Analyzing the Risk and Returns for a Spring- and Fall-Calving Beef Herd in Tennessee

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Gavin William Henry
August 2015

ACKNOWLEDGEMENTS

First, I would like to give a special thank you to my undergraduate advisor, Dr. John B Riley. His ability to motivate, acts of selflessness, and his expectance of perfection has instilled many of my personal goals and values that I have developed through my adulthood thus far. I owe many things to him, but above all is his influence in my pursuit of a M.S. degree. His memory will be with me always.

I would also like to extend a special thanks to my major professor, Dr. Christopher N. Boyer. Your advice, patience, and persistence in helping me further my education will never be forgotten. I would like to thank my committee members, Dr. Andrew P. Griffith, Dr. James A. Larson, and Dr. S. Aaron Smith for your support and assistance during this research.

I would like thank Dr. J. Travis Mulliniks, assistant professor for the Department of Animal Science at The University of Tennessee, for his collaboration and enhancement of my understanding in the use of the National Research Council: Nutrient Requirements of Beef Cattle program.

Above all, I would like to thank my parents, Mr. and Mrs. William Henry, and my grandparents, Mr. and Mrs. Phil Henry for their love, support, and encouragement throughout my collegiate studies.

ABSTRACT

There is limited research on the profitability and risk of spring- and fall-calving beef seasons grazing tall fescue in the southeast. The objective of this research is to evaluate the profitability and risk of spring- and fall-calving seasons in Tennessee while considering the seasonality of cattle and feed prices for various feeding rations. Two commonly used rations and two least-cost feed rations meeting the nutritional requirements of a spring- and fall-calving cow with two weaning dates in Tennessee were developed. Enterprise budgets were established for each calving-season, two weaning dates per calving season, and feed ration. Net returns were simulated for all budgets while considering seasonal prices for cattle and ingredients in feed rations to compare the profitability and risk for each scenario. Animal data from a 19-year study at Grand Junction, Tennessee were used to conduct the analysis. For the commonly used rations, a risk neutral- to slightly-risk averse producer would select a fall-calving season with an April calf weaning and corn silage feed ration. A slightly- to highly-risk averse producer however, would select a fall-calving herd weaning calves in May and feeding a corn silage ration. For the least-cost feed rations, a risk neutral- to slightly- risk-averse producer would select a fall-calving season with an April calf weaning and does not feed a minimum 20 lb/day of orchardgrass hay. However, a slightly- to highly-risk averse producer would select a fall-calving season that weans calves in May and does not feed a minimum 20 lb/day of orchardgrass hay. Overall, the fall-calving season was found to be preferred to the spring-calving season for all rations and weaning months.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION AND PROBLEM IDENTIFICATION

In Tennessee, beef cattle production accounted for $735 million in cash receipts in 2012, which is 20.4% of the state's agricultural sales, making beef cattle the second largest grossing commodity in the state's agricultural sector (Menard et al., 2013; United States Department of Agriculture National Agricultural Statistical Service (USDA-NASS, 2013). Similar to most of the southeastern United States, Tennessee has a mixture of cow-calf and stocker operations with cow-calf production being the predominant enterprise (Campbell et al., 2013). Cow-calf producers are confronted with many complex decisions, one of which is selecting a calving season. Studies have shown that a controlled calving season (e.g., spring- or fall-calving season) is more profitable for beef cattle producers than year-round calving (Julien and Tess, 2012; Pruitt et al., 2012). However, selecting an optimal calving season such as a spring- or fall-calving season depends on a complex set of factors including seasonality in cattle and feed prices, weaning weights, calving rates, labor availability, etc. (Bagley et al., 1987; Caldwell et al., 2013; Campbell et al., 2013; Leesburg, Tess, and Griffith, 2007; Smith et al., 2012).

