ECONOMICALLY-OPTIMAL MATURE BEEF COW WEIGHT IN THE U.S. SOUTHERN PLAINS

By

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WEIGHT IN THE U.S. SOUTHERN PLAINS

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Title of Study: ECONOMICALLY-OPTIMAL MATURE BEEF COW WEIGHT IN THE U.S. SOUTHERN PLAINS

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Abstract: This research builds on previous studies by determining the profit-maximizing beef cow weight under common herd scenarios for U.S. Southern Plains beef cow-calf operations. Scenarios included Angus and Brangus cattle, Bermuda and native range pasture, as well as spring and fall calving. The relationship between cow size and calf weaning weight were determined by utilizing data from two Oklahoma and one Arkansas research stations. Data were collected from 1988 to 2009 and include 3,041 observations. Using historical data for cow cull prices, calf prices, and feed prices, prices were projected for 15 years to reflect price variation observed in a recent cattle cycle. A direct profit function was computed using cow-calf revenues and production costs for cows with a mature weight between 950 and 1,800 pounds, in 50 pound increments. A grid search was used to find the most profitable cow size across the cow's lifetime and per acre. Results concluded the optimal cow size varied from 950 to 1,800 pounds across scenarios, feed cost variations and the year of the cattle cycle that the heifer entered the herd.

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CHAPTER I

INTRODUCTION

Cattle prices have been on an overall upward trend since 1996 (Peel, 2014). With more money at stake for cow-calf producers, the importance of matching beef cow traits with economic and environmental conditions is amplified. The main source of revenue for cow-calf producers is sales of calves and cull cows. According to Smith (2014) producers have been selecting cattle for muscle, growth and milk production in an effort to increase profit, resulting in an increase in cow weight and frame size over the years. Using historical slaughter cow data and working backwards to determine live weight, McMurry (2013) has determined that national average mature cow weight has increased from 1,050 pounds in 1975 to 1,350 pounds today. Bulls are selected with EPDs that indicate higher growth rate and muscling, and their daughters, who are more likely to be large, serve as replacement cows. Although these characteristics are reported as the most profitable in feed lot scenarios, this may not be the case for replacement heifers used in the cow-calf operation (Smith, 2014). With producers focused on increasing pounds of calf weaned, the balance between cow nutritional requirements, which depend on cow weight and the natural un-supplemented environment, has fallen out of focus and supplementation has become the norm (Schmid, 2013). While larger cows generally have calves with higher weaning weights, Doye and Lalman (2011) report that heavier cows require more feed in the form of grain, hay and acres of pasture. So, there is the potential that additional revenue from more pounds of calf weaned may not offset the additional cost.

Selection of forage type and breed characteristics that match the herd type and environment can help producers improve weaning weights and overall profitability, which may also affect the profit maximizing cow weight (Brown and Lalman, 2008). Similarly, Arango and Van Vleck (2002) determined that the profit-maximizing weight of the cow is dependent on forage quality and calving season. Larger cows outperformed smaller cows on higher quality grasses, but struggled to meet their nutritional needs on lower quality grasses. As a result, smaller cows outperformed their larger counterparts on low quality grasses (Arango and Van Vleck, 2002). Due to the calf price slide, lighter calves receive higher prices than heavier calves at the sale barn. So although larger calves weigh more, they are receiving less money per pound than smaller calves (Doye and Lalman, 2011).

The stage in the cattle cycle at time of sale is another factor that affects the price received for calves. The cattle cycle is caused by fluctuations in cattle prices and the national herd size and has been documented as early as the1880s. As cattle prices rise, producers generally increase their herd size and reduce herd size as prices decline (Bently and Shumway, 1981). So, the cyclical price and herd size affects producers' annual profits and also may be a factor in their herd planning strategies.

Miller et al. (2001) identified the most influential determinants of profit as the cost of maintaining cows, calf sale price, and weaning weight. Environment including forage type, herd composition and price conditions all influence the profit-maximizing cow weight. Although researchers have examined this problem in the past, varying regional herd and environmental factors affect optimal cow weight. Previous studies have limited the cow weights included in the study to three or less or made linear assumptions about ration requirements and the relationship between cow weight and calf weaning weight.

This research builds on previous studies by determining the profit-maximizing beef cow weight for U.S. Southern Plains beef cow-calf operations. Profits associated with various beef cow weights are compared under two breed types (Angus and Brangus), two pasture types, (native and improved) and under fall and spring calving seasons. Both calf birth and weaning weights are estimated as functions of cow weight, age, breed, forage type, and calving season. The regression models allow for decreasing marginal physical product of both cow weight and age. Operating budgets are developed for each cow weight, breed, forage type and calving season. Feed, one of the highest costs associated with cow calf production, is varied based on beef cow weight, stage of gestation, calving season, forage type, and breed. As the stage of the beef cattle cycle potentially affects profit-maximizing beef cow weight, the cattle cycle stage (or year) is explicitly considered in the analysis by varying the year of the cycle when a heifer enters the breeding herd. Under each scenario, annual returns are calculated, discounted and summed to find the net present value of a beef cow across her lifetime and net present value-per cow-per acre. Finally, a grid search is used to find the cow weights that maximize net present values per head and per acre.

Objectives

The overall goal of this research is to determine the most profitable mature cow weight for producers under eight scenarios, including Angus and Brangus breeds, Bermuda grass and native range, and spring and fall calving seasons. These scenarios are common for producers in the U.S. Southern Plains. Specifically, this research

1) Estimate how beef cow weight affects calf weaning weight and cow-calf revenue and costs; and

2) Estimate profit-maximizing cow weight under each of the eight scenarios representative of the U.S southern plains.

Methodology

Data from two Oklahoma and one Arkansas research station were used to determine the relationship between cow weight and calf weaning weight under two breed, two forage types, and two calving seasons. Rations were calculated for the two breeds, under the two forage conditions for both spring and fall calving seasons using a software tool, CowCulator (Lalman and Gill, 2010), which is built on recommendations from National Research Council (2000). Using historical data for cull cow prices, calf prices, and feed prices, prices were projected for 15 years to reflect price variation and pattern observed in a recent cattle cycle. A direct profit function was computed using cow-calf revenues and production costs for cows with a mature weight between 950 and 1,800 pounds, in 50 pound increments. A grid search was used to find the most profitable cow weights per head and per acre under the eight scenarios.

Outline of study

The remainder of the study is organized as follows. Chapter two examines past literature involving both the relationship between cow weight and calf weaning weight and herd profitability. Chapter three presents the methodology, including the conceptual framework and hypothesis, data collection methods, and empirical models. Chapter four includes results of the study. Chapter five includes a summary, conclusions, and study limitations.

CHAPTER II

LITERATURE REVIEW

Factors Effecting Cow-Calf Profitability

Many factors determine the profitability of beef cow-calf production. Miller et al. (2001), analyzed financial and production information from Standardized Performance Analysis (SPA) data from Illinois and Iowa farmers. They determined that the top four factors that most influenced profitability included feed cost, depreciation cost, operating cost, and calf birth weight. Feed costs accounted for 63% of total annual cow cost. Calf birth weight was found to have a greater economic impact than calf price (Miller et al., 2001). Ramsey et al. (2005) also used SPA data to analyze the productivity and profitability of cow-calf herds, but for farms in Oklahoma, Texas, and New Mexico from 1991 to 2001. Three different models were evaluated that focused on costs, production, and profits. Economies of size were found in the cow-calf herd. As the herd size increased, the cost per unit decreased at a decreasing rate (Ramsey et al., 2005). Their finding has implications for determining the optimal cow weight on a per acre basis. When considering a set number of acres, a larger number of small cows can be stocked on the same land than large cows.

Cow Feed Rations

The method of calculating feed costs for varying cow weights differed across studies. Some studies assumed a linear relationship between cow weight and feed requirements including Olson et al. (1982) whom evaluated the effect of cow weight on cow productivity. Each one hundred kilogram increase in cow body weight (above four hundred kilograms) increased net energy required by twenty five percent. Doye and Lalman (2011) compared two cow weights in their analysis. They assumed a 100 head and a 76 head stocking rate for moderate (1,100 lb) and big (1,400 lb) cows respectively, per 1,000 acres. They also assumed larger cows have slightly higher supplemental needs in the form of additional protein and energy. Schmid (2013) found that the relationship between cow weight and feed requirements is not linear. Increasing cow weight by 27% increases maintenance requirements by 20%, assuming high lactation levels. Although the total feed energy for cows increases with weight, the amount of energy required per pound decreases (Schmid, 2013). Rations were calculated for three cow weights 1,000, 1,200, and 1,400 pounds in an analysis conducted by Russell (2014) using Cowculator software (Lalman and Gill, 2010). Rations were calculated for spring calving cows in intermountain feeding conditions which included meadow forage (Russell, 2014).

Other studies analyzed feed costs within data sets including Ramsey et al. (2005) who found that increased feed costs did not improve profitability. They hypothesized that the addition cost of the feed did not result in sufficient increases in pounds of beef produced to offset the cost (Ramsey et al., 2005). According to Miller et al. (2001) for every $1.00 increase in feed cost incurred, an increase of 0.5% in weaning weight would be necessary to break even using beef calf prices from 1996-1999. They did not determine if such a conversion rate was possible. Changes in feed costs associated with calving season were assessed by Bagley et al. (1987). For fall calving cows, less hay is produced but more nutrition is required when compared to the spring calving cows at the same point in their pregnancy. This requires the protein supplementation to be higher for fall calving cows when compared to spring calving cows, incurring a higher cost to the producer (Bagley et al., 1987).

Calf Weaning Weight

Calf weaning weight is a function of genetics and environmental factors. Minyard et al. (1965) found that cow age affects calf weaning weight. Two-year-old cows had the lowest weaning weights, with weaning weights increasing with cow maturity. The largest weaning weight change occurred between two and three years of age. Maximum calf weaning weight occurred at eight years of age, with only a small decline after age eight (Minyard, 1965). This conclusion was supported by Zalesky et al. (2007) using data from Colorado cow-calf herds. They found that five- to nine-year-old cows have calves with the heaviest weight per day-of-age at weaning (Zalesky et al., 2007).

When determining calf weaning weight for their analysis, Doye and Lalman (2011) assumed that calf weaning weight is 45% of cow weight for both cow weights considered. Additional studies analyzed data and found that larger cows produced calves with a heavier weaning weight, but did not further examine the relationship (Ramsey et al., 2005; Olsen et al., 1982; Bagley et al., 1987).

Optimal Cow Weight

Ringwall (2008) examined optimal beef cow weight in terms of pounds of calf gained grazing North Dakota pastures. He compared cows ranging from 1,300 pounds to 1,600 pounds in 100 pound increments. Cows were compared by measuring the growth of calves in pounds from birth to weaning as a percentage of the cows weight. The larger cows weaned a smaller percentage of calf weight for their body weight. Cows weighing less than 1,300 pounds had the highest increase in calf weight as a percentage of cow weight. Doye and Lalman (2011) reported that cows weighing 1,100 pounds returned higher profits than the heavier 1,400 pound cows considered.

Russell (2014) found that the optimal cow weight varies based on methods of charging acreage rental, as well as the forage type available. When people were charged rent on an animal unit per acre basis the smallest cow considered at 1,000 pounds had the highest net returns. However, when producers were charged rent on a per head basis, the larger 1,400 pound cow had the highest net returns when grazing higher nutrition forage, but the small cow had the highest net returns on lower nutrition forage (Russell, 2014).

CHAPTER III

METHODOLOGY

Conceptual Framework and Hypothesis

Cows of varying weight have different feed requirements, and produce different sized revenue generating calves. So, cow-calf operators' profits are directly influenced by cow weights.

Behavioral Model

To calculate profitability on a per-cow and per-acre basis, it is necessary to establish a culling model. The equation for the probability of a cow being culled from the herd at any given age is as follows

(1)

$$Prob\ (Cull\ at\ Age_t) = Prob(Cull \mid Age_t) \times (1 - Cumulative\ Probability\ of\ Culling\ Before\ Age_t)$$

In equation (1), the *Prob(Cull at* Age_t*)* is the probability that the cow is culled at age *t*, considering that she has not been culled in a previous year, *Prob(Cull|*Age_t*)* is the probability that the animal is culled given age *t*, *Cumulative Probability of Culling Before* Age_t is the probability that the cow has been culled at any previous age.

Further the cumulative probability of culling before Age_t is as follows

$$Cumulative\ Probability\ of\ Culling\ Before\ Age_t = \sum_{i=1}^{t-1} Prob(Cull\ at\ age_i)$$

The probability of being culled at a specific age was sourced from Azzam et al. (1990).

It is assumed that producers maximize the net present value of profits per-cow as in equation (2). (Later, producers are model as maximizing net present value per-cow-per acre). Profit is calculated from revenues generated by calves, cull cows, and cull bulls as well as the costs associated with feeding and managing livestock. The model assumes the objective function for maximizing the net present value of expected annual profits per-cow with a lifetime of 10 years as

(2)

$$\begin{aligned} \max_{CowWeight_6} \sum_{t=1}^{10} & CalfWeanWeight_t \times \left(\frac{CalfPriceHeifer_t + CalfPriceSteer_t}{2}\right) \\ & \times (1 - Prob(Cull\ at\ Age_t)) + CowWeight_t(CowAge_t) \\ & \times Prob(Cull\ at\ Age_t) \times CowCullPrice_t(Season) + BullWeight \\ & \times CullBullPrice_t(Season) \times \frac{1}{125} - (FeedCost_t \\ & + FixedCost_t(CowWeight_t) + OtherVarCost_t(CowWeight_t)) \\ & \times (1 - Prob(Cull\ at\ Age_t)). \end{aligned}$$

In equation (2), $CalfWeanWeight_t$ denotes calf weaning weight in year *t*, $CalfPriceHeifer_t$ is calf sale price for heifers, $CalfPriceSteer_t$ is calf sale price for steers, $Prob(Cull\ at\ Age_t)$ is the probability that a cow is culled at a given age ($CowAge_t$), $CowWeight_t$ is the weight of the cow as a function of cow age ($CowAge_t$), $CowCullPrice_t$ is the price of cull cows in year *t* as a function of season calved (*Season*), *BullWeight* is the weight of cull bulls (10/7 mature cow weight) with a price of $CullBullPrice_t$ as a function of calving season (*Season*), $FeedCost_t$ is the cost of feeding a cow, her calf, and 1/25 of a bull, $FixedCost_t(CowWeight_t)$ are the fixed costs associated with a cow, her calf and 1/25 of a bull in year *t* as a function of cow weight ($CowWeight_t$),

$OtherVarCost_t(CowWeight_t)$ are the other variable costs associated with a cow, her calf and 1/25 of a bull in year *t* as a function of cow weight ($CowWeight_t$). It is assumed that the operation requires one bull per 25 cows and heifers, and a bull's longevity is five years.

A second model of producer behavior assumes the objective is to maximizing the net present value of expected annual profits per acre as

(3)

$$\max_{CowWeight_6} \sum_{t=1}^{10} [CalfWeanWeight_t \times \left(\frac{CalfPriceHeifer_t + CalfPriceSteer_t}{2}\right) \times (1 - Prob(Cull\ at\ Age_t)) + CowWeight_t(CowAge_t) \times Prob(Cull\ at\ Age_t) \times CowCullPrice_t(Season) + BullWeight \times CullBullPrice_t(Season) \times \frac{1}{125} - (FeedCost_t + FixedCost_t(CowWeight_t) + OtherVarCost_t(CowWeight_t)) \times \left(1 - Prob(Cull\ at\ Age_t)\right)]/Acres\ Per\ Cow.$$

In equation (3), $CalfWeanWeight_t$ denotes calf weaning weight in year *t*, $CalfPriceHeifer_t$ is calf sale price for heifers, $CalfPriceSteer_t$ is calf sale price for steers, $Prob(Cull\ at\ Age_t)$ is the probability that a cow is culled at a given age ($CowAge_t$), $CowWeight_t$ is the weight of the cow as a function of cow age ($CowAge_t$), $CowCullPrice_t$ is the price of cull cows in year *t* as a function of season calved (*Season*), *BullWeight* is the weight of cull bulls (10/7 mature cow weight) with a price of $CullBullPrice_t$ as a function of calving season (*Season*), $FeedCost_t$ is the cost of feeding a cow, her calf, and 1/25 of a bull, $FixedCost_t(CowWeight_t)$ are the fixed costs associated with a cow, her calf and 1/25 of a bull in year *t* as a function of cow weight ($CowWeight_{it}$),

$OtherVarCost_t(CowWeight_t)$ are the other variable costs associated with a cow, her calf and 1/25 of a bull in year *t* as a function of cow weight ($CowWeight_t$),and *Acres Per Cow* is the number of acres required to meet the cows nutritional needs. It is assumed that the operation requires one bull per 25 cows and heifers, and a bull's longevity is five years.

