on water relations, mineral uptake, water-soluble carbohydrate accumulation and survival of two contrasting populations of Cocksfoot (Dactylis glomerata L.). Annals of Botany. 75:513-524.

Volaire, F., H. Thomas, and F. Lelievre. 1998. Survival and recovery of perennial forage grasses under prolonged Mediterranean drought I. Growth, death, water relations and solute content in herbage stubble. New Phytol. 140:439-449.

Vough, L.R., and G. C. Marten. 1971. Influence of soil moisture and ambient temperature on yield and quality of alfalfa forage. Agron. J. 63:40-42.

Wallace, J. D. 1987. Supplemental feeding options to improve livestock efficiency on rangelands. Achieving efficient use of rangeland resources. R. S. White and R. E Short, ed. Fort Keogh Research Symposium, Miles City MT.

Wagner, J. J., K. S. Lusby, J. W. Oltjen, J. Rakestraw, R. P Wettemann, and L. E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603-612.

Wiley, J. S., M. K. Petersen, R. P. Ansotegui, and R. A. Bellows. 1991. Production from first-calf beef heifers fed a maintenance or low level of prepartum nutrition and ruminally undegradable or degradable protein postpartum. J. Anim. Sci. 69:4279-4293.