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Livestock Management During Drought in the Northern Great Plains. II. Evaluation of Alternative Strategies for Cow-Calf Enterprises[1]

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ABSTRACT

The objective of this study was to evaluate alternative drought management strategies for their effects on beef cow-calf enterprise profitability based on early detection of drought. A bioeconomic model was parameterized to represent a range-based cow-calf production system in the Northern Great Plains. The base management system was characterized by inputs required to maintain herd size of approximately 511 cows during an average climatic year with a fixed forage base. Treatments were factorially arranged where management (early vs. normal), intensity of drought (moderate, 20% reduction in available forage vs. severe, 40% reduction in available forage), and forage quality [average CP (%), ME (Mcal/kg), and NDF (%) vs. drought-affected values] were evaluated for effects on system performance. Early management (EM) included detecting drought by July 15 and weaning calves at 90 d. Normal management (NM) responded to drought by providing nutritional supplements as needed to maintain animal performance. A second bioeconomic computer model was used to simulate drylot performance for early-weaned calves. Treatments were evaluated based on their effects on ranch gross margins (RGM; gross revenue – variable costs). For EM, RGM was calculated with and without the drylot component. During drought, RGM was reduced compared with the base system: EM at 26 and 57% and NM at 33 and 72% for moderate and severe drought, respectively. For all levels of drought and forage quality, EM had equal or higher RGM than NM. Directly feeding EM calves was generally more efficient than feeding NM cows to produce milk to maintain calf performance.

Key words: beef cattle, drought management, early weaning

INTRODUCTION

Drought is a recurring phenomenon in the Northern Great Plains affecting forage production (Reed and Peterson, 1961; Heitschmidt et al., 1999), forage quality (Sheaffer et al., 1992), and diet quality of grazing animals (Laude, 1953; Cook and Sims, 1975). Agricultural drought (Felch, 1978; Kulshreshtha, 1989; Smith and Foran, 1992; Thurow and Taylor, 1999) leads to plant stress, reduced forage production, decreased livestock performance, and reduced enterprise profitability. Negative effects of drought might be mitigated if beef managers could 1) predict agricultural drought in a timely manner, and 2) implement practical and economically viable management responses to drought.

In a companion paper, we described the potential of detecting emerging drought by July 1 (Kruse

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et al., 2007). Our intent was to predict forage production early in the growing season, which in turn would enable beef cow-calf managers to make proactive changes in management that could potentially forestall many of the negative effects of drought. The objective of this study was to evaluate the effects of early weaning and culling based on early detection of drought, intensity of drought, and forage quality on the profitability of eastern Montana cow-calf production systems.

MATERIALS AND METHODS

Our approach used 2 bioeconomic computer models to simulate changes in enterprise profitability of cow-calf production systems in response to different management scenarios during drought. The Montana State University (**MSU**) beef production system model (Tess and Kolstad, 2000a,b) was parameterized to represent a hypothetical cow-calf enterprise in the Northern Great Plains. The MSU model simulated cattle performance and ranch profit for each specified management scenario. The USDA-ARS US Meat Animal Research Center (**MARC**) model modified by Williams and Bennett (1995) was used to simulate a drylot scenario for early-weaned calves.

Base Management System

The base management system was characterized by inputs required to maintain a herd size of approximately 511 cows during an average climatic year as described by Tess (1999). Herd size was the number of cows exposed to breeding including 70 replacements. Table 1 presents production and management values for the base system. Cows were culled if they were nonpregnant, unsound, or were 13 yr of age. Calves and cull females were sold immediately after weaning. Input and marketing costs used in the model were valued at regional 1999 prices (Table 2).

Table 1. Production and management characteristics of base system

Item	Base value
Cows exposed (herd size)	511
Cow mature wt, kg	560
Peak milk yield, kg/d	12
Start of breeding season	June 5
Length of breeding season, d	60
Cows/bull	25
Weaning and sale date	October 31
Turnout to native range	May 1
Begin hay feeding	January 1

Table 2. Input prices and marketing assumptions

Item	Value
Feed	
Alfalfa hay, $/ton	
Average year	68.04
Drought year	86.18
Grass hay, $/ton	
Average year	58.97
Drought year	77.11
Supplement, 12% CP, $/ton	125.00
Supplement, 20% CP, $/ton	180.00
Native range, $/animal unit month	13.00
Marketing	
Brand inspection and checkoff, $/head	1.30
Commission on cows, %	2
Commission on calves, %	0
Shrink of calves, %	2
Shrink of yearlings and cows, %	3.5
Trucking, $/100 kg (100 km) – cows and yearlings	0.78
Cattle prices	
Steers, $/100 kg	200.13
Slide[1]	0.11
Heifers, $/100 kg	189.99
Slide[1]	0.09
Yearling heifers, $/100 kg	166.54
Cull cows	75.70
Dystocia, $/incidence	16.00
Annual expenses,[2] $/animal	
Steer calves	10.86
Heifer calves	10.86
Yearling heifers	39.07
Two-year-old cows	45.46
Mature cows	46.07
Bulls	577.43
Interest on variable expenses, %	10

[1]Slide is the change in price per kilogram of change in weight.