Calf weaning weight, $CalfWeanWeight_{it}$, for animal *i* in year *t* is a function of cow age ($CowAge_{it}$), cow weight ($CowWeight_{it}$), calf birth weight ($CalfBirthWeight_{it}$), dam breed ($DamBreed_i$ ε {Angus, Brangus}), sire breed ($SireBreed_i$ ε {Angus, Brangus}), sex of calf (Sex_i ε {Heifer, Steer}), calf age at weaning ($AgeWean_i$), forage type ($Forage_i$ ε {Bermuda, Native}), and calving season ($Season_i$ ε{Spring, Fall}). Or,

$$CalfWeanWeight_{it} = f\big(CowAge_{it}, Cow\ Weight_{it}, CalfBirthWeight_{it}, DamBreed_i, SireBreed_i, Sex_{i,} AgeWean_i, Forage_i, Season_i\big).$$

Calf birth weight, $CalfBirthWeight_{it}$, for animal *i* in year *t* is a function of cow age ($CowAge_{it}$), cow weight ($CowWeight_{it}$), dam breed ($DamBreed_i$ ε {Angus, Brangus}), sire breed ($SireBreed_i$ ε {Angus, Brangus}), sex of calf (Sex_i ε {Heifer, Steer}),conditional on forage type ($Forage_i$ ε {Bermuda, Native}), and calving season ($Season_i$ ε{Spring, Fall}). Or,

$$CalfBirthWeight_{it} = g\big(CowAge_{it}, Cow\ Weight_{it}, DamBreed_i, SireBreed_i, Sex_{i,} Forage_i, Season_i\big).$$

The price of the calf at weaning, $CalfPriceHeifer_{it}$, in year *t* for animal *i* is a function of calf weaning weight ($CalfWeanWeight_{it}$), calving season (*Season*) and sex of the calf (*Sex*). Mathematically,

$$CalfPriceHeifer_{it} = h(CalfWeanWeight_{it}, Season, Sex).$$

The price of the calf at weaning, $CalfPriceSteer_{it}$, in year *t* for animal *i* is a function of calf weaning weight ($CalfWeanWeight_{it}$), calving season (*Season*) and sex of the calf (*Sex*). Mathematically,

$$CalfPriceSteer_{it} = o(CalfWeanWeight_{it}, Season, Sex)$$

Feed cost, $FeedCost_{it}$, in year *t*, is a function of cow weight ($CowWeight_{it}$), cow breed *(DamBreed)* forage type (*Forage*), and calving season (*Season*). Mathematically,

$$FeedCost_{it} = l(CowWeight_{it}, DamBreed, Forage, Season).$$

Hypotheses

Two hypotheses are tested. These are listed below, including references to previous research reporting similar results.

H1: Cows of a moderate weight will be the most profitable weight cow for a typical cow-calf operation.

This hypothesis is postulated due to the balance between higher feed costs associated with larger cattle and pounds of calf produced. It is unlikely, based on previous literature, that extremely large cows will be able to produce enough pounds of calf to offset their significantly higher feed costs (Miller et al., 2001; Ramsey et al., 2005; Doye and Lalman, 2011).

H2: There is a positive relationship between cow weight and operating costs.

Larger cows require more feed, comprising a large portion of the cost within a profit function (Miller et al., 2001; Ramsey et al., 2005; Doye and Lalman, 2011).

Empirical models and procedures

Birth weight model

The calf birth weight model was estimated using the MIXED procedure in SAS Enterprise Guide 5.1 (SAS Institute Inc., 2012). The SAS MIXED procedure uses restricted maximum likelihood estimation.

The equation used to estimate calf birth weight (*$CalfBirthWeight_{it}$*) has the following form

(4)

$$CalfBirthWeight_{it} = \beta_1 + \beta_2 CowAge_{it} + \beta_3 CowAge_{it}^2 + \beta_4 DamBreed_{it} + \beta_5 SireBreed_{it} + \beta_6 Sex_{it} + \beta_7 Ln(CowWeight_{it}) + \beta_8 Forage_{it} + \beta_9 Season_{it} + e_{it} + v_t.$$

In equation (4), $CalfBirthWeight_{it}$ denotes calf birth weight for animal *i* and year *t*; $CowAge_{it}$ denotes cow age; $DamBreed_{it}$ ε {Angus, Brangus} denotes the breed of the calf's dam;

SireBreed$_{it}$ ε {Angus, Brangus} denotes the sire's breed; *Sex*$_{it}$ ε {Heifer, Steer} indicates calf sex; *Ln(CowWeight*$_{it}$*)* denotes the natural log of the cow's weight; and *Forage*$_{it}$ ε {Bermuda, Native range} indicates forage type; *Season*$_{it}$ ε {Fall, Spring} denotes calving season. The error term e_{it} and the random effect for year v_t were assumed to be independent and normally distributed.

Other equations tested included different mathematical forms of cow weight (*CowWeight*$_{it}$*)* including linear squared terms. AIC fit statistics (Greene, 1993) were used to determine the model including the natural log of cow weight best fit the data set. Multicollinearity in the calf birth weight model was tested by using Variance Inflation Factor (VIF) (Kutner, 2004). The standard value of five served as a benchmark to determine if multicollinearity existed in a variable. All variables showed a VIF value of less than five, and so multicollinearity was not judged to be problematic.

White's heteroscedasticity test (White, 1990) was used to determine detect heteroscedasticity. The variables *CowWeight* or *CowAge* showed signs of heteroscedasticity. Heteroscedasticity was corrected by using SAS *repeated/local* command to estimate a heteroscedastic consistent variance-covariance matrix (SAS Institute Inc., 2012).

Weaning weight model

The calf weaning weight model was also estimated using the MIXED procedure in SAS Enterprise Guide 5.1 (SAS Institute Inc., 2012).

The equation used to estimate calf weaning weight has the following form

(5)

$$CalfWeanWeight_{it} = \beta_1 + \beta_2 CowAge_{it} + \beta_3 CowAge_{it}{}^2 + \beta_4\, DamBreed_{it} + \beta_5\, SireBreed_{it} + \beta_6 Sex_{it} + \beta_7 AgeWean_{it} + \beta_8 CalfBirthWeight_{it} + \beta_9 Ln(CowWeight_{it}) + \beta_{10} Season_{it} + \beta_{11} Forage_{it} + u_{it} + w_t.$$

In equation (5), *CalfWeanWeight*$_{it}$ denotes calf weaning weight for animal *i* and year *t*; *CowAge*$_{it}$ denotes cow age; *CowAge*$_{it}^{2}$ denotes cow age squared; *DamBreed*$_{it}$ ε {Angus, Brangus} denotes the breed of the calf's dam; *SireBreed*$_{it}$ ε {Angus, Brangus} denotes the sire's breed; *Sex*$_{it}$

ε {Heifer, Steer} indicates calf sex; $AgeWean_{it}$ denotes the weaning age; $CalfBirthWeight_{it}$ denotes the birth weight of the calf; $Ln(CowWeight_{it})$ denotes the natural log of the dam's weight; $Season_{it}$ ε {Fall, Spring} denotes calving season; and $Forage_{it}$ ε {Bermuda, Native range} indicates forage type. The error term u_{it} and the random effect for year w_t are assumed to be independent and normally distributed.

Other equations tested included different mathematical forms of cow weight (*CowWeight)* including linear and squared terms. The linear form of cow age *(CowAge)* was also tested. AIC fit (Greene, 1993) statistics (a smaller number indicates a better fit) were used to determine the model including the natural log of cow weight and a quadratic for cow age best fit the data set. To confirm this assumption, the mean calf weaning weight for each cow weight from the raw data were graphed and included in Figure 1. The shape of the raw data suggests that the natural log form of cow weight fits the data well.

Multicollinearity in the calf weaning weight model was tested by using Variance Inflation Factor (VIF) (Kutner, 2004). The standard value of five served as a benchmark to determine if multicollinearity existed in a variable. All variables showed a VIF value of less than five except for variables $CowAge_{it}$ and $CowAge_{it}^2$. This result is expected given that one is just the square of the other, so no correction was needed for multicollinearity.

As in the previous estimation, White's heteroscedasticity test (White, 1990) was used to detect heteroscedasticity. The variables *CowWeight* or *CowAge* again showed signs of heteroscedasticity and were corrected by using SAS *repeated/local* command to estimate a heteroscedastic variance-covariance matrix (SAS Institute Inc., 2012).

Cow weight by year

Mature cow weights for calculations ranged from 950 pounds to 1,800 pounds, in 50 pound increments. Cows are assumed to reach their mature weight at age six. It was also assumed cows reached 65% of their mature weight at age one, 85% of their mature weight at age two, and gained an additional 4% of their mature weight in years three through five. Table 1 shows cow weight by year.

Ration Calculations

Rations were calculated by month based on calf birth weight predicted by the calf birth weight regression, breed type (Angus or Brangus), forage type (Bermuda or native range), and season (spring or fall) using CowCulator (Lalman and Gill, 2010), which uses recommendations from National Research Council (2000). It was assumed that spring-calving cows calved on April 10 and fall-calving cows calved on September 15 based on the average calving dates in the data set. Values for Bermuda and native range nutrition by month were taken from Brorsen et al. (1983) and Doye and Lalman (2011) and entered into CowCulator. Cow rations were developed to allow an increase from a body condition score of 5.0 to a body score of 5.5 during mid gestation through early lactation and fall from a body condition score of 5.5 to a body condition score of 5.0 during early through late lactation. It was imposed that intake ratio was maintained at a level of 1.00 and crude protein was maintained at a minimum level of 1.00. Average daily gain was used to assure body condition score goals were being met. Appendix tables A1 A8 show rations by year under the various scenarios. A total of 10,368 monthly rations were developed.

Price Forecasts

Forecasts reflecting past cattle cycle price fluctuations were calculated for calf, cull cow, cull bull, alfalfa hay, wheat mid, cottonseed, and molasses prices by adjusting past prices to 2014-levels using the percentage change between years (USDA-AMS, 2015; University of Wisconsin, 2015). Historical annual prices were taken from 1990-2004. Prices were adjusted by calculating the percentage change between annual prices in the historical years and imposing those established changes on the 2014 prices to simulate possible price fluctuations associated with the cattle cycle for years 2014 through 2028. Wheat mid, cottonseed, and molasses price forecasts were combined to create the 20% range cube price forecasts. Range cube price forecasts encompassed 65% of the wheat mids price, 30% of the cottonseed price and 3% of the molasses price. Appendix tables A9 A12 report price projections.

GAMS Models

From Brorsen et al. (1983), Bermuda grass yielded 7,720 pounds per acre with 35% utilization rate while native range pasture yielded 4,970 pounds per acre with 20% utilization rate (Doye and Lalman, 2011). Hay loss was assumed at 21% (Stotts, 2011). Bermuda grass pasture rent was assumed as $21.01 and native range pasture rent as $13.39 per acre (Doye and Lalman, 2011). Other ration component prices are as listed in the data section. Feed costs were then scaled to range from 60% of baseline to 150% of baseline cost, in 10% increments, representing variations in feeding management and variations in the quality of range at individual farms was included.

Feed costs were calculated as

(6)

$$\begin{aligned} FeedCost_{it}|CowWeight_{it} &= [(Cubes_{it}(CowWeight_{it}|Breed_i, Forage_i, Season_i) \times CubePrice_t \\ &+ Hay_{it}(CowWeight_{it}|Breed_i, Forage_i, Season_i) \times 1.21 \times HayPrice_t \\ &+ \frac{Forage_{it}(CowWeight_{it}|Breed_i, Forage_i, Season_i)}{Forage\ Yield(Forage_i)} \\ &* ForagePrice_t(Forage_i))] \times (1 - Prob\ (Cull\ at\ Age_t)). \end{aligned}$$

In equation (6) $FeedCost_{it}|CowWeight_{it}$ denotes the feed cost for cow-calf pair *i* in year *t* given cow weight ($CowWeight_{it}$); $Cubes_{it}$ denotes cube quantity fed as a function of cow weight ($CowWeight_{it}$) given breed ($Breed_i$), forage ($Forage_i$), season ($Season_i$); $CubePrice_t$ denotes cube price; Hay_{it} denotes hay quantity fed as a function of cow weight ($CowWeight_{it}$) given breed ($Breed_i$), forage ($Forage_i$), season ($Season_i$); $HayPrice_t$ denotes hay price; $Forage_{it}$ denotes forage quantity fed as a function of cow weight ($CowWeight_{it}$) given breed ($Breed_i$), forage ($Forage_i$), season ($Season_i$); $Forage\ Yield$ denotes the amount of forage produced in pounds per acre dependent on forage type (*Forage$_i$*); $ForagePrice_t$ denotes forage price for forage type (*Forage$_i$*); *Prob(Cull at Age$_t$)* denotes the probability of the cow being culled at cow age (*CowAge$_t$*).

Revenue includes calf revenue, cull cow revenue, and cull bull revenue. Bull weight was determined by assuming cow weight is 70% of bull weight. Bull service rates were assumed at 25 cows per bull, so bull revenues and costs were distributed across 25 cows, and then further divided by five to indicate that bulls were replaced every five years. A price discount of $3.48 cents was assumed for Brangus calves (Williams et al., 2007).

The equation for revenue is as follows

(7)

$$Revenue_{it} = CalfWeanWeight_{it}(\cdot) \times \frac{CalfPriceHeifer_{it}(\cdot) + CalfPriceSteer_{it}(\cdot)}{2} \times (1 - Prob\ (Cull\ at\ Age_t)) \times\ CowWeight_{it} \times CowCullPrice_t(Season_i) \times Prob\ (Cull\ at\ Age_t) + \frac{CowWeight_{i6}}{0.7} \times CullBullPrice_t(Season_i) \times \left(\frac{1}{125}\right).$$

Equation (7), $Revenue_{it}$, is the revenue generated from cow-calf pair *i* in year *t*; $CalfWeanWeight_{it}$ denotes calf weaning weight, *CalfPriceHeifer$_{it}$* denotes calf price for heifer calves, *CalfPriceSteer$_{it}$* denotes calf price for steer calves, *Prob(Cull at Age$_t$)* denotes the probability of the cow being culled from the herd at a given age; *CowWeight$_{it}$* denotes cow weight; $CowCullPrice_t$ denotes cull cow price given calving season (*Season$_i$*); $CullBullPrice_t$ denotes bull cull price.

Bull purchase costs were assumed as $3,400 per bull and then divided by 25 to represent the cost to each individual cow, and further divided by five to represent a five-year replacement schedule. Fixed costs and other variable costs were sourced from Doye and Lalman (2011). Appendix table A15 lists fixed and other variable costs. A discount rate of 5% was assumed. Annual net returns were computed as

(8)

$$NetRet_{it}|CowWeight_{it}$$
$$= Revenue_{it} - FeedCost_{it}|CowWeight_{it} - FixedCost_t|CowWeight_{it}$$
$$\times (1 - Prob\ (Cull\ at\ Age_t)) - OtherVarCost_t|CowWeight_{it}$$
$$\times (1 - Prob\ (Cull\ at\ Age_t)) - BullCost \times \left(\frac{1}{125}\right).$$

In equation (8), $NetRet_t|CowWeight_{it}$, is the net return generated from animal *i* in year *t* given cow weight ($CowWeight_{it}$); $Revenue_{it}$ is the revenue from weaned calf sales; $FeedCost_{it}|CowWeight_{it}$ denotes feed costs given cow weight ($CowWeight_{it}$); $FixedCost_t|CowWeight_{it}$ denotes fixed cost given cow weight ($CowWeight_{it}$); $OtherVarCost_t|CowWeight_{it}$ denotes other variable costs given cow weight ($CowWeight_{it}$); $Prob(Cull\ at\ Age_t)$ is the probability of a cow being culled from the herd at cow age ($CowAge_t$); $BullCost$ denotes bull costs.