Most cow-calf producers using a defined calving season in Tennessee follow a spring-calving season, beginning in January and ending around mid-March (Campbell et al., 2013). Cows are typically bred in late spring-early summer (May and June) and calves are weaned in the fall (September and October). The other calving-time strategy used by Tennessee beef cattle producers is a fall-calving season (Campbell et al., 2013), which begins in mid-September and ends in mid-November. Fall-calving cows are bred in the winter months (December and January) and calves are weaned in the spring (April and May). Therefore, nutritional demands for spring- and fall-calving cows will be different across months in a production year.

The timing of nutritional needs for spring-calving cows closely matches the growth cycle of warm-season grasses (Bagley et al., 1987), which typically break dormancy in early April, and grows primarily from mid-May through August (Keyser et al., 2011). Warm-season grass growth is typically peaking at the time when spring-calving cows are requiring their highest nutritional intake to continue to produce milk, maintain body condition, and rebreed. By comparison, the growth and development of cool-season grasses such as tall fescue [*Schedonorus arundinaceus* (Schreb.) Dumort], more closely matches the nutritional needs of fall-calving cows (Bagley et al., 1987). Cool-season grasses grow primarily from late February and early March to May with additional growth in the end of September to November (Keyser et al., 2011). Therefore, the nutritional intake requirement for fall-calving cows is highest when the cool-season grass production is peaking.

In the southeastern United States and Tennessee, tall fescue is the primary forage used by cattle producers due to suitable growing conditions (Keyser et al., 2011). Tall fescue, however, can cause several managerial challenges for beef cattle producers. Tall fescue is semi-dormant during the warmer summer months in Tennessee (Keyser et al., 2011), which can negatively impact cattle performance. Additionally, tall fescue has physiological characteristics that can also negatively impact beef cattle during the summer grazing months (Volenec and Nelson, 2007). Grazing cattle on endophyte-infected tall fescue during the summer months can increase the risk of fescue toxicosis (Volenec and Nelson, 2007) in spring-bred cattle and can negatively impact pregnancy rates, weight gains, and net returns (Smith et al., 2012). Thus, fall-calving cows might be more productive and profitable in the Southeast, even though, most cow-calf operators calve in the spring months (Campbell et al., 2013).

The seasonality of beef and feed prices is also an important component to consider when selecting a calving season to maximize profits. Typically, the prices of steer and heifer calves in the spring are higher than in the fall (Julien and Tess, 2002). Fall-born calves weaned in the spring (April and May) may bring higher prices than the same weight, spring-born calves weaned in the fall (September and October). On the other hand, feed costs for fall-calving cows can be higher than the feed costs for spring-calving cows (Campbell et al., 2013). Fall-calving cows could require greater nutritional intake over the winter months than spring-calving cows since fall-calving cows are bred in the winter.

Studies by Caldwell et al. (2013) and Smith et al. (2012) in Arkansas and Campbell et al. (2013) in Tennessee have compared animal performance of spring- and fall-calving herds grazing tall fescue. The Arkansas studies found that fall-born calves have higher weaning weights than spring-born calves (Caldwell et al., 2013; Smith et al., 2012). In contrast, the study in Tennessee showed that spring-born calves have higher weaning weights than fall-born calves (Campbell et al., 2013). In both locations, the calf crop was lower for the spring-calving season, which might be linked to fescue toxicity. Caldwell et al. (2013) and Smith et al. (2012) compared the profitability of spring- and fall-calving seasons for cows grazing tall fescue in Arkansas. They used partial budgets to evaluate expected net returns and found the fall-calving season to have the greater net returns.

Research in the southeastern United States (e.g., Bagley et al., 1987; Caldwell et al. 2013; Smith et al., 2012) that evaluated the profitability of the calving season decision did not assess the potential tradeoffs in risk and return of using a fall-calving season rather than a spring-calving season, the predominant calving system in Tennessee. Studies evaluating the risk and return to the calving season decision has been conducted for other regions in the United States (Evans et al., 2007; Leesburg, Tess, and Griffith, 2007; Strauch, Peck, and Held, 2010) and Canada (Khakbazan et al., 2014; Sirski, 2012), but not the southeastern United States. Currently, there is no research reported in the literature that compares the profitability and risk of the calving season decision in the southeastern United States that considers the seasonality of feed and beef prices. Thus, information is lacking about how the tradeoffs associated with spring- and fall-calving seasons impact the profitability as well as the variability (i.e., riskiness) of profits of a cow-calf operation. If such information were available, cow-calf producers in Tennessee would have better economic information to make decisions concerning the most advantageous calving season as it relates to calf prices and feed costs.