[2]Include vaccinations, property taxes, opportunity cost of investment (5% for yearlings and older), miscellaneous health treatments, ear tags, and depreciation ($427, bulls only).

The MSU simulation model determined annual animal unit months (**AUM**; 304 kg of DM/mo; Society for Range Management, 1989) of range forage required to sustain herd size under the base management. Number of AUM was fixed at this level assuming this to be the amount of grazable forage produced from the range in an average climatic year. Hay production was also fixed in the same manner. Forage resources for the ranch on an average climatic year and typical management were 4,329 AUM of range forage, plus 571 tons of grass and 189 tons of alfalfa hay.

During the winter-feeding period, alfalfa hay (DM basis: 2.1 Mcal of ME/kg, 17% CP, and 46% NDF) was fed to replacement heifers and first-calf heifers. Replacement heifers were offered 5.5 kg/d until January 1, then 6.5 kg/d until range turnout. First-calf heifers were offered ad libitum access to alfalfa hay from January 1 until turnout. Alfalfa grass hay (DM basis: 2.0 Mcal of ME/kg, 14% CP, and 55% NDF) was fed ad libitum to mature cows from range removal through turnout to grass (May 1). Protein supplements (DM basis: 3.1 Mcal of ME/kg, and 12% and 20% CP) were provided as needed after calving and weaning and during the winter-feeding period. Replacement heifers were offered 2.0 kg/d of 12% CP range cubes from January 1 until April 30, and 1.0 kg/d of 20% CP range cubes from October 31 until January 1. First-calf heifers were offered 0.25 and 1.5 kg/d of the same supplements from March 1 until April 30 and October 31 until January 1. Mature cows were offered 1.5 kg/d of 12% CP range cubes after calving March 1 to April 30, and 1.5 kg/d of 20% CP range cubes after weaning until January 1. Quality parameters for hays fed (Julien and Tess, 2002) and pastures grazed (Adams and Short, 1987) were assumed to be representative of the Northern Great Plains region.

Simulation of Drought and Management Scenarios

Treatments applied to the base system were arranged in a factorial design. Factors examined were management strategy (early vs. normal), intensity of drought (moderate — 20% reduction in available forage, or severe — 40% reduction in available forage), and forage quality (average CP, ME, and NDF vs. drought-affected CP, ME, and NDF). For each treatment, herd size and average weaning weight (where applicable) were maintained. Cattle were managed to maintain performance without damaging the range resource. Strategies that allow cattle performance to decline or that decrease herd size were not considered in this study.

The early management (**EM**) scenario, implemented by July 15, included weaning calves at an average 90 d of age, culling nonlactating cows at weaning, and culling aged and nonpregnant cows 45 d after the start of breeding season to reduce grazing pressure on the drought-stressed forage resource. The normal management (**NM**) scenario included no ‘early’ management changes to emerging drought, but no decline in animal performance was permitted. Cows were fed hay or purchased supplements or both to maintain cow BW and BCS, herd size, and average calf weaning weight. Cow BW and BCS are both related to reproductive performance (Tess and Kolstad, 2000a).

Two levels of drought were chosen to consider the changes in intensity and duration of drought on enterprise profitability. Level of drought was defined as moderate (20% reduction in available forage) and severe (40% reduction in available forage) where both levels of drought were deviated from the base system (Table 3).

Forage quality, as measured by DM concentrations of nutrients like ME, CP, and NDF, may change in response to drought, but there is limited research quantifying the corresponding changes in animal diets. Average diet quality curves utilized in the model were developed by Julien and Tess (2002) based on results reported by Adams and Short (1987). Drought-affected diet quality was harder to determine. Nelson and Moser (1994) described how concentrations of various nutrients in range plants increased during drought due to an increased number of leaves and delayed maturity. Sheaffer et al. (1992) found increased CP and decreased NDF and ADF within plants that were drought-stressed. However, studies by Huston and Pinchak (1991) and Heitschmidt et al. (1995) demonstrated that forage quality measures vary largely as a function of the relative amounts of live and senesced tissue. Drought leads to a decrease in forage yield (Reed and Peterson, 1961; Heitschmidt et al., 1999). Holecheck and Vavra (1983) concluded that during drought, cattle will consume more forbs and shrubs, if available. Hence, depending on the vegetative composition of the range, drought might force grazing animals to consume lower quality diets compared with average years due to higher proportions of dead material consumed. Figures 1 to 3 present the simulated diet quality curves used in this study.

As mentioned above, during drought when forage quantity or quality or both were reduced, the simulated cow herd was supplemented as needed to maintain performance and herd size. Table 4 summarizes changes in characteristics of the production scenarios in response to drought under normal and early management. Unless otherwise stated, types of hays and cubes fed were the same as described above for average climatic conditions. Hay feeding started when cattle were removed from native range. Hay was fed at or near ad libitum levels.

Normal Management

Assuming average forage quality and under moderate drought, early

Table 3. Changes in forage production due to level of drought

	Level of drought		
Item	Average climatic year	Moderate (20% reduction)	Severe (40% reduction)
Range forage, AUM[1]	4,329	3,463	2,597
Grass hay, ton	189	151	113
Alfalfa hay, ton	571	457	343

[1]AUM = animal unit months.

hay feeding eliminated the need for protein supplement for cows that had lactated, except that mature cows were fed 0.6 kg/d of 12% CP cubes from August 28 to weaning. Under severe drought, mature cows were fed 1.7 kg/d of 12% cubes from range removal until weaning.