Net present value on a per cow basis, assuming a ten-year maximum productive cow life and a 5% discount rate, is then calculated as

(9)

$$NPV_i|CowWeight_{it} = \sum_{t=1}^{10} \frac{NetRet_t|CowWeight_{it}}{(1+0.05)^t}.$$

Acres per cow is calculated assuming Bermuda pasture yields 2,702 pounds of grass per acre and native pasture yields 994 pounds per acre (Doye and Lalman, 2011; Brorsen et al., 1983).

$$Acres\ Per\ Cow = \frac{Forage_{it}(CowWeight_{it}|Breed_i, Forage_i, Season_i)}{Forage\ Yield(Forage_i)}$$

Net present value on a per acre basis, assuming a ten-year maximum productive cow life and a 5% discount rate, is then calculated as

(10)

$$NPV_i|CowWeight_{it} = \sum_{t=1}^{10} \frac{NetRet_t|CowWeight_{it}}{(1+0.05)^t \times acres\ per\ cow}.$$

Data

Data on cows, calves, bulls, calving season, and forage type were collected from two Oklahoma research stations, Oklahoma State University North Range and El Reno, and one Arkansas research station, Booneville. Data were collected from 1988 to 2009 and include 3,041 observations. Data included year, age of cow, cow weight, breed of calf dam, breed of calf sire, calf birth weight, season calf was born, calf weaning date, calf weaning weight, age at weaning in days and forage type at that location. Table 2 and Table 3 show the summary statistics for the data.

The last complete cattle cycle was determined by graphing historical cattle prices and the number of head in the United States as seen in Appendix figure 1. The number of cattle in the US was at a relative low in the early 1990's. Numbers rose until peaking in 1996 and then fell to a new relative low in 2004 (USDA-AMS, 2015). This time period was used to simulate price trends depicting a complete cattle cycle.

Cattle rations consisted of grazed forage (Bermuda or native range), 20% protein range cubes, and alfalfa hay. Forage prices on a per acre basis were from Doye and Lalman (2011). Historical price data for Bermuda hay, Prairie hay, and cubes were used to determine percentage changes in price between years throughout a full cattle cycle, 1990-2004. Bermuda and Prairie hay price data for 1990-2004 were from USDA-AMS (2015). Historical price data for 20% protein range cubes were not available. It was assumed that a 20% range cube is composed of 65% wheat mids, 30% cottonseed and 3% molasses. Historical data from those ingredients were used to approximate historical prices per ton of 20% protein range cubes. Wheat mids, cotton seed, molasses, soybean and corn price data were obtained from University of Wisconsin (2015).

Wheat mids, cottonseed and molasses prices were available for years 1992 through 2004. Wheat mid and wheat prices are positively correlated, so wheat prices were used to approximate 1990 and 1991 prices for wheat mids. Wheat price data were sourced from USDA (2015). The relationship between wheat and wheat mids was then imposed on the 1990 and 1991 data to approximate the prices for wheat mids for 1990 and 1991. Cotton seed prices and soybean prices, as well as molasses prices and corn prices, are also correlated, so the same process was used to approximate 1990 and 1991 prices for cotton seed and molasses. Soybean and corn prices also were obtained from University of Wisconsin (2015).

USDA-AMS (2015) auction data were used to determine calf, cull cow prices, and cull bull prices. Calf prices from 1990-2014 were used. Calves were assumed to be weaned at 205 days. Fall–born calf prices were taken from April 1, each year, plus or minus seven days. Spring–born calf prices were taken November 1, each year, plus or minus seven days. Prices were given for steers and heifers within the weight range of 300-700 pounds, in 50 pound increments. Linear interpolation was used to approximate calf prices for predicted calf weaning weights. Brangus calves were assumed to be discounted in price at the sale barn by $3.48 per cwt. when compared to Angus (Williams et al., 2012). Oklahoma City data did not include historic cull cow and cull bull prices. Colorado auction data were used to establish cattle cycle price trends for cull cows, by determining the percentage change in prices for historical years. The price variations were then applied to the recorded 2014 Oklahoma City data to establish a forecast. It was assumed that open cows would be culled 41 days after breeding season ended. Cull price was recorded annually on January 17 plus or minus seven days for fall calving cows, and August 12 plus or minus seven days for spring calving cows. Bull prices from as early as 1990 were not available, so the year-to-year relationship to cull cow prices were used to model cull bull prices.

Cow culling data by age of cow were from Azzam et al. (1990). Data from Montana herds were used as culling was based on several factors including health, management decisions, and a maximum age of ten years. Non-feed cost data including veterinary care, marketing, fuel, labor and operating interest as well as fixed costs were from Doye and Lalman (2011). Costs for only two cow weights, 1100 and 1400 pounds were reported, so linear interpolation/extrapolation was used to approximate fixed and variable costs for cows ranging from 950-1800 pounds, in 50 pound increments.

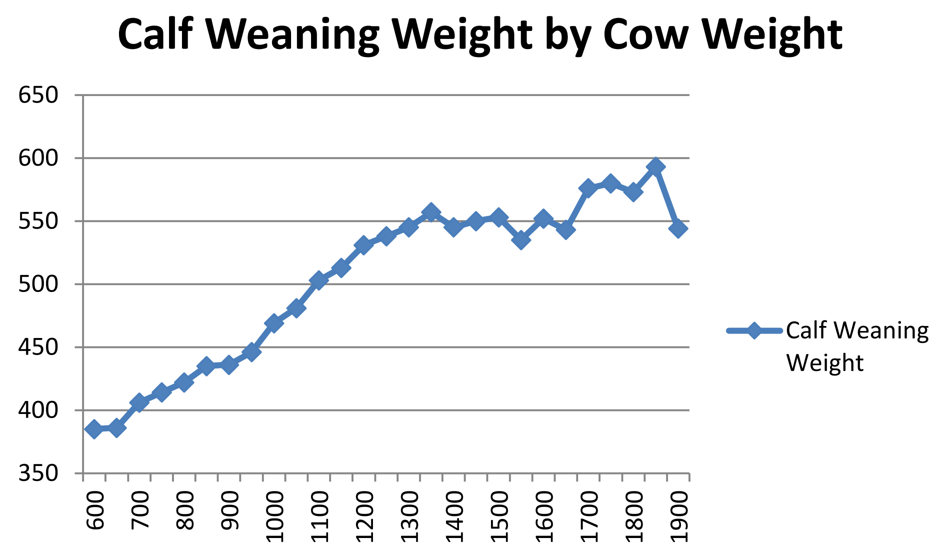

Figure 1. Graph of average calf weaning weight by cow weight.

Table 1. Cow weight by years of age

Mature Weight	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
950	618	808	840	873	908	950
1000	650	850	884	919	956	1000
1050	683	893	928	965	1004	1050
1100	715	935	972	1011	1052	1100
1150	748	978	1017	1057	1100	1150
1200	780	1020	1061	1103	1147	1200
1250	813	1063	1105	1149	1195	1250
1300	845	1105	1149	1195	1243	1300
1350	878	1148	1193	1241	1291	1350
1400	910	1190	1238	1287	1339	1400
1450	943	1233	1282	1333	1386	1450
1500	975	1275	1326	1379	1434	1500
1550	1008	1318	1370	1425	1482	1550
1600	1040	1360	1414	1471	1530	1600
1650	1073	1403	1459	1517	1578	1650
1700	1105	1445	1503	1563	1625	1700
1750	1138	1488	1547	1609	1673	1750
1800	1170	1530	1591	1655	1721	1800

Note: Cow weight (lbs) calculated by age of cow in years based on stated mature weights.

Table 2. Summary statistics of cattle characteristics

Item	Mean	SD	Minimum	Maximum
Observations (n)	3041	--	--	--
Cow Age	4.9	1.8	1.8	11.0
Cow Weight (lbs.)	1190.1	206.1	635.0	1922.0
Calf Birth Weight (lbs.)	83.7	15.6	40.0	168.0
Weaning Weight (lbs.)	505.6	93.7	195.0	875.0
Year Born	2000.5	6.9	1988.0	2009.0
Age at Weaning in Days	208.5	22.2	132.0	277.0

Table 3. Summary statistics of cattle characteristics

Category	Frequency	Percent
Season		
Fall	390	12.8
Spring	2651	87.1
Calf Sex		
Heifer	1515	49.8
Steer	1526	50.2
Breed of Dam		
Angus	1111	36.7
Angus x Brangus	220	7.3
Brangus	1087	35.9
Brangus x Angus	193	6.4
Bosmara x Brangus	73	2.2
Charolais	65	2.1
Gelbvieh	85	2.8
Herford	88	2.9
Maine	1	0.0
Romosinuano	68	2.2
South Devon	35	1.2
Unknown	15	0.2
Breed of Sire		
Angus	963	31.7
Brangus	395	13.0
Bonsmara	110	3.6
Charolais	166	5.5
Gelbvieh	67	2.2
Herford	833	27.4
Maine	323	10.6
Red Polled	90	3.0
Romosinuano	59	1.9
Simmental x Angus	35	1.1
Forage		
Bermuda	623	20.5
Fescue	430	14.1
Native Plain	1826	60.0
Rye	162	5.3
Location		
Booneville, AR	1215	39.9
El Reno, OK	1095	36.0
OSU North Range, OK	731	24.0

CHAPTER IV

Results

Regression Diagnostics

As detailed in Chapter 3, both *CalfBirthWeight*, and *CalfWeanWeight* models were estimated using the MIXED procedure in SAS Enterprise Guide 5.1 (SAS Institute Inc., 2012). White's heteroscedasticity test detected heteroscedasticity in both models (White, 1990) and a heteroscedasticity consistent variance-covariance matrix was estimated.

Regression Variable Results

Birth Weight Variables

Coefficient estimates for the *CalfBirthWeight* model are shown in Table 4. Statistical tests of fixed effects are reported in Table 5. Of the 28 variables in the model, 19 are significant at $p \leq 0.05$ or smaller, with 11 of the 28 significant at $p \leq 0.0001$.

The coefficient for cow age *(CowAge*) is positive and statistically significant, in agreement with Minyard et al. (1965). The coefficient for cow age squared (CowAge^2) is negative and statistically significant. These two coefficients indicate weaning weight increases with cow age at a diminishing rate, with a maximum weaning weight at age eight. The coefficients for Angus and Brangus cow breed (*DamBreed*) dummy variables are statistically significant with a base of unknown breed. Birth weight increases by 6.78 pounds for an Angus cow and increases by 4.70 pounds for a Brangus cow. The coefficient for the natural log of cow weight (*Ln(CowWeight)*) is positive and statistically significant. As cow weight increases, calf birth weight increases at a decreasing rate, similar to Minyard et al. (1965). A cow weighing 1,800 pounds will give birth to a calf 16 pounds heavier than a cow weighing 950 pounds, *ceteris paribus*. The coefficients for Angus and Brangus calf breed of sire (*SireBreed*) dummy variables are statistically significant with a base of Simmental-Angus cross, similar to Dodenhoff (1999). Birth weight increases by 0.24 pounds for an Angus bull and increases by 8.85 pounds for a Brangus bull. The coefficient for calf sex dummy variable (*Sex*) is statistically significant with heifer calves weighing 2.81 pounds less than steer calves at birth. Zalesky et al. (2007) also found that bull calves are heavier at birth. The coefficient for dummy variable season (*Season*) is not statistically significant. This finding is in agreement with Bagley et al. (1987) who found spring and fall calving birth weights to be the same. The coefficients for Bermuda and native forage type (*Forage*) dummy variables are statistically significant with a base of Rye grass. Bermuda grass decreases birth weight by 2.49 pounds and native range increases birth weight by 4.47 pounds.

Weaning Weight Variables

Coefficient estimates for each variable in this research for *CalfWeanWeight* are shown in Table 6. Statistical tests of fixed effects are reported in Table 7. Of the 30 variables in the model, 23 are significant at $p \leq 0.05$ or less, with 16 significant at $p \leq 0.0001$. When comparing these estimates to similar studies (Minyard et al., 1965; Selk and Buchanon, 1990; Zalesky et al., 2007), most variables are similar in sign and significance.

The coefficient for cow age *(CowAge*) is positive and statistically significant, in agreement with Minyard et al. (1965). The coefficient for cow age squared (CowAge^2) is negative and statistically significant. These two coefficients indicate weaning weight increases with cow age at a diminishing rate, with a maximum weaning weight at age eight, similar to Minyard (1965). The coefficients for Angus and Brangus cow breed (*DamBreed*) dummy variables are statistically significant with a base of unknown breed. Weaning weight decreases by 43.4 pounds for an Angus cow and increases by 2.3 pounds for a Brangus cow compared to the base breed of unknown. The coefficient for the natural log of cow weight (*Ln(CowWeight)*) is positive and statistically significant. As cow weight increases, calf weaning weight increases at a decreasing rate, in agreement with Minyard et al. (1965). A cow weighing 1,800 pounds weans 58 more pounds of calf than a cow weighing 950 pounds, *ceteris paribus*. The coefficient for Angus and Brangus calf breed of sire (*SireBreed*) dummy variables with a base of Simmental-Angus cross are statistically significant, similar to Dodenhoff (1999). Weaning weight decreases by 55.4 pounds for an Angus bull and decreases by 74.0 pounds for a Brangus bull. The coefficient for dummy variable calf sex (*Sex*) is statistically significant. Heifer calves weigh 15.4 pounds less than steer calves at weaning, similar to Zalesky et al. (2007). The coefficient for dummy variable season (*Season*) is statistically significant. Fall born calves weigh 50.1 pounds less at weaning than spring born calves, similar to Selk and Buchanan (1990). The coefficients for Bermuda and native range forage type (*Forage*) dummy variables (base of Rye grass) are also significant. Relative to rye grass, calves on Bermuda grass have a 39.2-pound heavier average weaning weight. Calves grazing native range have a 24.2-pound heavier average weaning weight when compared to those on rye grass.

Optimal Cow Weights—Maximum NPV per head

The net present value (NPV) per head was computed and the cow weight that maximizes NPV per head is defined as the optimal mature cow weight for a given breed, forage, and calving season. Feed costs were systematically varied from 60% of the baseline cost up to 150%, in 10% increments. Baseline lifetime feed costs for cows in each scenario are reported in Table 8. As feed costs increased, the optimal cow weight decreased for all scenarios. Cow revenues over ten years for each scenario are reported in Table 9. The summary of acres required by cow weight and scenario are reported in Table 10. The maximum NPVs per head and per head NPV -maximizing cow weights for all feed cost scenarios are reported in Table 11.

The year of the cattle cycle that a heifer enters the herd was varied to determine if optimal cow weight would change. The cattle cycle was assumed to repeat after year 15. Maximum NPVs and optimal cow weights for baseline feed costs and varied year in the cattle cycle heifers enter the herd are reported in Table 12.

Calving Season

Feed costs for fall-calving scenarios are higher than spring-calving scenarios. The nutritional needs of the fall-calving cow do not match up well with the monthly nutritional value of the forage, causing higher supplementation when compared to spring-calving scenarios. Feed costs for fall-calving cows were between 17%-34% higher than spring-calving cows. The revenue per cow across her lifetime is lower for fall-calving cows on native grass when compared to spring-calving cows, driven in part by higher prices for spring-born calves. Spring-calving scenarios had higher maximum net present values relative to their fall-calving counterparts. Fall-calving scenarios are more sensitive to increases in feed costs than spring scenarios, resulting in negative NPVs for high feed cost scenarios. This is not surprising due to the higher supplementation needs of fall-calving cows.