Research Objectives

The objective of this research is to evaluate the profitability and variability of profits for spring- and fall-calving seasons for beef cattle in Tennessee while considering the seasonality of cattle prices and feed prices for various feed rations.

CHAPTER II: REVIEW OF LITERATURE

Many studies have shown spring- and fall-calving seasons can improve animal performance and profitability relative to year-round calving (Pruitt et al., 2012; Julien and Tess, 2012). Pruitt et al. (2012) stated that controlled calving can increase the number of calves, uniformity of calves, and help determine the reproductive efficiency of individual cows, which can positively impact producers' profits. While animal performance and economic benefits from controlled calving are well documented, selecting the optimal calving season can depend on many factors making this decision complex (Campbell et al., 2013).

Several studies have been conducted in the southern United States to evaluate the effects of calving season on animal performance measures such as calf death loss, 205-day calf weaning weight, calving rate (calves weaned per cow exposed to a bull), and cow culling rate (Table 1). Bagley et al. (1987) compared spring- and fall-born calves grazing warm-season grasses in Louisiana using 5-years of animal performance data. The fall-born calves grazed a combination of bermudagrass [*Cynodon dactylon* (L.) Pers.], ryegrass [*Lolium multiflorum* (L.) var. Gulf], and white clover [*Trifolium repens* (L.) var. La. S-1], while the spring-born calves grazed bermudagrass. They found that fall-born calves had higher weaning weights than the spring-born calves. Additionally, the calf death loss was lower for fall-born calves than for spring-born calves.

McCarter, Buchanan, and Frahm (1991) analyzed the impact of spring- and fall-calving seasons on various animal performance measures for crossbred cattle using analysis of variance. The cattle grazed a combination of warm-season grasses in Oklahoma over a 5-year period. Regardless of the sire breed, they found the spring-calving cows had a higher calving rate than the fall-calving cows, but there was not a difference in the average adjusted weaning weight across calving seasons. Gaertner et al. (1992) analyzed the impact of spring- and fall-calving seasons on weaning weight in Texas over a 15-year period. Cows grazed a variety of cool- and warm-season grasses and legumes such as ryegrass, clover, and bermudagrass pastures depending on the month. They discovered that the fall-born calves were heavier than the spring-born calves at weaning.

Campbell et al. (2013) used 19 years of data from Tennessee to compare calf performance in spring- and fall-calving seasons grazing tall fescue. They found no difference in the birth weight of the spring- and fall-born calves, but the spring-born calves had a higher average daily gain and 205-day adjusted weaning weight than the fall-born calves. Over the 19 years, the spring-calving herd produced 193 fewer calves with four more cows than the fall-calving herd. In another study, Caldwell et al. (2013) used a mixed model to analyze animal performance for spring- and fall-calving herds grazing tall fescue in Batesville, Arkansas over a 3-year period. Results from this study showed the 205-day adjusted weaning weights were higher for the fall-born calves than the spring-born calves, and the calf crop was higher for fall-calving cows.

The above animal performance studies provided mixed results for weaning weights with the spring- and fall-calving systems: two studies (Oklahoma and Texas) showing no differences in weaning weights, two studies (Arkansas and Louisiana) finding higher 205-day adjusted weaning weights with the fall-calving herd, and one study indicating higher weaning weights with the spring-calving herd (Tennessee). Birth weight of calves did not appear to be an important factor in the performance of a calving season. Results for studies reporting calving rates were more consistent with fall-calving herds having higher rates in the Arkansas, Oklahoma, Tennessee, and Texas studies.