Assuming drought forage quality and moderate drought, replacement heifers were fed 0.5 kg/d of 12% CP cubes from weaning to January 1. Yearlings were fed 1.5 kg/d of 20% CP cubes starting September 21. Early hay-feeding (alfalfa) removed the need for fall protein supplement for 2-yr olds. Mature cows started receiving protein cubes on September 21. Under severe drought, replacement heifers started receiving 0.5 kg/d of 12% CP cubes at weaning, and yearlings were fed 1.0 kg/d of 20% CP cubes starting September 5. Early hay-feeding removed the need for cubes in the fall for 2-yr-old cows, whereas 1.25 kg/d of 12% CP cubes were fed to mature cows from September 5 to January 1.

Early Management

For either forage quality, early weaning removed the need for range cubes in the fall for yearlings, 2-yr-old cows, and mature cows. Figure 4 illustrates the changes in feeding strategies for mature cows under different levels of drought, management, and average forage quality.

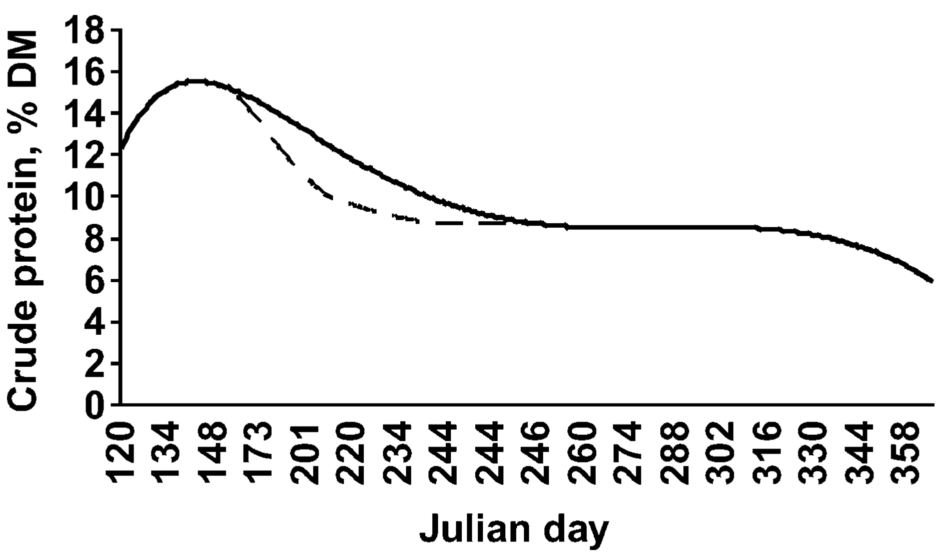

Figure 1. Simulated concentration of CP in cattle diets during average climatic conditions (solid line) and drought (dashed line).

US Meat Animal Research Center Model

The MARC model was used to simulate performance of early-weaned calves fed in a drylot for the early management scenarios. Williams et al. (1992, 1995) presented parameters to predict gut fill and provided detailed descriptions of specific inputs for Angus × Hereford cattle. Parameters for a spring-calving scenario (Reisenauer, 2002) were modified to represent early-weaned calves in a drylot. Input data from the MSU model included average weight, age, and number of steers and heifers from the early management scenario for each level of drought.

Rations were balanced to establish diets representative for early-weaned calves placed in a drylot using commercial software. Inputs consisted of average weaning weight of calves, target average daily gain, target end weight, feedstuffs to be fed, and cost of individual feedstuffs. Early-weaned steers and heifers were assumed to be fed in separate pens and fed a high concentrate diet formulated to contain approximately 14.5% CP (Table 5).

Diet value parameters for the MARC model included fraction of concentrate (63.97 and 71.04% for steers and heifers, respectively) and NDF in the forage fraction (46%). These variables calculated weight of gut contents for use in converting full BW to empty BW. Feed costs were calculated by the model utiliz-

Table 4. Characteristics of production scenarios

Scenario	Weaning	Cull date[1]		Range removal[2]
Average forage quality				
Average climatic year				
Base system	October 31	October 31	—	January 1
Early management	July 15	July 15	September 15	April 1[3]
Moderate drought				
Normal management	October 31	October 31	—	October 20
Early management	July 15	July 15	September 15	January 1
Severe drought				
Normal management	October 31	October 31	—	September 5
Early management	July 15	July 15	September 15	October 2
Drought forage quality				
Moderate drought				
Normal management	October 31	October 31	—	October 20
Early management	July 15	July 15	September 15	October 31
Severe drought				
Normal management	October 31	October 31		September 5
Early management	July 15	July 15	September 15	October 2

[1]Cull date: for early management scenarios, dry cows culled at weaning and cows not pregnant culled 45 d after breeding season started (June 5).

[2]Range removal = date cows removed from range and full supplementation started.