Sensitivity analyses were performed on the impact of feed costs. Feed costs were varied from 60% to 150% of baseline feed costs. For fall-calving Angus cows on Bermuda grass, increasing feed costs 130% or greater above baseline results in negative NPVs. For fall-calving Brangus cows on Bermuda grass, increasing feed costs above 150% baseline results in negative NPVs. Less acres per cow are required for fall-calving cows, when compared to spring as CowCulator shows that fall-calving cows receive more nutrition from hay and cubes than spring calvers. When comparing between breeding seasons, per head-profit-maximizing weight, as per equation (2), changes as feed costs are varied from baseline. As feed costs increase for both spring and fall-calving scenarios, the optimal cow weight decreases. Spring scenarios have the largest spread of NPV-per-head-maximizing cow weights between high and low feed costs

When the feed costs are lowest, 60% of baseline feed costs, the heaviest cow at 1,800 pounds is optimal for all Angus spring-calving scenarios. At 150% of baseline feed costs, the NPV-per-head-maximizing cow weight for spring-calving scenarios decreases to 1,050 pounds for Angus grazing Bermuda or native forage. The NPV-per-head-maximizing cow weight for fall-calving Angus cows on Bermuda grass is 950 pounds for all feed cost scenarios. Feed costs are highest for fall-calving Angus cows on Bermuda, resulting in the lowest optimal cow weight for all feed costs scenarios. For all other fall-calving scenarios, the optimal cow weight varies with feed cost. The optimal cow weight for fall-calving Angus cows on native grass ranges from 1,750 pounds for high feed costs to 1,100 pounds for low feed costs. The optimal cow weight for spring calving Angus cows on native grass decreases more rapidly as feed costs increase, when compared to fall calving Angus cows on native grass. The feed, fixed and variable costs associated with spring calving cows on native grass increases more rapidly as cow weight increases as observed in Figure 2. This causes the optimal cow weight to decrease faster as feed costs increase when compared to fall-calving cows on native grass.

When feed costs are lowest, 60% of baseline feed costs, the heaviest cow at 1,800 pounds is optimal for all Brangus spring-calving scenarios. At 60% of baseline feed costs, fall-calving Brangus cows on Bermuda have an optimal cow weight of 1,350 pounds. At 150% of feed costs, spring-calving Brangus cows on Bermuda have a NPV-per-head-maximizing cow weight of 1,300 pounds and fall-calving Brangus cows on Bermuda have an optimal cow weight of 950 pounds. Feed costs are much higher for fall-calving Brangus cows on Bermuda grass when compared to spring so the smaller 950 pound cow is optimal. At 60% of baseline feed costs, fall-calving Brangus cows on native grass have an optimal cow weight of 1,750 pounds. At 150% of feed costs, spring-calving Brangus cows on native grass have an optimal cow weight of 950 pounds and fall-calving cows on native grass have an optimal cow weight of 1,400 pounds. Feed costs, fixed costs, and variable costs for spring-calving Brangus cows on native increase at a faster rate as cow weight increases, when compared to fall-calving Brangus cows grazing native grass. This results in a faster decrease in optimal cow weight as feed costs increase, causing the large optimal weight range between 60% and 150% of baseline feed costs for this scenario. There are no clear trends between optimal cow weight and calving season when the year in the cattle cycle the heifer enters the herd is varied.

Forage Type

Feed costs are higher for cows grazing Bermuda grass when compared to those grazing native grass. Late season Bermuda grass is of a lower quality than native grass and requires more supplementation. Forage is the least expensive of the feed components, so higher supplementation required by cows grazing Bermuda grass greatly impacts feed costs. On average, feed costs for cows grazing Bermuda grass ranges 18%-34% higher compared to cows grazing native grass. However, forage type has a negligible effect on revenue generated.

The profit-maximizing cow weight per head, as in equation (2), for most scenarios is responsive to feed cost increases. There is no trend in NPV-per-head-maximizing cow weight for forage type without also considering calving season. Spring-calving cows on Bermuda grass have equal or heavier optimal weights when compared to spring-calving cows on native grass, as feed costs vary from 60%-150% of baseline feed costs. As feed cost increases for spring-calving cows on Bermuda grass, the optimal cow weight does not decrease as rapidly as spring-calving cows on native grass. The feed, fixed and variable costs associated with spring-calving cows on native grass increases more rapidly as cow weight increases. This causes the optimal cow weight to decrease faster as feed cost increases when compared to spring-calving cows on Bermuda grass.

Fall-calving cows on Bermuda grass have lower NPV-per-head-maximizing weights when compared to their counterparts on native grass for all feed costs. Supplementation costs are the highest of all scenarios for fall-calving cows on Bermuda grass. This leads to lighter cows which require less supplementation, as optimal despite variations in feed costs. When nutritional needs are highest for fall-calving cows on Bermuda grass, the forage quality is near its lowest.

The NPV-maximizing per head cow weight, as in equation (2), varies for most scenarios depending on the year in the cattle cycle the heifer enters the herd. The exception is fall-calving Angus and Brangus cows on Bermuda grass where the optimal cow weight is 950 pounds. Fall-calving Angus and Brangus cows grazing Bermuda grass have the highest feed costs of all scenarios, resulting in the lightest cow weight as optimal regardless calf and feed prices levels.

NPV-per-head-maximizing cow weights across cattle cycle heifer entrance years are higher for spring-calving Bermuda scenarios for both breeds when compared to fall. Spring-calving Bermuda scenarios have lower feed costs when compared to fall-calving Bermuda scenarios, resulting in heavier NPV-per-head-maximizing cow weight. Optimal cattle weights are higher for spring-calving cows on Bermuda grass when heifers enter the herd in cattle cycle years one through five and 15. Entering in those years means that annual Bermuda hay costs are lower when the cow has high feed requirements later in life.

The NPV-per-head-maximizing cow weights for both fall- and spring-calving cows on native range fluctuates more throughout cattle cycle entrance years than cows grazing Bermuda grass. The price of native hay is forecasted to vary more from year to year, causing the NPV-per-head-maximizing cow weight to vary across the cattle cycle. In years where the cow reaches maturity during low feed price years, the optimal cow weight is heavier.

Spring-calving Brangus cows on native grass have the heaviest NPV-per-head-maximizing cow weights of 1,700 for most years of the cattle cycle, when compared to the other native grass scenarios. This scenario has lower feed cost compared to other native grazing scenarios, which results in a heavier optimal cow weight.

Breed

Feed costs are slightly higher for Angus cows in all scenarios when compared to Brangus cows. On average feed costs are 3%-6% higher for Angus cows. Revenue is higher for Brangus cows. Although Brangus cows receive less per pound for calves, they wean heavier calves than Angus cows, resulting in a 5% average increase in revenue. Brangus cattle are less sensitive to increases in feed price as they require less additional supplementation.

The per-head-profit-maximizing cow weight varies in response to changes in feed costs depending on breed. In general, the optimal cow weights for Angus cows are 50 pounds lighter than Brangus cows as feed price varies. The largest difference is spring-calving cows on native grass, where the optimal cow weight for Brangus cows is 150 pounds heavier than for Angus cows. Brangus cows have heavier optimal cow weights because they are able to produce more pounds of calf on less feed supplementation.

The per-head-profit-maximizing cow weight also varies in response to the year in the cattle cycle that the heifer enters the herd, breed, and calving season. Spring-calving Angus cows have lower optimal cow weights across the cattle cycle when compared to Brangus cows. This is most likely due to consistently lower feed costs for Brangus cows. Fall-calving Angus and Brangus cows on Bermuda grass have the same optimal cow weight of 950 pounds regardless of cattle cycle year. Feed costs are high for both Angus and Brangus cows on Bermuda grass, so the lighter cow that requires less supplementation is optimal. There is not a clear trend between fall-calving Angus and Brangus cows grazing native grass.

Optimal Cow Weights—Maximum NPV per acre

Net present value (NPV) per-head per-acre was computed based on the number of acres needed by forage, cow weight and calving season. A grid search was used to find the mature cow weight that maximizes NPV-per head-per acre, or optimal mature cow weight, for each breed, forage, and calving season combination. Feed costs were then varied from 60% to 150% of baseline costs and optimal cow weights determined again to assess sensitivity of the results to feed efficiency and resource quality. The annual NPV-per head-per acre and NPV-per head-per acre maximizing cow weights for all feed cost scenarios on a per acre basis are reported in Table 13. The year of the cattle cycle that the heifer entered the herd was also varied to determine if NPV-per head-per acre maximizing cow weights changes as price varies cyclically. The cattle price cycle was assumed to repeat after year 15. Maximum NPV-per head-per acre and optimal cow weights for baseline feed costs and varied year in the cattle cycle heifers enter the herd are reported in Table 14.

Calving Season

The profit-maximizing cow weight per-head per-acre, as per equation (3), was compared between calving seasons. Spring-calving scenarios had higher NPVs-per head-per acre than their fall-calving counterparts. Fall-calving cows require more acres per cow than spring-calving scenarios. Forage quality is low in the fall, so meeting the cow's nutritional needs requires more acres and more supplementation. Profit generated per-head-per acre by fall-calving scenarios is more sensitive to increases in feed costs than spring scenarios. Similar to the profit per head evaluation, NPV- per acre-per head for fall calving Angus and Brangus cows are negative at higher feed costs. For fall-calving Angus cows on Bermuda grass, increasing feed costs to 130% or greater than baseline results in negative NPVs-per head-per acre. For fall-calving Brangus cows on Bermuda grass feed costs of 150% baseline, results in negative NPVs-per head-per acre. The NPV-per head-per acre are lower for fall-calving scenarios compared to spring-calving scenarios. The average NPV-per head-per acre throughout the cattle cycle for fall scenarios ranges 57%-78% lower than spring scenarios. The NPV-per head-per acre maximizing cow weights for varied feed costs and varied years of the cattle cycle heifers enter the herd does not change. The smallest cow at 950 pounds is the NPV-per head-per acre maximizing cow weight for both spring and fall scenarios under all feed and cattle cycle conditions. A greater number of lighter cows can be fed on fewer acres, which is not overcome by increased revenue per heavier cow.

Forage

On average, cows grazing native grass require seven more acres per cow across all mature cow weights when compared to cows grazing Bermuda grass. This is due to the CowCulator model predicting higher levels of supplementation for cows on Bermuda grass where cows on native grasses are able to receive most of their annual nutritional requirements from grass. So, the stocking rate for Bermuda grass is higher because the quality of grass is poor and cows rely more on supplementation to meet their nutritional needs compared to native grazing. The lightest cows require six more acres per cow when grazing native grass, and the largest cows require ten more acres per cow. NPVs-per cow-per acre, as in equation (3), are generally higher for cows grazing Bermuda grass when compared to cows grazing native. The main reason behind the higher NPV for cows grazing Bermuda grass is the higher stocking rate. The lightest cows grazing Bermuda require on average two acres per cow while cows grazing native require on average nine acres. An individual cow's returns are being divided over fewer acres in the Bermuda scenario. The exceptions are fall-calving scenarios, which require more supplementation. If feed costs are 130% of baseline feed costs or higher for Angus cows, and 150% for Brangus cows, NPV-per head-per acre becomes negative. Additionally due to the higher supplementation when grazing Bermuda grass, NPV-per head-per acre decreases more rapidly as feed cost increases when compared to native grazing scenarios. The NPV-per head-per acre maximizing cow weight remains at the 950 pounds for all grazing scenarios despite varying the feed cost and the year in the cattle cycle the heifer enters the herd.

Breed

Brangus cows require slightly more acres per cow than Angus cows as CowCulator predicts that they rely less on supplementation and more on forage to meet their nutrient requirements. So, NPVs-per cow-per acre are higher for Brangus cows than Angus cows, despite a lower selling price for Brangus calves. In the spring calving scenarios, NPVs-per cow-per acre from Brangus cows are 8% higher than Angus cows. In fall calving scenarios, the gaps were larger with NPV-per cow-per acre from Brangus cows 25% higher on native grass and 40% higher on Bermuda grass. Brangus cows perform better under scenarios where the feed requirements of the animals and the nutrients provided by the environment are not well matched. The NPV-per cow-per acre maximizing cow weight did not vary from the 950-pound cow with feed costs and the year of the cattle cycle the heifer entered the herd.

Sensitivity Analysis

The NPV-per cow-per acre maximizing cow weights found are sensitive to calf price assumptions and herd productivity assumptions. It was assumed in this study that smaller-framed calves did not receive a discount at the sale barn when compared to medium- or large-framed calves. This has implications to optimal cow weight as the lighter 950 pound cows are more likely to have smaller-framed calves. Studies conducted using Arkansas sale barn data found that animals identified as small-framed cattle received a price discount of as high as $22 per head. These cattle were then followed through the feedlot. It was found that it was an unjustified discount based on their performance. The smaller animals actually had higher net returns (Newport, 2013). The national average cow weight is currently 1,350 pounds (McMurry, 2013). The analysis showed that a 950-pound cow's calves would have to be discounted by $43 dollars per head each year of her life for a producer to be indifferent between a 950-pound cow and 1,350-pound cow on a per acre basis.

Finally, the model assumed that dystocia rates between large and small cows were identical. If bulls with low birth weight and high calving ease EPDs are used on herds with lighter cows, this may be the case. Unfortunately, no published data were found to support or reject the assumption of the same dystocia rates. So a simple calculation was performed to evaluate the sensitivity of predicted optimal cow weights. For a producer to be indifferent between cows weighing 950 and 1,350 pounds on a per acre basis, dystocia rates would need to be 5% higher for the 950-pound cow.

Table 4. Parameter estimates for calf birth weight (lb) model (N=3,041)

Variable	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-7.27	5.66	-1.29	0.1986
CowAge	6.47	0.73	8.91	<0.0001
$CowAge^2$	-0.52	0.07	-7.94	<0.0001
SireBreed (Simmental Angus Base)				
Angus	0.24	2.19	0.11	0.9130
Brangus	8.85	2.30	3.84	0.0001
Bonsmara	10.11	2.55	3.97	<0.0001
Charolais	7.16	2.35	3.05	0.0023
Gelbvieh	12.47	2.72	4.59	<0.0001
Herford	6.66	2.33	2.86	0.0042
Maine	13.79	2.40	5.74	<0.0001
Red Poll	14.80	2.68	5.52	<0.0001
Romosinuano	7.22	2.78	2.60	0.0094
DamBreed (Unknown Base)				
Angus	6.78	3.11	2.18	0.0294
Angus ×Brangus	2.11	3.30	0.64	0.5231
Brangus	4.70	3.19	1.48	0.1403
Brangus ×Angus	3.91	3.33	1.18	0.2398
Bonsmara	10.57	3.54	2.99	0.0028
Charolais ×Brangus	12.27	3.60	3.41	0.0007
Gelbvieh	10.92	3.54	3.09	0.0020
Herford ×Brangus	11.03	3.51	3.14	0.0017
Maine ×Brangus	-0.43	13.02	-0.03	0.9736
Romosinuano	5.18	3.58	1.45	0.1481
South Devon	5.78	3.67	1.57	0.1155
Sex (Steer Base)				
Heifer	-2.81	0.45	-6.26	<0.0001
Ln(CowWeight)	24.70	1.96	12.58	<0.0001
Season (Spring Base)				
Fall	-1.18	0.92	-1.29	0.1976
Forage (Rye Base)				
Bermdua	-2.49	1.14	-2.19	0.0288
Fescue	0.77	1.18	0.65	0.5143
Native	4.47	1.33	3.35	0.0008

Table 5. Tests of fixed effects for calf birth weight model

Effect	F Value	Pr>F
CowAge	79.3	<0.0001
$CowAge^2$	62.97	<0.0001
SireBreed	27.53	<0.0001
DamBreed	5.91	<0.0001
Sex	39.17	<0.0001
Ln(CowWt)	158.36	<0.0001
Season	1.66	0.1976
Forage	23.17	<0.0001

Table 6. Parameter estimates for calf weaning weight (lb) model (N=3041)