Animal performance data from the aforementioned Louisiana and Arkansas studies were used to evaluate the profitability of the calving season decision. Bagley et al. (1987) found that fall-born calves produced higher mean net returns under Louisiana conditions. Smith et al. (2012) calculated mean partial net returns for the spring- and fall-calving herds to be $199 and $269 per acre, respectively, for Arkansas. The two studies concluded that the fall calving was the most profitable but did not evaluate the risk associated with the calving season decision. The study by Campbell et al. (2013) found the fall-calving herd to have higher revenue than spring-calving herd in Tennessee. This was due to the fall-calving herd producing more calves per cow, selling calves at higher prices at weaning, and having to replace fewer cows over the 19-year period. A limitation of the Campbell et al. (2013) study is that they did not consider the changes in feed and other costs that affect profitability.

Where animal performance data on calving season was limited, a common approach to compare the profitability of spring- and fall-calving season is to develop dynamic programming and simulation models. Pang et al. (1999) simulated net returns for spring- and fall-calving seasons in Canada. They found the spring-calving cows to have higher average net returns when the calves were weaned in less than 200-days, but if the calves were weaned after 200-days, the fall-calving season was more profitable on average. Leesburg, Tess, and Griffith (2007) compared the profitability of spring- and fall-calving cows in the Northwest United States using a dynamic programming model, and found the gross margins were higher for the spring-calving season. Payne et al.

(2009) used a simulation model to predict the financial performance of spring- and fall-calving seasons in Texas using future cattle prices, and found the fall-calving season to have the greatest net returns.

The above profitability studies for spring- and fall-calving herds provided mixed results for net returns: four studies (Arkansas, Louisiana, Tennessee, and Texas) showing the fall-calving herd was more profitable when compared to a spring-calving herd, one study (Canada) finding the spring-calving herd to have higher average net returns, and one study (Northwest United States) found when calves were weaned in less than 200-days, the spring-calving season was more profitable on average. If the calves were weaned after 200-days, however, the fall-calving season was more profitable on average.

While these studies provide insight into the profitability of spring- and fall-calving seasons, the business risk (i.e., variability of net returns) associated with spring- and fall-calving seasons is also important to consider when selecting a calving season. The seasonality of beef cattle prices and feed prices are major factors that drive the risk associated with spring- and fall-calving seasons. These prices commonly fluctuate across months with seasonal supply and demand factors of cattle production and crop production (Julien and Tess, 2002; Griffith, 2012; McKinley, 2013). Calf prices are commonly higher in the spring (i.e., February through May) than in the fall and winter months in Tennessee (McKinley, 2013). This might be due to most cow-calf operators in Tennessee following a spring-calving season (Campbell et al., 2013), resulting in more calves being sold in the early fall (September and October). Furthermore, feed price generally demonstrates a seasonal pattern. Depending on the commodity, prices are typically the lowest around crop harvest and increase during the winter months when livestock feed demand increases (Griffith, 2013).

A few studies have considered both the profitability and risk when selecting a calving season. Evans et al. (2007) compared the profitability and probability of returns being above variable costs for spring- and fall-calving seasons on various farm sizes and production systems. Evans et al. (2007) used two years of data from an experiment in West Virginia where cows grazed pasture mixtures of orchardgrass [*Dactylis glomerata*], tall-fescue, and red clover [*Trifolium pratense*]. They found the spring-calving season to bring greater profits and increased probability of being profitable than the fall-calving season for all production systems.

Strauch, Peck, and Held (2010) used simulated data to compare spring- and fall-calving seasons for Colorado. They found the fall-calving season generated higher profits and had less risk than the spring-calving season. Sirski (2012) evaluated the profitability and risk of a spring- and summer-calving season in Canada using a simulation model, and found summer-calving had a higher average net income but spring-calving had lower variability. Khakbazan et al. (2014) conducted a similar study that analyzed the risk and returns for spring- and summer-calving seasons in western Canada. Khakbazan et al. (2014) found that summer-calving resulted in higher net returns and was preferred by a risk-neutral to slightly risk-averse producer; however, a slightly- to highly- risk averse producer preferred a spring-calving season. These studies are insightful, but the literature is lacking knowledge on the profitability and risk of spring- and fall-calving herds grazing tall fescue in the southeastern United States. Table 2 includes a summary of these studies evaluating the animal performance and profitability of the spring-and fall-calving seasons.