[3]Early weaning under normal climatic conditions provided more forage for dry cows; i.e., enough graze through the winter if range remained free of snow cover.

ing ME density of the diet (2.74 and 2.80 Mcal of ME/kg of DM for steers and heifers, respectively) and the cost per Mcal of dietary ME ($0.0252 and $0.0265/Mcal of ME for steers and heifers in an average year, and $0.0270 and $0.0282/ Mcal of ME for steers and heifers in a drought year, respectively).

There is evidence to suggest that early-weaned calves will grow more rapidly (Myers et al., 1999b; Fluharty et al., 2000; Barker-Neef et al., 2001), show increased feed efficiency (Myers et al., 1999b), and weigh more (Fluharty et al., 2000) at 205 d than calves weaned at 180 to 210 d of age. Our objective for early weaning was to maintain normal calf gains during drought and to evaluate the economic viability of that option. Therefore, early-weaned calves were fed to reach a target weight that reflected the performance of the normal-weaned calves. Early-weaned steers and heifers entered the drylot at a weight of 137 and 124 kg, respectively, and were fed to reach a target weight of 249 and 231 kg, respectively. All early-weaned calves were fed for 108 d. The ADG for steers was 1.04 kg/d and for heifers was 1.00 kg/d.

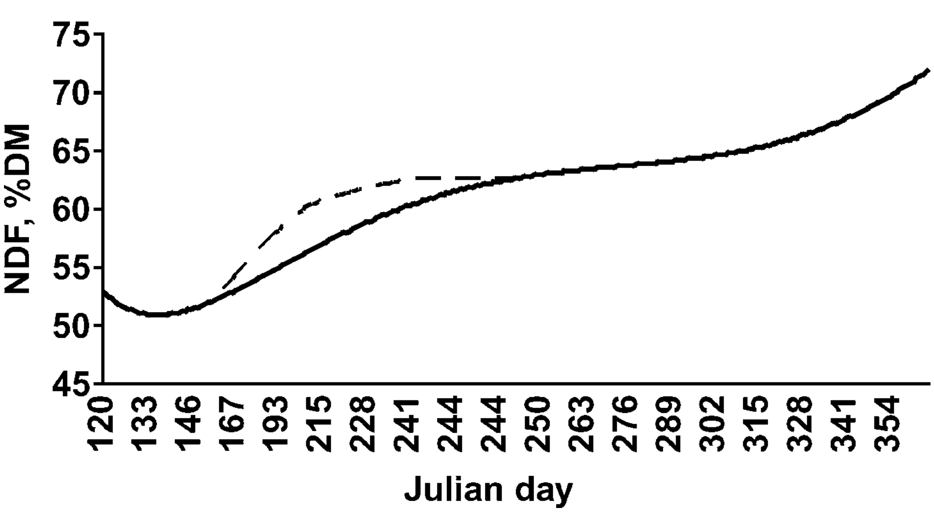

Figure 2. Simulated concentration of NDF in cattle diets during average climatic conditions (solid line) and drought (dashed line).

Enterprise Analyses

Simulated measures of system performance from the MSU model reported here include number of cows exposed (a measure of herd size), feed cost, average weaning weights of calves sold, calves weaned per

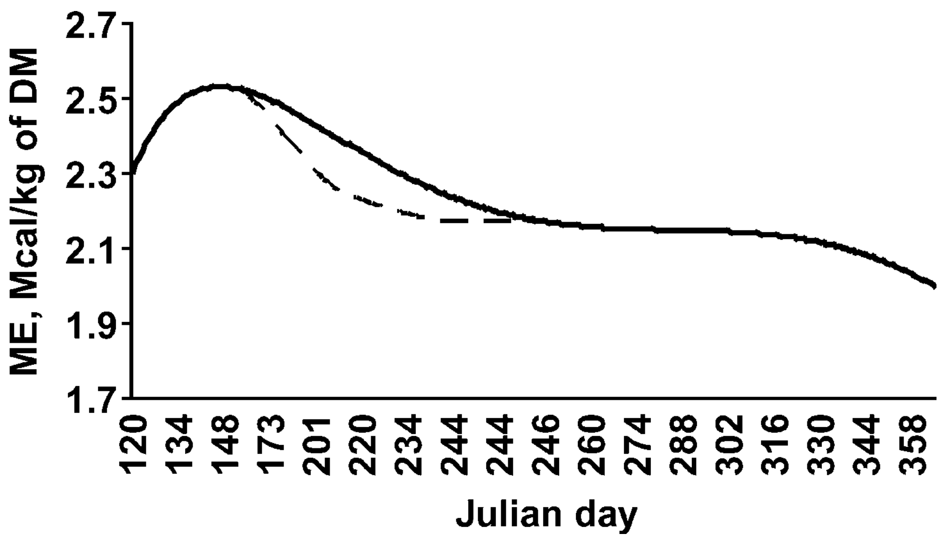

Figure 3. Simulated concentration of ME in cattle diets during average climatic conditions (solid line) and drought (dashed line).

cow exposed, and purchased feed cost. Ranch gross margin (**RGM**) was defined as gross revenue less variable costs, with calves valued at weaning. Variable costs included purchased feed, marketing expenses, labor, dystocia expenses, annual expenses per animal and interest (Table 2). Grazed forage and home-raised hay were considered fixed expenses in the computation of RGM. Contingent on the amount required, hay was purchased or sold at market value to maintain a constant inventory. Market values for hay were intended to reflect the higher prices of hay during drought caused by increased demand and reduced supply. Calves were assumed to be sold directly off the ranch, whereas cull cows and yearlings were sold via auction.