Variable	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-211.38	30.02	-7.04	<0.0001
CowAge	24.16	3.53	6.84	<0.0001
CowAge^2	-1.73	0.32	-5.43	<0.0001
SireBreed (Simmental Angus Base)				
Angus	-55.42	10.48	-5.29	<0.0001
Brangus	-74.02	11.05	-6.70	<0.0001
Bonsmara	-58.80	12.15	-4.84	<0.0001
Charolais	-64.13	11.23	-5.71	<0.0001
Gelbvieh	-43.15	12.96	-3.33	0.0009
Herford	-58.37	11.12	-5.25	<0.0001
Maine	-80.41	11.53	-6.98	<0.0001
Red Poll	-102.52	12.91	-7.94	<0.0001
Romosinuano	-73.64	13.22	-5.57	<0.0001
DamBreed (Unknown As Base)				
Angus	-43.36	15.17	-2.86	0.0043
Angus X Brangus	37.40	16.04	2.33	0.0198
Brangus	2.32	15.53	0.15	0.8812
Brangus X Angus	47.07	16.16	2.91	0.0036
Bonsmara	12.20	17.16	0.71	0.4774
Charolais X Brangus	4.73	17.42	0.27	0.7859
Gelbvieh	7.77	17.15	0.45	0.6506
Herford X Brangus	2.42	17.01	0.14	0.8868
Maine X Brangus	-69.66	61.94	-1.12	0.2609
Romosinuano	-14.47	17.35	-0.83	0.4043
South Devon	-36.68	17.83	-2.06	0.0398
Sex (Steer as Base)				
Heifer	-15.41	2.16	-7.13	<0.0001
AgeWean	2.13	0.05	40.32	<0.0001
CalfBirthWeight	2.01	0.09	22.68	<0.0001
Ln(CowWeight)	40.93	9.67	4.23	<0.0001
Season (Spring as Base)				
Fall	-50.14	4.42	-11.34	<0.0001
Forage (Rye as Base)				
Bermuda	39.23	5.46	7.18	<0.0001
Fescue	-16.32	5.67	-2.88	0.0041
Native Range	24.20	6.40	3.78	0.0002

Table 7. Tests of fixed effects calf weaning weight model

Effect	F Value	Pr>F
CowAge	46.80	<0.0001
CowAge^2	29.52	<0.0001
SireBreed	10.91	<0.0001
DamBreed	39.43	<0.0001
Sex	50.89	<0.0001
AgeWean	1625.99	<0.0001
CalfBirthWeight	514.32	<0.0001
Ln(CowWeight)	17.90	<0.0001
Season	128.51	<0.0001
Forage	77.23	<0.0001

Table 8. Summary of lifetime feed costs ($/head) by cow weight (lb) for baseline feed cost scenario

Mature cow weight	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
950	$3,429	$2,636	$2,978	$1,495	$3,241	$2,428	$2,716	$1443
1000	$3,499	$2,657	$3,013	$1,533	$3,301	$2,442	$2,740	$1,489
1050	$3,564	$2,678	$3,047	$1,573	$3,358	$2,455	$2,763	$1,532
1100	$3,626	$2,699	$3,082	$1,614	$3,414	$2,469	$2,787	$1,574
1150	$3,688	$2,720	$3,114	$1,655	$3,470	$2,483	$2,810	$1,616
1200	$3,752	$2,741	$3,147	$1,697	$3,524	$2,497	$2,832	$1,657
1250	$3,814	$2,761	$3,179	$1,740	$3,579	$2,511	$2,854	$1,699
1300	$3,873	$2,782	$3,212	$1,783	$3,632	$2,525	$2,876	$1,741
1350	$3,933	$2,803	$3,243	$1,825	$3,686	$2,539	$2,904	$1,783
1400	$3,992	$2,823	$3,274	$1,867	$3,738	$2,553	$2,932	$1,825
1450	$4,051	$2,844	$3,305	$1,908	$3,791	$2,570	$2,962	$1,865
1500	$4,110	$2,865	$3,336	$1,950	$3,844	$2,594	$2,992	$1,906
1550	$4,168	$2,885	$3,370	$1,991	$3,894	$2,619	$3,023	$1,946
1600	$4,226	$2,906	$3,406	$2,031	$3,949	$2,646	$3,054	$1,985
1650	$4,284	$2,926	$3,443	$2,071	$3,997	$2,675	$3,088	$2,023
1700	$4,340	$2,948	$3,480	$2,110	$4,047	$2,704	$3,121	$2,025
1750	$4,397	$2,977	$3,518	$2,150	$4,096	$2,736	$3,157	$2,099
1800	$4,454	$3,007	$3,557	$2,189	$4,147	$2,768	$3,191	$2,137

Table 9. Summary of lifetime revenue by cow weight and scenario

Mature cow weight	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
950	$6,332	$6,321	$8,761	$8,749	$6,726	$6,717	$9,141	$9,125
1000	$6,417	$6,406	$8,862	$8,849	$6,814	$6,806	$9,241	$9,232
1050	$6,500	$6,481	$8,967	$8,954	$6,889	$6,879	$9,333	$9,324
1100	$6,580	$6,570	$9,054	$9,042	$6,969	$6,958	$9,424	$9,411
1150	$6,654	$6,644	$9,129	$9,116	$7,046	$7,029	$9,514	$9,501
1200	$6,731	$6,719	$9,208	$9,203	$7,127	$7,115	$9,612	$9,587
1250	$6,808	$6,796	$9,307	$9,296	$7,204	$7,193	$9,696	$9,688
1300	$6,883	$6,872	$9,397	$9,386	$7,281	$7,269	$9,798	$9,774
1350	$6,958	$6,947	$9,499	$9,475	$7,368	$7,357	$9,880	$9,871
1400	$7,027	$7,020	$9,575	$9,564	$7,435	$7,424	$9,966	$9,955
1450	$7,096	$7,086	$9,648	$9,638	$7,505	$7,494	$10,051	$10,040
1500	$7,163	$7,153	$9,741	$9,726	$7,573	$7,562	$10,134	$10,123
1550	$7,237	$7,222	$9,821	$9,812	$7,643	$7,630	$10,228	$10,190
1600	$7,300	$7,290	$9,899	$9,890	$7,715	$7,704	$10,328	$10,300
1650	$7,361	$7,350	$9,975	$9,967	$7,786	$7,771	$10,407	$10,401
1700	$7,425	$7,415	$10,055	$10,041	$7,860	$7,841	$10,492	$10,478
1750	$7,481	$7,479	$10,119	$10,120	$7,922	$7,911	$10,591	$10,563
1800	$7,553	$7,535	$10,206	$10,192	$7,991	$7,975	$10,672	$10,660

Table 10. Summary of acres required by cow weight and scenario

Mature cow weight	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
950	1.55	7.64	1.49	8.42	1.60	7.81	1.59	8.41
1000	1.63	8.02	1.57	8.77	1.67	8.19	1.68	8.76
1050	1.70	8.38	1.65	9.10	1.75	8.55	1.76	9.09
1100	1.76	8.73	1.73	9.42	1.81	8.91	1.84	9.41
1150	1.83	9.08	1.81	9.73	1.89	9.27	1.92	9.74
1200	1.90	9.43	1.89	10.04	1.95	9.62	2.00	10.06
1250	1.97	9.77	1.96	10.36	2.02	9.96	2.08	10.37
1300	2.03	10.10	2.03	10.67	2.08	10.31	2.16	10.68
1350	2.09	10.44	2.11	10.98	2.15	10.64	2.23	10.99
1400	2.15	10.77	2.18	11.28	2.21	10.97	2.30	11.29
1450	2.21	11.09	2.25	11.59	2.28	11.30	2.37	11.59
1500	2.27	11.42	2.32	11.89	2.35	11.61	2.44	11.89
1550	2.33	11.74	2.39	12.18	2.41	11.92	2.51	12.19
1600	2.39	12.05	2.46	12.48	2.49	12.22	2.58	12.48
1650	2.46	12.37	2.53	12.77	2.53	12.52	2.65	12.77
1700	2.51	12.68	2.59	13.06	2.59	12.80	2.72	13.06
1750	2.58	12.98	2.65	13.34	2.65	13.10	2.79	13.35
1800	2.64	13.27	2.72	13.63	2.72	13.39	2.87	13.63

Table 11. Maximum net present value per head ($/head) and optimal mature cow weight (lb) for various feed cost scenarios

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on Native
Feed cost 60% of baseline								
Max NPV/head	$1,667	$2,168	$3,966	$4,560	$2,059	$2,606	$4,477	$4,933
Cow Weight	950	1750	1800	1800	1350	1750	1800	1800
Feed cost 70% of baseline								
Max NPV/head	$1,412	$1,947	$3,701	$4,397	$1,809	$2,402	$4,239	$4,773
Cow Weight	950	1700	1800	1750	1000	1750	1800	1800
Feed cost 80% of baseline								
Max NPV/head	$1,157	$1,727	$3,436	$4,236	$1,568	$2,198	$4,002	$4,614
Cow Weight	950	1600	1800	1750	950	1600	1800	1700
Feed cost 90% of baseline								
Max NPV/head	$902	$1,509	$3,177	$4,082	$1,326	$1,999	$3,764	$4,462
Cow Weight	950	1600	1700	1550	950	1600	1800	1700
Feed cost baseline								
Max NPV/head	$647	$1,291	$2,921	$3,937	$1,085	$1,802	$3,526	$4,311
Cow Weight	950	1600	1550	1100	950	1450	1800	1700
Feed cost 110% of baseline								
Max NPV/head	$391	$1,078	$2,671	$3,816	$844	$1,610	$3,290	$4,159
Cow Weight	950	1400	1500	1050	950	1450	1750	1700
Feed cost 120% of baseline								
Max NPV/head	$136	$866	$2,423	$3,698	$603	$1,417	$3,055	$4,022
Cow Weight	950	1400	1500	1050	950	1450	1750	1000
Feed cost 130% of baseline								
Max NPV/head	$-119	$655	$2,179	$3,580	$361	$1,224	$2,825	$3,910
Cow Weight	950	1400	1350	1050	950	1450	1600	1000
Feed cost 140% of baseline								
Max NPV/head	$-374	$444	$1,946	$3462	$120	$1,031	$2,597	$3,798
Cow Weight	950	1350	1050	1050	950	1450	1600	1000
Feed cost 150% of baseline								
Max NPV/head	$-629	$240	$1,718	$3,344	$-121	$840	$2,372	$3,688
Cow Weight	950	1100	1050	1050	950	1400	1300	950

Note: cows are started at the first year (price peak) of the cattle cycle.

Table 12. Maximum NPV-per head-per acre and optimal mature cow weight for various feed cost scenarios per acre

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on Native
Feed cost 60% of baseline								
NPV/head/acre	$108	$26	$249	$52	$128	$31	$259	$55
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 70% of baseline								
NPV/head/ acre	$91	$24	$234	$50	$113	$28	$246	$54
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 80% of baseline								
NPV/head/ acre	$75	$21	$219	$49	$98	$26	$233	$53
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 90% of baseline								
NPV/head/ acre	$58	$18	$204	$48	$83	$24	$220	$52
Cow Weight	950	950	950	950	950	950	950	950
Feed cost baseline								
NPV/head/acre	$42	$16	$189	$46	$68	$21	$208	$50
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 110% of baseline								
NPV/head/ acre	$25	$13	$174	$45	$53	$19	$195	$49
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 120% of baseline								
NPV/head/ acre	$9	$11	$159	$44	$38	$17	$182	$48
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 130% of baseline								
NPV/head/acre	$-8	$8	$144	$42	$23	$14	$169	$46
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 140% of baseline								
NPV/head/ acre	$-24	$6	$130	$41	$8	$12	$157	$45
Cow Weight	950	950	950	950	950	950	950	950
Feed cost 150% of baseline								
NPV/head/acre	$-41	$3	$115	$40	$-8	$10	$144	$44
Cow Weight	950	950	950	950	950	950	950	950

Note: cows are started at the first year (price peak) of the cattle cycle

Table 13. Maximum net present value per head and optimal cow weight for baseline feed cost and varied cattle cycle year heifer enters herd

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
Yr 1								
Max NPV/head	$647	$1,291	$2,921	$3,937	$1,085	$1,802	$3,526	$4,311
Cow Weight	950	1600	1550	1100	950	1450	1800	1700
Yr 2								
Max NPV/head	$545	$1,174	$2,751	$3,831	$970	$1,675	$3,334	$4,150
Cow Weight	950	1500	1550	1050	950	1600	1700	1700
Yr 3								
Max NPV/head	$493	$1,181	$2,664	$3,789	$960	$1,687	$3,261	$4,113
Cow Weight	950	1500	1050	1050	950	1450	1750	1700
Yr 4								
Max NPV/head	$479	$1,107	$2,578	$3,712	$890	$1,604	$3,114	$3,985
Cow Weight	950	1650	1050	1050	950	1450	1700	1700
Yr 5								
Max NPV/head	$425	$1,072	$2,759	$3,881	$870	$1,562	$3,295	$4,132
Cow Weight	950	1400	1050	1050	950	1350	1700	950
Yr 6								
Max NPV/head	$414	$1,253	$3,129	$4,429	$908	$1,746	$3,604	$4,701
Cow Weight	950	1600	1000	1000	950	1450	1650	1700
Yr 7								
Max NPV/head	$742	$1,569	$3,535	$4,803	$1,229	$2,090	$3,989	$5,078
Cow Weight	950	1550	1000	1000	950	1400	1650	1700
Yr 8								
Max NPV/head	$1,013	$1,824	$3,751	$5,013	$1,473	$2,350	$4,243	$5,313
Cow Weight	950	1400	1000	1050	950	1450	1750	1700

Table 13. Maximum net present value per head and optimal cow weight for baseline feed cost and varied cattle cycle year heifer enters herd Continued

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
Yr 9								
Max NPV/head	$1,266	$2,090	$4,252	$5,623	$1,755	$2,677	$4,808	$5,981
Cow Weight	950	1500	1000	1050	950	1450	1750	1700
Yr 10								
Max NPV/head	$1,016	$1,768	$3,817	$5,108	$1,453	$2,267	$4,310	$5,425
Cow Weight	950	950	950	1050	950	1300	1750	950
Yr 11								
Max NPV/head	$1,030	$1,780	$3,700	$4,990	$1,446	$2,248	$4,262	$5,362
Cow Weight	950	1000	1000	1000	950	1200	1700	1700
Yr 12								
Max NPV/head	$899	$1,710	$3,571	$4,852	$1,389	$2,165	$4,151	$5,201
Cow Weight	950	1250	950	1000	950	1050	1700	1750
Yr 13								
Max NPV/head	$642	$1,464	$3,382	$4,701	$1,135	$1,985	$3,934	$5,024
Cow Weight	950	1600	1000	1050	950	1400	1500	1700
Yr 14								
Max NPV/head	$609	$1,404	$3,229	$4,461	$1,098	$1,933	$3,818	$4,795
Cow Weight	950	1400	1000	1100	950	1450	1700	1700
Yr 15								
Max NPV/head	$679	$1,341	$2,969	$3,962	$1,125	$1,847	$3,570	$4,336
Cow Weight	950	1550	1600	1600	950	1450	1800	1700