The MSU model predicted the number of steers and heifers, weaning weights, cattle prices, shrink, and RGM. The MARC model then simulated days on feed, calf mortality, feed cost, yardage ($0.25/d per head to account for added labor and overhead) and interest costs (10%). Calf mortality in the drylot was set at 2% as reported by Myers et al. (1999b) for calves weaned at 90 d. Myers et al. (1999a,b) also found a significant increase in respiratory and digestive morbidity in calves weaned at 90 d. This was attributed to calves not being vaccinated prior to weaning. Preweaning vaccinations were accounted for in the MSU model; therefore, no extra cost was added for increased incidences of sickness, vaccinations, or veterinary costs. It was assumed that the drylot was located on the ranch (i.e., no transportation costs were assumed). When the drylot component was included in EM, RGM included the added revenue and added expenses associated with this part of the enterprise.

Data from these simulations were not evaluated using typical statistical methods. Differences can be evaluated among replicates due to the stochastic nature of the MSU model (Tess and Kolstad, 2000a; Julien and Tess, 2002). However, the MARC model is deterministic and does not contain random elements. In order to combine the results of the 2 models, variation in mean ranch performance was reduced for the MSU model by performing 30 replications for each treatment where average results were utilized.

RESULTS AND DISCUSSION

Table 6 presents enterprise performance measures under average climatic conditions and the base management system. Enterprise performance under the various drought, forage, and management scenarios may be compared with these values. For all treatments (Tables 8 to 10), herd size averaged 511 cows (the number of cows exposed to breeding) and ranged from 505 to 516. Further, calves weaned per cow exposed was consistent across all treatments. These results reflect the fact that nutritional management was altered during drought in order to sustain performance and herd size (Table 4).

Drylot Component for Early Weaned Calves

During drought, if early-weaned calves were sold at weaning, RGM was 25 to 32% less than NM assuming average forage quality (Table 7), and 22 to 41% less assuming drought affected forage quality (Table 8). When calves were placed in the drylot and added expenses and revenues from the heavier calves were included in RGM, EM was much more profitable than NM for all drought scenarios except moderate drought and drought forage quality, in which they were similar (Tables 7 and 8).

When forage is limited and low in quality, calf productivity may decline. Herbel et al. (1984) found that during drought, weaning weights were significantly lower than during normal climatic years. Similarly, Bellido et al. (1981) found drought reduced calf gain by 20%, and adjusted weaning weights were 17% lower than during average years. A portion of these reductions in calf gain are explained by reduced milk production (Neville 1962; Robison et al., 1978), and another portion is associated with reduced productivity of pastures. Burns et al. (1983) found that cows could not consume enough low-quality forage to sustain milk production, and calf gains suffered. The MSU beef model accounts for both forage quality and cow milk