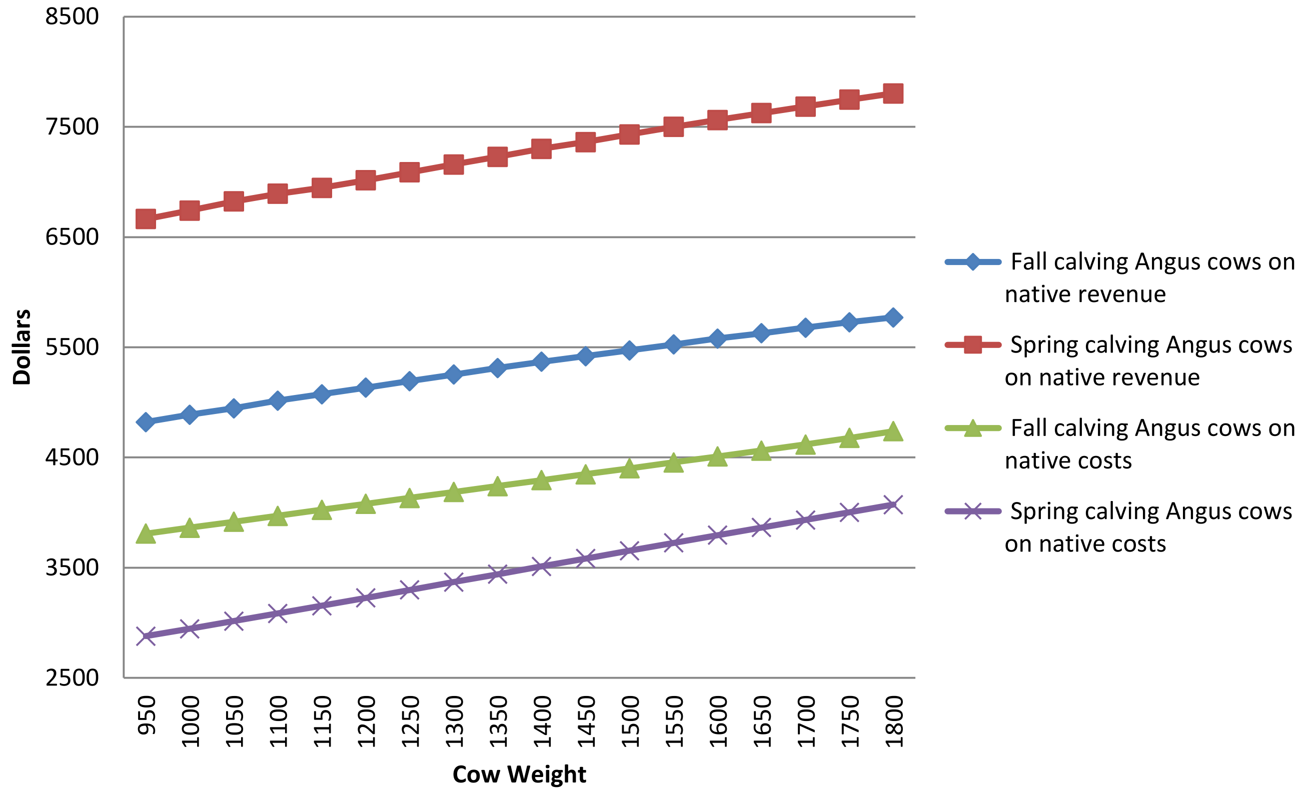

Figure 2. Revenues and Costs for fall and Spring Calving Angus cows on Native grass

Table 14. Maximum NPV-per cow-per acre and optimal cow weight per acre for baseline feed cost and varied cattle cycle year heifer enters herd

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
Yr 1								
NPV/head/acre	$42	$16	$189	$46	$68	$21	$208	$50
Cow Weight	950	950	950	950	950	950	950	950
Yr 2								
NPV/head/acre	$35	$15	$182	$45	$61	$20	$198	$49
Cow Weight	950	950	950	950	950	950	950	950
Yr 3								
NPV/head/acre	$32	$14	$177	$45	$60	$20	$193	$48
Cow Weight	950	950	950	950	950	950	950	950
Yr 4								
NPV/head/acre	$31	$14	$171	$44	$56	$19	$187	$47
Cow Weight	950	950	950	950	950	950	950	950
Yr 5								
NPV/head/acre	$28	$13	$184	$46	$54	$19	$199	$49
Cow Weight	950	950	950	950	950	950	950	950
Yr 6								
NPV/head/acre	$27	$15	$210	$52	$57	$21	$223	$56
Cow Weight	950	950	950	950	950	950	950	950
Yr 7								
NPV/head/acre	$48	$20	$237	$57	$77	$26	$247	$60
Cow Weight	950	950	950	950	950	950	950	950
Yr 8								
NPV/head/acre	$65	$23	$251	$59	$92	$29	$264	$63
Cow Weight	950	950	950	950	950	950	950	950

Table 14. Maximum NPV-per cow-per acre and optimal cow weight per acre for baseline feed cost and varied cattle cycle year heifer enters herd continued

	Fall calving Angus cows on Bermuda	Fall calving Angus cows on native	Spring calving Angus cows on Bermuda	Spring calving Angus cows on native	Fall calving Brangus cows on Bermuda	Fall calving Brangus cows on native	Spring calving Brangus cows on Bermuda	Spring calving Brangus cows on native
Yr 9								
NPV/head/acre	$82	$27	$284	$66	$110	$33	$299	$71
Cow Weight	950	950	950	950	950	950	950	950
Yr 10								
NPV/head/acre	$40	$18	$198	$50	$91	$28	$271	$64
Cow Weight	950	950	950	950	950	950	950	950
Yr 11								
NPV/head/acre	$67	$23	$248	$59	$91	$28	$264	$63
Cow Weight	950	950	950	950	950	950	950	950
Yr 12								
NPV/head/acre	$58	$21	$240	$58	$87	$27	$253	$61
Cow Weight	950	950	950	950	950	950	950	950
Yr 13								
NPV/head/acre	$42	$18	$227	$56	$71	$24	$242	$59
Cow Weight	950	950	950	950	950	950	950	950
Yr 14								
NPV/head/acre	$39	$17	$216	$53	$69	$23	$233	$57
Cow Weight	950	950	950	950	950	950	950	950
Yr 15								
NPV/head/acre	$44	$16	$191	$46	$70	$22	$210	$50
Cow Weight	950	950	950	950	950	950	950	950

CHAPTER V

Conclusions

Conclusion

To date, a handful of studies have assessed economically-optimal cow weight. However, with many biological, price, environmental and industry factors to consider, assumptions and methodology vary between studies. This research builds on previous research considering a nonlinear relationship between cow weight and calf birth weight. Several herd scenarios common to U.S. Southern Plains beef cow-calf operations are included. Two forage types (Bermuda and native), two breeds (Angus and Brangus), and two calving seasons (spring and fall) are considered in all possible combinations. The model computes net present values associated with each of these scenarios and cow weights ranging from 950 pounds to 1,800 pounds, in 50 pound increments, and then the NPV-maximizing weight was found on a per head basis and a per acre basis.

Data from two Oklahoma and one Arkansas research stations were utilized to determine the relationship between cow weight and calf weaning weight. Data were collected from 1988 to 2009 and included 3,041 observations. Rations were calculated using a software tool, CowCulator (Lalman and Gill, 2010). Using historical data, cow cull prices, calf prices, and feed prices were projected for 15 years to reflect price variation observed in a recent cattle cycle

Results indicate that NPV-per head maximizing cow weight is sensitive to feed cost levels. Fall-calving scenarios have much higher feed costs then spring-calving scenarios. Angus cows have higher feed costs than Brangus cows, and cows on Bermuda grass have higher feed costs when compared to native grass scenarios. Spring-calving scenarios have higher NPVs-per head and NPVs- per acre than fall-calving scenarios. Cows on native range have higher NPVs-per head than cows grazing Bermuda grass, and Brangus cows have higher NPVs-per head than Angus cows. When calculated on NPV- per acre basis, NPVs- per head-per acre are higher for spring-calving scenarios when compared to fall, Bermuda are higher than native, and Brangus are higher than Angus.

When calculated on a per head basis, NPV maximizing cow weight varies between scenario, with variations in feed cost, and with the year in the cattle cycle the heifer entered the herd. The NPV-per head maximizing cow weight ranges from 950 to 1,700 pounds. The strongest factors driving the differences in optimal weight are related to calving season and forage type.

In contrast, on a per acre basis NPV acre maximizing cow weight does not vary with forage, feed cost, or with the year in the cattle cycle the heifer enters the herd. The lightest cow at 950 pounds is always the NPV- per acre maximizing cow weight. The additional revenue from larger cows is not high enough to overcome the ability to stock more light weight cows on a fixed number of acres. In short, more pounds per acre are produced with smaller cows than with larger cows.

Implications

Most producers are constrained on the number of acres available in a given production year. The results here and elsewhere suggests that cow weights in the US beef cow herd are too heavy. Some studies have suggested that if calves can be identified as small frame they will be discounted (Newport, 2013). Sensitivity analysis indicates that as long as the price discount is less than $43 dollars, the 950-pound cow is more profitable than the national-average cow weight of 1,350 pounds. If producers believe their smaller framed calves will be highly discounted, there may be advantages to retaining ownership through the feedlot process (Newport, 2013).

Dystocia data related to cow weight was not available. There may be some concern that smaller cows will have more calving difficulties than larger frame cows. Unfortunately, these data were not included in the data and no literature was available to support or refute this concern. So, it is necessary to qualify the results of this study. The implied assumption is that cow-calf producers match bull birth weight and calf ease direct EPDs with the frame size of their cows. At a dystocia rate of 5% higher for smaller cows, the optimal cow weight changes to favor heavier cows.

While this study found that, smaller beef cows are generally more economical than larger cows, EPD selection for larger, faster growing calves has caused the average cow weight to surpass the optimal weight (Smith, 2014). A possible solution is to create a maternal heifer replacement line that focuses on producing smaller cows that still maintain high calving ease and fertility standards. As cow frame size increases certain cuts of steak with a set shape, such as the ribeye, have larger surface areas. These larger steaks have to be cut thinner in order to meet the pound per package consumers' preferences. Behrends et al. (2009) found that consumers were willing to pay $1 more per pound for thicker steaks. Basically consumers are willing to pay more for thicker steaks with a smaller surface area (Behrends et al., 2009). Steaks from the offspring of smaller cows could be marketed to these consumers at a premium.

Study Limitations

Although the cattle cycle is well documented, it can be difficult to determine when a new cycle will start and the variability in prices. To be of the most value to the industry, accurate predictions of the stage of the cattle cycle are needed to implement the recommended above. The Forage quality and ration calculations were based on published data from research stations, but actual farm forage quality will vary. So, optimal mature beef cow weights will vary across producers.

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APPENDICES

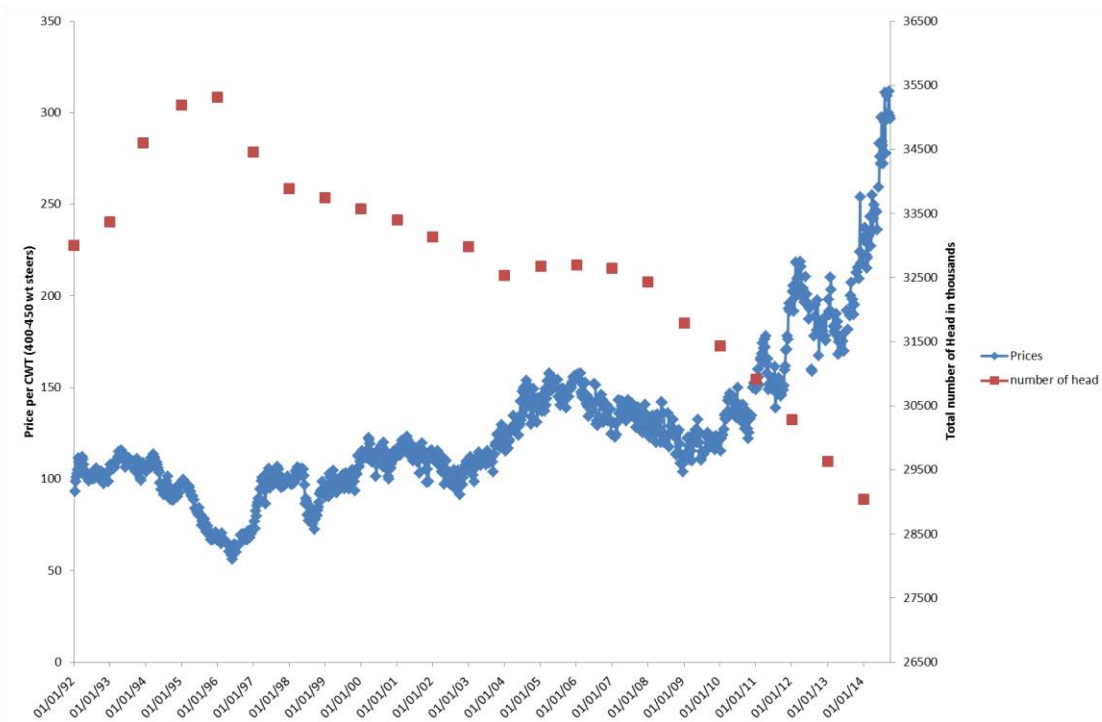

Figure A1. Graph of cattle prices and number of head in the US., Source:(USDA-AMS (2015).

Table A1. Annual feed requirements by cow weight in lbs

Fall Calving Angus Cows on Bermuda

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo.	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bermuda.	1823	1840	1886	1927	1950	1970	1976	1984	2001	2018	2035	2054	2067	2090	2115	2127	2141	2150
	Cubes	121	121	121	121	121	121	121	121	122	123	124	124	124	124	124	124	125	126
1	Hay	1800	1908	2017	2122	2229	2331	2434	2534	2636	2733	2832	2928	3025	3119	3215	3307	3401	3492
	Bermuda	3377	3589	3749	3848	4005	4155	4307	4454	4604	4747	4894	5035	5179	5317	5459	5595	5734	5868
	Cubes	1775	1763	1751	1740	1728	1718	1707	1697	1687	1677	1668	1658	1649	1640	1631	1623	1614	1606
2	Hay	2463	2595	2728	2856	2985	3109	3236	3357	3481	3600	3721	3837	3956	4070	4187	4300	4414	4525
	Bermuda	4185	4371	4620	4752	4941	5185	5308	5555	5669	5844	6022	6194	6369	6538	6717	6876	7045	7220
	Cubes	1770	1756	1743	1730	1717	1705	1693	1681	1669	1657	1646	1635	1623	1612	1601	1591	1580	1570
3	Hay	2567	2703	2837	2970	3104	3233	3360	3486	3611	3738	3860	3981	4101	4219	4340	4457	4573	4688
	Bermuda.	4307	4509	4706	4960	5097	5287	5540	5660	5951	6030	6210	6389	6566	6742	6920	7093	7274	7434
	Cubes	1770	1756	1742	1729	1716	1703	1691	1679	1667	1654	1643	1631	1620	1609	1597	1586	1576	1565
4	Hay	2671	2812	2951	3088	3223	3357	3489	3619	3748	3876	4002	4127	4251	4374	4496	4617	4737	4855
	Bermuda.	4447	4714	4859	5060	5323	5456	5650	5951	6104	6221	6408	6593	6777	6958	7139	7358	7495	7762
	Cubes	1767	1753	1739	1725	1712	1699	1686	1673	1661	1649	1637	1625	1613	1602	1590	1579	1568	1557
5	Hay	2780	2925	3069	3210	3349	3484	3620	3755	3888	4020	4148	4277	4405	4532	4657	4779	4903	5026
	Bermuda	4604	4810	5086	5295	5436	5635	5836	6106	6232	6426	6615	6814	6996	7184	7457	7551	7824	8008
	Cubes	1761	1746	1732	1718	1704	1691	1678	1665	1652	1640	1628	1615	1603	1591	1580	1568	1557	1546
6	Hay	2893	3057	3205	3350	3493	3635	3775	3913	4050	4186	4320	4453	4585	4715	4844	4973	5100	5226
	Bermuda	4761	5066	5284	5433	5645	5934	6133	6266	6468	6669	6868	7064	7271	7453	7645	7835	8024	8212
	Cubes	1751	1735	1720	1706	1692	1678	1665	1652	1639	1626	1613	1601	1588	1576	1564	1552	1541	1529
7	Hay	2893	3057	3205	3350	3493	3635	3775	3913	4050	4186	4320	4453	4585	4715	4844	4973	5100	5226
	Bermuda	4761	5066	5284	5433	5645	5934	6133	6266	6468	6669	6868	7064	7271	7453	7645	7835	8024	8212
	Cubes	1751	1735	1720	1706	1692	1678	1665	1652	1639	1626	1613	1601	1588	1576	1564	1552	1541	1529
8	Hay	2893	3057	3205	3350	3493	3635	3775	3913	4050	4186	4320	4453	4585	4715	4844	4973	5100	5226
	Bermuda	4761	5066	5284	5433	5645	5934	6133	6266	6468	6669	6868	7064	7271	7453	7645	7835	8024	8212
	Cubes	1751	1735	1720	1706	1692	1678	1665	1652	1639	1626	1613	1601	1588	1576	1564	1552	1541	1529
9	Hay	2893	3057	3205	3350	3493	3635	3775	3913	4050	4186	4320	4453	4585	4715	4844	4973	5100	5226
	Bermuda	4761	5066	5284	5433	5645	5934	6133	6266	6468	6669	6868	7064	7271	7453	7645	7835	8024	8212
	Cubes	1751	1735	1720	1706	1692	1678	1665	1652	1639	1626	1613	1601	1588	1576	1564	1552	1541	1529

Table A2. Annual feed requirements by cow weight in lbs
Spring Calving Angus Cows on Bermuda

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bermuda	1456	1463	1498	1527	1533	1541	1555	1572	1578	1584	1601	1629	1650	1657	1657	1657	1683	1709
	Cubes	500	500	500	520	522	524	531	538	539	541	543	545	547	552	558	561	571	579
1	Hay	1671	1735	1801	1864	1928	1989	2052	2113	2174	2233	2294	2352	2411	2469	2527	2583	2641	2697
	Bermuda	3716	3930	4148	4355	4567	4769	4976	5173	5375	5568	5765	5955	6148	6334	6524	6706	6893	7072
	Cubes	1276	1252	1227	1204	1181	1158	1136	1114	1093	1072	1051	1031	1010	991	971	952	933	915
2	Hay	2763	2873	2985	3093	3202	3307	3414	3518	3623	3725	3828	3928	4029	4128	4228	4325	4421	4507
	Bermuda	3915	4136	4359	4574	4792	5001	5213	5418	5625	5825	6028	6225	6424	6616	6812	7001	7198	7390
	Cubes	1235	1202	1169	1138	1105	1074	1043	1012	981	951	921	891	861	832	803	774	746	725
3	Hay	2835	2950	3063	3175	3288	3398	3506	3614	3720	3829	3933	4037	4140	4243	4346	4447	4547	4647
	Bermuda	4076	4306	4532	4754	4979	5196	5411	5623	5833	6045	6250	6453	6655	6855	7057	7253	7434	7608
	Cubes	1241	1207	1174	1141	1107	1075	1043	1011	979	947	917	886	855	825	795	765	743	724
4	Hay	2912	3031	3148	3264	3379	3493	3605	3717	3827	3937	4045	4153	4260	4366	4471	4575	4679	4782
	Bermuda	4244	4481	4714	4944	5172	5396	5618	5837	6054	6268	6481	6691	6899	7106	7309	7492	7674	7854
	Cubes	1238	1203	1168	1134	1100	1066	1033	1000	968	935	903	871	840	808	778	758	738	718
5	Hay	2997	3120	3241	3361	3480	3595	3711	3827	3941	4054	4164	4275	4386	4496	4604	4710	4817	4924
	Bermuda	4421	4665	4906	5144	5378	5605	5834	6060	6284	6505	6719	6936	7151	7357	7548	7734	7921	8108
	Cubes	1225	1189	1153	1118	1083	1049	1014	980	946	913	880	847	815	786	765	744	723	703
6	Hay	3089	3229	3354	3478	3600	3721	3841	3960	4078	4195	4310	4425	4539	4652	4764	4875	4986	5095
	Bermuda	4608	4885	5133	5377	5618	5856	6091	6324	6554	6782	7007	7230	7436	7634	7830	8025	8218	8410
	Cubes	1203	1162	1125	1088	1052	1016	981	946	911	876	842	808	783	761	739	717	696	674
7	Hay	3089	3229	3354	3478	3600	3721	3841	3960	4078	4195	4310	4425	4539	4652	4764	4875	4986	5095
	Bermuda	4608	4885	5133	5377	5618	5856	6091	6324	6554	6782	7007	7230	7436	7634	7830	8025	8218	8410
	Cubes	1203	1162	1125	1088	1052	1016	981	946	911	876	842	808	783	761	739	717	696	674
8	Hay	3089	3229	3354	3478	3600	3721	3841	3960	4078	4195	4310	4425	4539	4652	4764	4875	4986	5095
	Bermuda	4608	4885	5133	5377	5618	5856	6091	6324	6554	6782	7007	7230	7436	7634	7830	8025	8218	8410
	Cubes	1203	1162	1125	1088	1052	1016	981	946	911	876	842	808	783	761	739	717	696	674
9	Hay	3089	3229	3354	3478	3600	3721	3841	3960	4078	4195	4310	4425	4539	4652	4764	4875	4986	5095
	Bermuda	4608	4885	5133	5377	5618	5856	6091	6324	6554	6782	7007	7230	7436	7634	7830	8025	8218	8410
	Cubes	1203	1162	1125	1088	1052	1016	981	946	911	876	842	808	783	761	739	717	696	674

Table A3. Annual feed requirements by cow weight in lbs

Fall Calving Angus Cows on Native

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	1776	1804	1827	1850	1872	1895	1914	1937	1943	1949	1967	1997	2020	2042	2060	2069	2085	2096
	Cubes	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	171	173
1	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	5939	6246	6559	6858	7164	7455	7751	8036	8326	8602	8887	9163	9443	9711	9987	10251	10520	10780
	Cubes	1715	1695	1675	1656	1636	1618	1600	1582	1565	1548	1531	1515	1498	1483	1467	1452	1437	1422
2	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	7707	8082	8457	8821	9189	9540	9899	10249	10600	10942	11285	11619	11957	12281	12613	12935	13261	13578
	Cubes	1602	1580	1557	1535	1513	1493	1472	1452	1432	1413	1394	1375	1357	1339	1321	1304	1287	1270
3	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	7993	8379	8761	9138	9515	9882	10249	10608	10966	11325	11674	12020	12359	12698	13041	13375	13701	14029
	Cubes	1585	1561	1539	1516	1494	1473	1452	1432	1412	1392	1372	1354	1335	1317	1298	1281	1263	1246
4	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8284	8683	9078	9464	9849	10232	10608	10982	11349	11713	12075	12428	12782	13132	13480	13820	14162	14506
	Cubes	1567	1543	1520	1497	1475	1453	1432	1411	1390	1370	1351	1331	1312	1293	1275	1257	1239	1221
5	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8588	9001	9405	9808	10208	10592	10982	11365	11745	12121	12482	12851	13216	13578	13932	14281	14638	14969
	Cubes	1549	1524	1500	1477	1454	1433	1411	1389	1369	1348	1328	1308	1289	1270	1251	1233	1214	1208
6	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8907	9375	9791	10208	10617	11022	11420	11815	12206	12590	12973	13352	13723	14096	14469	14828	15160	15489
	Cubes	1530	1502	1478	1454	1431	1409	1386	1365	1343	1322	1302	1282	1262	1242	1223	1208	1208	1209
7	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8907	9375	9791	10208	10617	11022	11420	11815	12206	12590	12973	13352	13723	14096	14469	14828	15160	15489
	Cubes	1530	1502	1478	1454	1431	1409	1386	1365	1343	1322	1302	1282	1262	1242	1223	1208	1208	1209
8	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8907	9375	9791	10208	10617	11022	11420	11815	12206	12590	12973	13352	13723	14096	14469	14828	15160	15489
	Cubes	1530	1502	1478	1454	1431	1409	1386	1365	1343	1322	1302	1282	1262	1242	1223	1208	1208	1209
9	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8907	9375	9791	10208	10617	11022	11420	11815	12206	12590	12973	13352	13723	14096	14469	14828	15160	15489
	Cubes	1530	1502	1478	1454	1431	1409	1386	1365	1343	1322	1302	1282	1262	1242	1223	1208	1208	1209

Table A4. Annual feed requirements by cow weight in lbs

Spring Calving Angus Cows on Native

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	118	121	136	148	148	148	150	153	153	153	156	160	164	165	165	165	171	176
	Nat.[1]	1184	1189	1217	1239	1239	1246	1273	1306	1313	1319	1327	1338	1346	1358	1370	1377	1381	1383
	Cubes	609	610	613	615	615	617	624	633	646	658	668	677	683	685	685	685	692	698
1	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	7115	7410	7712	7998	8290	8570	8856	9131	9413	9680	9955	10203	10452	10687	10932	11166	11406	11636
	Cubes	153	137	121	106	91	76	61	47	32	18	4	0	0	0	0	0	0	0
2	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	8658	9016	9379	9729	10065	10380	10697	11014	11321	11624	11951	12260	12573	12877	13183	13481	13785	14079
	Cubes	360	346	332	318	316	320	324	327	331	335	338	341	344	347	350	353	356	358
3	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	8919	9290	9658	10007	10345	10669	10989	11307	11634	11975	12299	12618	12936	13249	13568	13878	14185	14490
	Cubes	369	354	340	334	339	343	347	350	354	357	361	364	367	370	373	375	378	381
4	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9188	9573	9945	10291	10630	10965	11311	11640	11988	12326	12660	12991	13318	13644	13967	14287	14606	14922
	Cubes	372	357	348	352	356	360	364	368	372	375	378	381	384	387	390	393	395	398
5	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9475	9871	10232	10587	10937	11277	11634	11996	12349	12697	13036	13376	13715	14052	14385	14710	15040	15365
	Cubes	369	355	360	365	369	373	377	380	384	387	391	394	397	400	402	405	408	410
6	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9781	10200	10570	10935	11297	11668	12046	12412	12774	13132	13487	13840	14189	14535	14880	15221	15559	15894
	Cubes	361	363	368	373	377	381	385	388	392	395	398	401	404	407	410	413	415	418
7	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9781	10200	10570	10935	11297	11668	12046	12412	12774	13132	13487	13840	14189	14535	14880	15221	15559	15894
	Cubes	361	363	368	373	377	381	385	388	392	395	398	401	404	407	410	413	415	418
8	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9781	10200	10570	10935	11297	11668	12046	12412	12774	13132	13487	13840	14189	14535	14880	15221	15559	15894
	Cubes	361	363	368	373	377	381	385	388	392	395	398	401	404	407	410	413	415	418
9	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9781	10200	10570	10935	11297	11668	12046	12412	12774	13132	13487	13840	14189	14535	14880	15221	15559	15894
	Cubes	361	363	368	373	377	381	385	388	392	395	398	401	404	407	410	413	415	418

[1]Nat. indicates Native forage

Table A5. Annual feed requirements by cow weight in lbs

Fall Calving Brangus Cows on Bermuda

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bermuda	1823	1840	1886	1927	1950	1970	1976	1984	2001	2018	2035	2054	2067	2090	2115	2127	2141	2150
	Cubes	121	121	121	121	121	121	121	121	122	123	124	124	124	124	124	124	125	126
1	Hay	1850	1959	2069	2175	2283	2386	2491	2591	2694	2792	2893	2989	3087	3182	3279	3372	3467	3558
	Bermuda	3500	3662	3827	3985	4146	4300	4457	4607	4827	4909	5059	5204	5352	5494	5640	5780	5923	6069
	Cubes	1609	1591	1573	1557	1540	1523	1507	1492	1476	1461	1446	1432	1418	1404	1390	1376	1363	1350
2	Hay	2524	2656	2791	2920	3050	3176	3303	3426	3550	3671	3792	3910	4030	4145	4263	4376	4492	4604
	Bermuda	4323	4521	4721	4913	5108	5296	5487	5671	5857	6037	6221	6397	6586	6749	6928	7098	7272	7441
	Cubes	1567	1546	1525	1505	1484	1464	1445	1426	1406	1388	1369	1351	1333	1316	1298	1281	1263	1247
3	Hay	2628	2766	2901	3035	3170	3300	3429	3556	3682	3810	3933	4055	4176	4296	4417	4535	4652	4768
	Bermuda	4466	4665	4868	5068	5342	5465	5658	5850	6039	6231	6415	6609	6781	7057	7145	7322	7499	7775
	Cubes	1561	1539	1518	1497	1476	1456	1436	1416	1397	1377	1358	1340	1321	1303	1285	1267	1250	1232
4	Hay	2734	2876	3016	3154	3291	3425	3558	3690	3820	3949	4076	4203	4328	4451	4574	4696	4817	4937
	Bermuda	4600	4816	5088	5233	5438	5640	5840	6038	6234	6428	6629	6810	6999	7186	7371	7555	7737	7919
	Cubes	1552	1530	1508	1486	1465	1444	1423	1403	1383	1363	1344	1325	1306	1287	1269	1251	1232	1215
5	Hay	2843	2990	3135	3277	3418	3554	3691	3827	3961	4094	4223	4353	4482	4610	4737	4860	4985	5108
	Bermuda	4756	4978	5195	5409	5621	5826	6032	6237	6439	6649	6834	7157	7225	7418	7710	7795	7984	8172
	Cubes	1540	1517	1494	1472	1450	1429	1408	1387	1366	1346	1327	1307	1287	1268	1249	1231	1212	1194
6	Hay	2957	3123	3272	3419	3563	3706	3847	3987	4125	4262	4397	4531	4664	4795	4926	5055	5183	5311
	Bermuda	4922	5175	5398	5618	5836	6051	6265	6475	6691	6889	7093	7296	7496	7794	7893	8102	8282	8475
	Cubes	1524	1498	1474	1452	1429	1407	1386	1364	1343	1323	1302	1282	1262	1242	1223	1203	1184	1165
7	Hay	2957	3123	3272	3419	3563	3706	3847	3987	4125	4262	4397	4531	4664	4795	4926	5055	5183	5311
	Bermuda	4922	5175	5398	5618	5836	6051	6265	6475	6691	6889	7093	7296	7496	7794	7893	8102	8282	8475
	Cubes	1524	1498	1474	1452	1429	1407	1386	1364	1343	1323	1302	1282	1262	1242	1223	1203	1184	1165
8	Hay	2957	3123	3272	3419	3563	3706	3847	3987	4125	4262	4397	4531	4664	4795	4926	5055	5183	5311
	Bermuda	4922	5175	5398	5618	5836	6051	6265	6475	6691	6889	7093	7296	7496	7794	7893	8102	8282	8475
	Cubes	1524	1498	1474	1452	1429	1407	1386	1364	1343	1323	1302	1282	1262	1242	1223	1203	1184	1165
9	Hay	2957	3123	3272	3419	3563	3706	3847	3987	4125	4262	4397	4531	4664	4795	4926	5055	5183	5311
	Bermuda	4922	5175	5398	5618	5836	6051	6265	6475	6691	6889	7093	7296	7496	7794	7893	8102	8282	8475
	Cubes	1524	1498	1474	1452	1429	1407	1386	1364	1343	1323	1302	1282	1262	1242	1223	1203	1184	1165