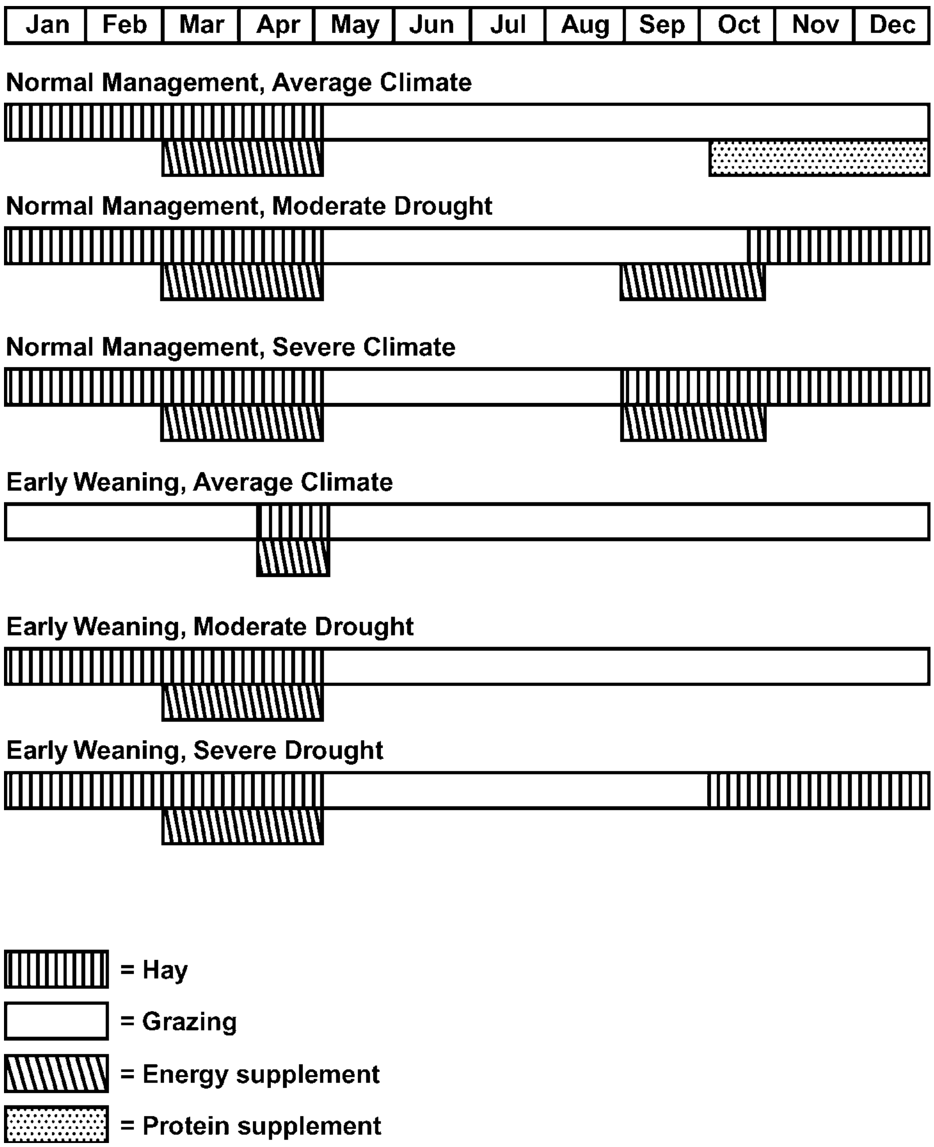

Figure 4. Grazing and supplementation timelines - mature cows, average forage quality.

Table 5. Diet for early-weaned drylot calves

Item	Amount: Steers	Heifers
Ingredient, % DM basis		
Alfalfa hay	35.99	28.98
Corn grain	52.42	56.53
Range cubes (30% CP)	10.58	13.47
Mineral mix	1.01	1.02
Chemical component		
CP, %	14.64	14.77
NDF, %	24.57	22.49
ADF, %	15.03	13.04
NE_m, Mcal	7.53	7.62
NE_g, Mcal	5.34	5.49

production, which is predicted to decline with decreasing forage quality (Tess and Kolstad, 2000a,b). Results demonstrated these responses for NM where on average calves weighed 10 kg less at weaning under severe drought (Table 7) and drought forage quality treatments (Table 8) compared with normal forage and management conditions (Table 6).

The merits of alternative supplementation strategies to increase average weaning weights under NM were also studied (data not shown; Kruse, 2002). Simulated mature lactating cows were given alfalfa hay as a replacement for alfalfa grass hay in the fall, and an alfalfa creep feed was given to the calves. Although these supplementation strategies increased RGM under NM, the effect was not sufficient to overcome the advantage of early weaning strategies during drought.

It has been shown that early-weaned calves weigh as much or more at normal weaning than normal-weaned calves during an average climatic year (Lusby et al., 1981; Neville and McCormick, 1981; Harvey and Burns, 1988; Myers et al., 1999a,b,c; Fluharty et al., 2000). Harvey et al. (1975) showed gains to be improved by approximately 0.30 kg/d when calves were early weaned compared with calves that remained on their dams. Added efficiency of early-weaned calves is often confounded by breed, calving season, and region. Therefore, in this study the simulated performance of the early-weaned calves in the drylot was targeted at 245 kg to allow the management strategies to be directly comparable and not confounded by added income from heavier calves.

Level of Management

Figures 5 and 6 demonstrate that, for every climatic condition and level of forage quality, EM was equal to or more profitable than NM. With the drylot option, EM consistently had lower total purchased feed costs and generally higher RGM than NM for both levels of drought and forage quality. For average forage quality, purchased feed cost for EM was 41 and 27% lower than NM for moderate and severe drought, respectively. This was due primarily to maintaining herd size and performance, which required shortening the grazing season and increasing the total

Table 6. System performance under average climatic conditions and average forage quality

Item	Base system	Early management[1]
Herd size	511	516
AWW,[2] kg	245	132
CWCE,[3] %	86	86
Purchased feed cost, $	13,911	–11,889
Ranch gross margin,[4] $	137,055	99,277
With drylot component		
Drylot feed cost, $	—	15,970
Drylot nonfeed cost, $	—	11,834
Ranch gross margin, $	—	134,033

[1]This early management scenario reflects the effects of implementing a proactive drought strategy (early weaning) when, if in fact, drought did not occur.

[2]AWW = average weaning weight.

[3]CWCE = calves weaned per cow exposed.

[4]Ranch gross margin = gross revenue minus variable costs.

amount of harvested feed needed. Under drought forage quality, differences in feed costs between NM and EM were smaller; purchased feed cost for EM was 15 and 29% lower than NM for moderate and severe drought, respectively.

Level of Drought

Severe drought greatly decreased the profitability of the cow-calf enterprises studied here. For NM compared with normal climatic conditions, RGM decreased by 33 and 72% under moderate and severe drought with average forage quality, respectively. Using drought forage quality, the effects of drought on RGM were even more severe. Although RGM for EM was equal to or higher than for NM (Figures 4 and 5), drought still had negative effects on profitability.