Table A6. Annual feed requirements by cow weight in lbs

Spring Calving Brangus Cows on Bermuda

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bermuda	1456	1463	1498	1527	1533	1541	1555	1572	1578	1584	1601	1629	1650	1657	1657	1657	1683	1709
	Cubes	500	500	500	520	522	524	531	538	539	541	543	545	547	552	558	561	571	579
1	Hay	1477	1534	1593	1648	1705	1759	1815	1868	1923	1975	2028	2080	2132	2183	2235	2285	2336	2385
	Bermuda	4068	4295	4525	4745	4968	5182	5400	5609	5822	6026	6234	6434	6639	6835	7035	7228	7425	7615
	Cubes	1121	1091	1061	1032	1004	977	949	923	896	871	845	820	795	771	747	724	700	677
2	Hay	2654	2760	2868	2973	3078	3180	3284	3384	3486	3584	3684	3775	3858	3933	4008	4081	4154	4225
	Bermuda	4187	4417	4650	4874	5100	5318	5539	5752	5968	6176	6387	6600	6815	7015	7221	7421	7625	7822
	Cubes	1038	997	955	915	874	835	795	757	718	680	642	606	580	563	546	529	513	496
3	Hay	2723	2834	2943	3052	3162	3268	3373	3477	3580	3685	3786	3886	3986	4082	4168	4244	4318	4391
	Bermuda	4356	4595	4830	5062	5296	5522	5745	5966	6184	6405	6618	6817	7005	7196	7403	7607	7814	8028
	Cubes	1037	995	952	910	868	827	787	747	707	667	628	597	570	545	524	507	490	473
4	Hay	2797	2912	3026	3138	3249	3360	3468	3576	3683	3789	3894	3999	4102	4204	4303	4390	4468	4544
	Bermuda	4530	4777	5020	5260	5496	5730	5961	6189	6414	6637	6842	7038	7232	7425	7620	7832	8051	8266
	Cubes	1028	983	939	896	853	811	769	728	687	646	614	587	559	532	506	484	467	453
5	Hay	2879	2998	3116	3232	3347	3458	3571	3683	3793	3903	4009	4117	4224	4330	4433	4521	4602	4680
	Bermuda	4715	4970	5220	5468	5712	5948	6186	6421	6654	6865	7065	7267	7468	7666	7874	8092	8309	8529
	Cubes	1008	962	917	872	828	785	742	699	656	625	596	567	539	511	483	462	448	435
6	Hay	2969	3104	3225	3345	3463	3581	3697	3812	3926	4039	4151	4262	4372	4480	4573	4658	4739	4818
	Bermuda	4910	5198	5456	5710	5961	6209	6454	6696	6910	7123	7333	7541	7749	7965	8192	8417	8645	8872
	Cubes	978	926	879	833	788	743	698	654	624	593	564	534	504	476	455	441	428	415
7	Hay	2969	3104	3225	3345	3463	3581	3697	3812	3926	4039	4151	4262	4372	4480	4573	4658	4739	4818
	Bermuda	4910	5198	5456	5710	5961	6209	6454	6696	6910	7123	7333	7541	7749	7965	8192	8417	8645	8872
	Cubes	978	926	879	833	788	743	698	654	624	593	564	534	504	476	455	441	428	415
8	Hay	2969	3104	3225	3345	3463	3581	3697	3812	3926	4039	4151	4262	4372	4480	4573	4658	4739	4818
	Bermuda	4910	5198	5456	5710	5961	6209	6454	6696	6910	7123	7333	7541	7749	7965	8192	8417	8645	8872
	Cubes	978	926	879	833	788	743	698	654	624	593	564	534	504	476	455	441	428	415
9	Hay	2969	3104	3225	3345	3463	3581	3697	3812	3926	4039	4151	4262	4372	4480	4573	4658	4739	4818
	Bermuda	4910	5198	5456	5710	5961	6209	6454	6696	6910	7123	7333	7541	7749	7965	8192	8417	8645	8872
	Cubes	978	926	879	833	788	743	698	654	624	593	564	534	504	476	455	441	428	415

Table A7. Annual feed requirements by cow weight in lbs

Fall Calving Brangus Cows on Native

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	1776	1804	1827	1850	1872	1895	1914	1937	1943	1949	1967	1997	2020	2042	2060	2069	2085	2096
	Cubes	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	171	173
1	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	6092	6404	6721	7025	7334	7629	7930	8219	8510	8793	9084	9362	9645	9917	10197	10463	10737	11000
	Cubes	1543	1517	1491	1466	1441	1417	1393	1370	1347	1325	1302	1281	1260	1239	1218	1198	1178	1158
2	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	7885	8265	8646	9015	9384	9744	10110	10462	10819	11164	11511	11849	12189	12520	12856	13174	13471	13755
	Cubes	1396	1366	1336	1308	1279	1252	1224	1198	1172	1146	1121	1096	1072	1048	1024	1005	1001	998
3	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8176	8566	8954	9336	9718	10094	10462	10826	11188	11552	11905	12252	12598	12941	13271	13574	13871	14169
	Cubes	1373	1343	1312	1283	1254	1226	1198	1171	1145	1118	1092	1067	1042	1018	1004	1000	996	993
4	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8469	8875	9275	9667	10060	10445	10826	11204	11576	11945	12307	12669	13027	13354	13666	13979	14290	14603
	Cubes	1350	1319	1288	1258	1228	1199	1171	1143	1116	1089	1063	1037	1012	1003	999	995	991	988
5	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	8778	9197	9607	10015	10420	10810	11204	11592	11977	12355	12723	13094	13430	13755	14081	14402	14724	15045
	Cubes	1326	1294	1262	1231	1201	1172	1143	1115	1087	1060	1033	1008	1002	998	994	990	986	982
6	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	9102	9573	9998	10420	10835	11245	11648	12049	12441	12833	13209	13554	13891	14230	14570	14904	15257	15603
	Cubes	1301	1265	1233	1201	1170	1140	1111	1082	1054	1026	1004	1000	996	992	988	984	980	976
7	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	9102	9573	9998	10420	10835	11245	11648	12049	12441	12833	13209	13554	13891	14230	14570	14904	15257	15603
	Cubes	1301	1265	1233	1201	1170	1140	1111	1082	1054	1026	1004	1000	996	992	988	984	980	976
8	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	9102	9573	9998	10420	10835	11245	11648	12049	12441	12833	13209	13554	13891	14230	14570	14904	15257	15603
	Cubes	1301	1265	1233	1201	1170	1140	1111	1082	1054	1026	1004	1000	996	992	988	984	980	976
9	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Native	9102	9573	9998	10420	10835	11245	11648	12049	12441	12833	13209	13554	13891	14230	14570	14904	15257	15603
	Cubes	1301	1265	1233	1201	1170	1140	1111	1082	1054	1026	1004	1000	996	992	988	984	980	976

Table A8. **Annual feed requirements by cow weight in lbs**

Spring Calving Brangus Cows on Native

Final Wt		950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Age	Feed																		
6 mo	Hay	118	121	136	148	148	148	150	153	153	153	156	160	164	165	165	165	171	176
	Nat.	1184	1189	1217	1239	1239	1246	1273	1306	1313	1319	1327	1338	1346	1358	1370	1377	1381	1383
	Cubes	609	610	613	615	615	617	624	633	646	658	668	677	683	685	685	685	692	698
1	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	7127	7479	7720	8007	8299	8580	8852	9101	9354	9596	9844	10095	10358	10604	10856	11098	11346	11585
	Cubes	96	78	60	43	25	9	0	0	0	0	0	0	0	0	0	0	0	0
2	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	8722	9049	9378	9696	10031	10364	10694	11014	11337	11651	11969	12283	12596	12898	13205	13504	13807	14101
	Cubes	275	278	281	284	286	289	292	294	296	298	300	302	303	305	307	308	309	311
3	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	8959	9297	9631	9973	10331	10670	11003	11335	11663	11995	12318	12637	12952	13266	13584	13892	14199	14496
	Cubes	296	299	302	304	307	309	312	314	316	318	320	322	323	325	326	328	329	330
4	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9203	9554	9909	10276	10631	10981	11327	11670	12010	12347	12680	13009	13336	13661	13983	14295	14622	14929
	Cubes	313	315	318	320	322	325	327	329	331	333	335	336	338	339	341	42	343	345
5	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9464	9827	10215	10587	10953	11307	11666	12020	12372	12719	13055	13396	13734	14069	14394	14727	15047	15374
	Cubes	324	326	329	331	333	335	337	340	341	343	345	346	348	349	351	352	353	354
6	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9741	10181	10569	10950	11328	11701	12070	12435	12796	13153	13507	13858	14206	14553	14897	15229	15569	15902
	Cubes	329	332	334	337	339	341	343	345	347	349	350	352	353	355	356	357	358	359
7	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9741	10181	10569	10950	11328	11701	12070	12435	12796	13153	13507	13858	14206	14553	14897	15229	15569	15902
	Cubes	329	332	334	337	339	341	343	345	347	349	350	352	353	355	356	357	358	359
8	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9741	10181	10569	10950	11328	11701	12070	12435	12796	13153	13507	13858	14206	14553	14897	15229	15569	15902
	Cubes	329	332	334	337	339	341	343	345	347	349	350	352	353	355	356	357	358	359
9	Hay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nat.	9741	10181	10569	10950	11328	11701	12070	12435	12796	13153	13507	13858	14206	14553	14897	15229	15569	15902
	Cubes	329	332	334	337	339	341	343	345	347	349	350	352	353	355	356	357	358	359

[1]Nat. indicates Native Range forage

Table A9. Forecasted calf prices

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Fall Steer Calf Prices ($/cwt)															
Weight															
325	253.9	280.2	246.8	213.2	246.8	198.3	133.5	199.9	234.7	228.6	265.5	259.3	236.2	230.6	265.0
375	245.5	272.0	228.0	240.9	236.4	192.6	134.0	205.7	216.8	213.3	248.6	251.5	237.7	237.0	270.9
425	235.4	260.6	225.7	234.0	226.4	190.0	132.8	201.4	215.1	197.6	242.8	240.3	211.2	227.7	273.7
475	227.5	250.3	220.7	235.5	217.1	181.0	133.4	192.0	202.4	193.5	238.3	236.9	208.0	214.9	261.0
525	220.8	241.6	202.6	219.0	220.2	175.3	126.7	191.0	193.4	190.7	219.8	225.2	211.0	206.9	247.1
575	209.6	228.2	192.7	210.5	212.1	168.4	125.0	182.9	181.1	179.6	208.7	214.3	200.6	201.1	232.6
625	200.2	218.4	178.1	191.1	191.1	159.7	122.6	164.2	170.2	166.1	201.6	205.1	191.5	195.3	226.0
Fall Heifer Prices ($/cwt)															
Weight															
325	229.0	260.3	215.2	227.9	225.8	177.2	104.7	165.4	193.7	173.0	236.0	245.8	224.0	226.8	252.6
375	222.7	254.0	214.2	222.5	223.6	176.3	116.1	164.3	191.9	177.9	233.0	236.9	234.4	215.0	258.9
425	207.6	236.4	196.6	213.4	202.9	163.6	109.6	167.7	173.3	174.4	223.3	224.1	186.9	206.6	242.2
475	199.3	225.7	195.4	201.0	197.9	158.7	109.5	167.0	177.6	166.7	217.1	218.6	194.1	201.6	235.6
525	196.1	220.4	185.4	198.0	195.8	155.3	114.0	162.8	173.5	165.7	205.5	213.1	191.1	194.2	231.8
575	187.2	208.2	177.6	190.2	183.4	149.0	113.3	154.3	166.6	156.4	197.1	73.8	178.0	186.0	219.5
625	178.9	198.0	165.7	180.2	179.7	143.9	107.8	144.1	156.2	147.4	180.3	190.9	170.3	170.4	205.4
Spring Steer Prices ($/cwt)															
Weight															
325.0	374.1	374.1	326.8	363.6	306.3	222.9	212.5	326.3	284.4	309.3	360.9	319.5	348.9	426.5	480.7
375.0	365.1	365.1	348.2	347.4	304.5	220.6	215.1	325.0	280.8	300.8	375.5	310.4	332.5	416.6	481.3
425.0	314.8	317.7	277.4	298.8	263.9	189.9	190.3	273.5	247.7	265.9	308.1	279.7	275.0	353.0	410.8
475.0	304.9	313.9	273.6	290.7	250.0	184.6	191.1	269.9	234.9	257.4	300.7	281.4	277.6	339.5	389.8
525.0	291.5	302.3	259.6	281.2	246.4	182.8	192.3	259.9	229.9	240.2	285.8	269.0	248.3	323.6	368.7
575.0	279.1	327.0	256.0	269.6	236.2	180.0	185.1	247.3	216.4	238.7	271.7	254.5	243.1	308.4	362.9

Table A9. Continued Forecasted calf prices

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Spring Steer Prices ($/cwt)															
Weight															
625.0	255.3	259.5	238.2	250.3	213.9	176.8	178.5	216.9	201.2	222.7	260.4	245.4	239.7	297.5	329.9
675.0	255.3	254.6	241.1	253.4	216.5	179.0	180.7	219.6	203.7	225.5	263.6	248.4	242.6	301.2	334.0
Spring Heifer Prices ($/cwt)															
Weight															
325	355.2	388.0	315.1	350.9	309.8	228.6	199.1	281.7	275.2	283.9	365.6	348.5	322.2	403.5	478.5
375	311.4	335.8	292.7	296.3	260.0	186.5	183.7	266.0	240.9	261.0	323.0	301.3	274.0	355.0	443.2
425	280.8	299.6	263.7	268.2	229.2	169.8	171.7	235.1	217.6	244.5	293.1	261.9	245.8	321.5	380.5
475	279.1	295.1	258.9	270.4	231.9	164.9	173.0	235.9	214.1	242.3	288.9	255.8	242.9	321.0	356.0
525	250.3	260.7	235.0	244.9	209.4	157.1	160.7	208.1	193.7	218.5	256.0	232.0	228.6	290.4	312.6
575	250.3	254.9	236.9	271.6	212.2	160.4	158.2	212.4	197.0	222.3	254.3	245.3	246.1	296.7	332.9
625	237.9	238.8	228.6	234.6	201.2	155.0	159.6	205.6	192.0	215.1	245.5	237.2	230.7	282.4	320.8

Source: USDA-AMS (2015).

Table A10. Forecasted cow prices

Year	Fall Cull Cows ($/cwt)	Spring Cull Cows ($/cwt)
2014	85.5	128.3
2015	86.7	122.6
2016	84.7	123.0
2017	82.6	120.4
2018	78.1	101.6
2019	66.2	88.4
2020	54.3	82.7
2021	56.4	91.3
2022	61.3	83.9
2023	57.2	90.0
2024	62.6	94.5
2025	70.8	104.8
2026	64.1	84.7
2027	63.3	105.2
2028	78.0	128.2

Source: USDA-AMS (2015).

Table A11. Forecasted bull prices

Year	Fall Cull Bulls ($/cwt)	Spring Cull Bulls ($/cwt)
2014	140.0	150.3
2015	142.0	143.6
2016	138.7	144.1
2017	135.2	141.1
2018	127.8	119.1
2019	108.4	103.6
2020	88.9	96.8
2021	92.3	107.0
2022	100.4	98.3
2023	93.6	105.4
2024	102.6	110.7
2025	115.9	122.7
2026	105.0	99.3
2027	103.6	123.3
2028	127.7	150.2

Source: USDA-AMS (2015).

Table A12. Forecasted feed prices

Year	Alfalfa Hay[1] ($/ton)	Wheat Mids[2] ($/ton)	Cotton Seed ($/ton)	Molases ($/ton)	20% Range Cube ($/ton)[3]
2014	200.4	128.1	468.2	197.5	234.4
2015	171.0	119.7	450.3	194.8	223.2
2016	163.5	137.2	399.5	196.3	219.3
2017	187.7	129.6	445.0	181.5	227.8
2018	202.7	143.3	479.8	204.5	248.2
2019	190.7	144.6	432.1	215.3	234.7
2020	205.8	230.8	546.9	235.0	327.7
2021	239.7	168.3	519.3	204.1	276.9
2022	204.2	127.7	509.0	174.7	245.9
2023	178.1	114.7	463.3	143.2	222.3
2024	181.6	110.6	446.2	167.9	215.1
2025	221.7	131.0	435.4	215.2	226.8
2026	219.3	145.6	416.3	200.9	230.2
2027	203.6	142.1	510.3	190.5	256.3
2028	205.8	142.3	530.0	208.7	263.0

[1] Alfalfa hay, wheat mids, cotton seed, molasses data, and soybean and cord data used in calculations sourced from University of Wisconsin (2015).
[2.] Wheat price used in calculation sourced from USDA (2015).
[3.] 20% range cubes are a composite of wheat mids, cotton seed, and molasses prices.

Table A13. Cull rate

Cow age	Probability of being culled
1	0.000
2	0.193
3	0.153
4	0.160
5	0.174
6	0.161
7	0.176
8	0.199
9	0.279
10	1.000

Note: Adapted from Azzam et al. (1990).

Table A14. Fixed and variable cost

Cow Weight	Fixed Cost	Variable Costs
950	$122.74	$82.83
1000	$123.53	$87.36
1050	$124.32	$91.89
1100	$125.11	$96.42
1150	$125.90	$100.95
1200	$126.69	$105.48
1250	$127.48	$110.02
1300	$128.27	$114.55
1350	$129.06	$119.08
1400	$129.85	$123.61
1450	$130.64	$128.14
1500	$131.43	$132.67
1550	$132.22	$137.21
1600	$133.01	$141.74
1650	$133.80	$146.27
1700	$134.59	$150.80
1750	$135.38	$155.33
1800	$136.17	$159.86

Note: Adapted from Doye and Lalman (2011)

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