Forage Quality

Forage quality may change in response to drought, but there is little research quantifying the changes in animal diets. Drought affects forage yield (Reed and Peterson, 1961; Heitschmidt et al., 1999), nutrient concentrations within plants (Sheaffer et al., 1992; Nelson and Moser, 1994), and grazing animals may substitute different plants into their diets (Holecheck and Vavra, 1983). Therefore, the forage actually consumed by grazing animals may be lower in CP and ME and higher in NDF (E. E. Grings and R. K. Heitschmidt, USDA-ARS LARRL, Miles City, MT, unpublished data). Forage quality curves were modified to reflect changes in cattle diets during drought (Figures 1 to 3).

Differences between average and drought forage quality did not change the rankings of the different management treatments under severe drought; however, for moderate drought EM was equal to NM for RGM. Drought forage quality increased feed costs and reduced RGM for all treatments. Total purchased feed costs for NM and EM, respectively, increased 12 and 60% for moderate drought and 5 and 2% for severe drought. Following feed costs, RGM for NM and EM, respectively, decreased 12 and 20% for moderate drought and 21 and 3% for severe drought. Effects of forage quality were smaller under severe drought because supplementation started early enough in the fall to thwart a decrease in cow condition, making large changes in supplementation unnecessary. The only treatment that required large changes was EM during moderate drought. This scenario needed almost no supplementation prior to January 1 under average forage quality, but changing the forage quality required feeding a limited amount of grass alfalfa hay beginning October 31 to maintain cow condition.

False Predictions of Drought

Although rare (Kruse et al., 2007), there is some economic risk stemming from instances wherein drought conditions disappear (i.e., it rains and forage production increases) shortly after management has initiated proactive drought management tactics such as EM. When the early management treatment was applied and no drought occurred (i.e., no reduction in forage production), purchased feed costs decreased by $9,830 and RGM decreased by 2% (Table 6; Figure 4). Available forage during an average climatic year was enough for early-weaned mature cows to graze through the following March, which allowed the ranch to sell the majority of home-raised hay.

In this study, computer simulation was used to evaluate the effects of early weaning and culling based on early detection of drought, intensity of drought, and forage quality on the profitability of eastern Montana cow-calf production systems. Simulation models facilitate the organization and integration of scientific concepts and experimental results into tools for addressing questions beyond the scope of live animal experimentation. Models are developed to represent important aspects of real systems based upon published research. Still, models are only an abstraction of reality, and assumptions made and the boundaries of the models define what inferences can be made from the results.

The model simulated alternative management scenarios as existing ranches with all resources available. Range forage resources were managed in a way as to avoid the possibility of overgrazing during drought. Hay was purchased as needed or sold if home-raised supply exceeded need. Due to the approach used (i.e., basically treating the forage resource as the unit of production rather than the cow), results for RGM are not easily compared with studies in which profit was measured on a per-cow basis (Julien and Tess, 2002). Calving occurred in the spring and all calf marketing occurred at the date of normal weaning. These assumptions represent many, but not all, ranches in the Northern Great Plains (Julien and Tess, 2002). Results reported here should not be used to make inferences about other production or marketing systems; specifically, systems calving in different seasons.

Results of this study suggest that an early weaning option is not economically viable unless calves are kept and fed in a drylot. Story et al. (2000) found that early-weaned calves did not weigh as much at weaning as normal-weaned calves, and even though price per unit of weight was greater for the lighter calves, there was not enough revenue generated to offset cow costs.

Comparing EM to NM addresses the question of whether it is more efficient and cost effective to feed cows at a level high enough to maintain lactation and preserve calf performance or to directly feed calves. Under every climatic condition and level of forage quality simulated, EM was equal to or more profitable than NM. This agrees with Estermann et al. (2002) who found it advantageous to supplement calves rather than maintain milk yield of dams through better forage quality. Peterson et al. (1987) found that early weaned cow-calf pairs consumed 20% less TDN and were 43% more efficient in converting TDN into calf gain than normal-weaned cow-calf pairs. Story et al. (2000) found that annual cow costs were lower for early-weaned cows than for those normal weaned.

Table 7. System performance under normal and early drought management strategies with average forage quality

Item	Normal management	Early management
Moderate drought		
Herd size	510	505
AWW,[1] kg	244	134
CWCE,[2] %	86	86
Purchased feed cost, $	59,015	18,394
Ranch gross margin,[3] $	91,442	68,954
With drylot component		
Drylot feed cost, $	—	16,654
Drylot nonfeed cost, $	—	11,567
Ranch gross margin, $	—	101,189
Severe drought		
Herd size	509	511
AWW, kg	235	134
CWCE, %	86	86
Purchased feed cost, $	107,863	62,349
Ranch gross margin, $	38,131	26,072
With drylot component		
Drylot feed cost, $	—	16,896
Drylot nonfeed cost, $	—	11,732
Ranch gross margin, $	—	58,663

[1]AWW = average weaning weight.

[2]CWCE = calves weaned per cow exposed.

[3]Ranch gross margin = gross revenue minus variable costs.

A number of drought management strategies might be employed to reduce the economic effects of drought. We chose to constrain the possible management strategies to those that we felt confident in simulating and that producers might find practical. Animal performance was maintained for all treatments to reflect the need for cows to remain in good condition for rebreeding the next spring. Allowing animal performance to decline (e.g., cow BW and BCS) could lead to interactions with cow reproduction that could have effects lasting several years. Herd size was held constant because a reduction in herd size reduces the potential calf crop for subsequent years, and producers tend to be reluctant to reduce cow numbers. However, results suggest that during severe drought, maintaining herd size may not be economically feasible even if early weaning is employed.

Our results showed that altering management early in the growing season by early weaning and feeding calves in a drylot had advantages over not altering management early for all levels of drought and forage quality. Most of the variation seen in RGM between normal management and early management scenarios was reflected in the higher feed costs for the normal management scenario required to maintain animal performance and herd size. Peterson et al. (1987) reported that feed cost was one of the most important variables influencing profit accounting for approximately 70% of the total cost in beef operations. May et al. (1999) noted that feed costs were highly related to weaning dates in studies evaluating sea-

Table 8. System performance under normal and early drought management strategies with drought forage quality

Item	Normal management	Early management
Moderate drought		
Herd size	511	511
AWW,[1] kg	237	133
CWCE,[2] %	86	86
Purchased feed cost, $	66,067	39,301
Ranch gross margin,[3] $	80,924	47,470
With drylot component		
Drylot feed cost, $	—	16,895
Drylot nonfeed cost, $	—	11,732
Ranch gross margin, $	—	80,851
Severe drought		
Herd size	511	514
AWW, kg	232	133
CWCE, %	86	86
Purchased feed cost, $	113,688	63,480
Ranch gross margin, $	30,107	23,474
With drylot component		
Drylot feed cost, $	—	17,057
Drylot nonfeed cost, $	—	11,842
Ranch gross margin, $	—	56,864

[1]AWW = average weaning weight.

[2]CWCE = calves weaned per cow exposed.

[3]Ranch gross margin = gross revenue minus variable costs.

son of calving. In real systems, actual margins will be sensitive to prices paid for inputs and prices received for cattle. Because the major variable expense in this study was purchased feed the effects of hay prices were also investigated (data not shown), and it was found that ranks of the management systems did not change (Kruse, 2002).

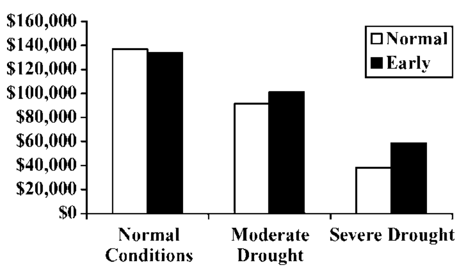

Figure 5. Ranch gross margin for normal and early management under normal conditions, moderate drought, and severe drought conditions utilizing average forage quality.

Little research quantifying the effects of drought on diet quality has been conducted. Forage quality was simulated in 2 ways: one in which forage quality was similar to average climatic years, and one in which forage quality was lower. Diet quality is very sensitive to the proportion of live vs. dead material in the diet (Huston and Pinchak, 1991; Heitschmidt et al., 1995; Haferkamp et al., 2005, Heitschmidt and Vermeire, 2006). Hence, the actual effects of drought on diet quality may be affected by stocking rate. In this study, the severity of drought effects were magnified by decreased diet quality. Compared with average forage quality, the advantage of EM over NM with reduced forage quality were reduced for moderate drought but increased for severe drought.

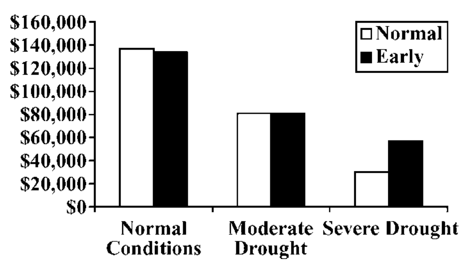

Figure 6. Ranch gross margin for normal and early management under normal conditions, moderate drought, and severe drought conditions utilizing drought forage quality.

Research quantifying the various economic aspects of drought and drought management comparable to this study is scarce. Peterson et al. (1987) found that early weaning was more economical than normal weaning, but calves were born in the fall and no drought was observed. A study done by Mjelde and Hill (1999) evaluated several systems models describing the economic effects of climate forecasts on production of several crops. They found that the use of climate forecasts improved net income.

Early weaning may add flexibility in management in response to a changing environment. Results reported here suggest that if early weaning was implemented during an average climatic year, RGM was equal to the base system. This has some limitations. In some regions, due to snow cover, it may not be possible to graze until early spring. Also, if producers employed this strategy every year, there would be no drought response possible except maybe to sell cows. Nevertheless, these results suggest little penalty associated with an inaccurate early prediction of agricultural drought.

IMPLICATIONS

For range-based cow-calf enterprises in the Northern Great Plains, an early management strategy, which includes early weaning and drylot feeding calves, can forestall the negative economic impacts of drought over that of merely supplementing cow-calf pairs. Level of drought did not change the ranking of the strategies, but did magnify the differences between the scenarios. Early weaning may not be an economically viable option unless calves are retained by the cow-calf producer and placed in a drylot and fed to a 'normal' weaning weight.

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