CHAPTER III: CONCEPTUAL FRAMEWORK

Net Returns

A profit-maximizing cow-calf producer will select the calving season that maximizes expected net returns. Annual revenue is earned from selling steers, heifers, and cull cows with the price of these animals changing each month. The size of the calves at marketing, calf death losses, and the number of brood cows culled may vary by calving season, which are also important variables in calculating revenue. Production costs include the annual cost of land, labor, pasture, feed, and marketing, along with several other inputs. Feed costs are primarily driven by the prices and quantities of feeds required for cows when supplementation is needed. Feed rations can be selected by producers based on several criteria, but the accessibility of the ingredients in the ration and the price of the ingredients are likely two of the important criteria for selecting feed rations for beef cattle production. Also, the price of the ration ingredients will vary by month. The quantity of the feed ration will vary by calving season due to different nutritional requirements for cows in each calving season.

Therefore, the producer's decision to select the optimal calving season that maximizes expected net returns above variable costs while considering seasonality of feed and beef prices is generally expressed as

$$\max_{ik} \pi_{ik} = \sum_{j=1}^{3}\sum_{m=1}^{12}[p_{mj}y_{imj} - FC_{imk} - OC] \tag{1}$$

where π_{ik} is the expected annual net returns above cost of production (in \$/head) for the ith calving season (fall-calving or spring-calving) for the kth (k=1,…,K) ration; p_{mj} is the price of cattle (in \$/lb) in the *m*th month (m=1,…,12) for the *j*th sex (j=1,…,3) (steers, heifers, and culled cows); y_{imj} is beef yield (in lb/head); FC_{imk} is the feed costs (in \$/head) for cows; *OC* are all other annual production costs (in \$/head) which are likely similar across calving seasons.

The feed rations must include a composition of ingredients that will meet the monthly nutritional needs of dry matter intake (DMI), energy (NEm), and metabolizable protein (MP) for spring- and fall-calving cows using the available feed ration ingredients. The feed costs (*FC*) can be calculated by multiplying the price of the ration by the quantity needed of the each ingredient to maintain a cow. First, the price of the ration is determined by ingredients required, which is defined as

$$E[\rho_{imk}] = \sum_{n=1}^{N} \phi_{imkn} I_{imkn} \tag{2}$$

where ρ_{imk} is the expected price (\$/lb) for the *k*th (k=1,…,K) ration; ϕ_{imkn} is the proportion ($0 \leq$; $\phi_{imkn} \leq 1$) of the *n*th (n=1,…,N) ingredient in one pound of the *k*th ration; and I_{imkn} is the price of the *n*th ingredient (in \$/lb) in the *k*th ration. The quantity of the feed ration is defined as

$$E[w_{imk}] = \sum_{n=1}^{N} \phi_{imkn} z_{imkn} \tag{3}$$

where w_{imk} is the quantity (lb/head) of each ration; z_{imkn} is the quantity (in lb) of each ingredient needed to make a pound of the ration. The total cost of the feed ration is

$$E(FC_{imk}) = \rho_{imk} w_{imk} \tag{4}$$

where $w_{imk} \geq \rho_{imk}$, where ρ_{imk} is the overall minimal nutrient requirements for a spring- and fall-calving cow by month.

Variability of Net Returns

Additionally, a cow-calf operator also can consider the variability of the net returns or risk in their decision framework. The primary sources of risk an operator must consider are production and price risks (Kay, Edwards, and Duffy, 2012). Production risk is defined as the uncertainty around annual animal production such as death loss, pregnancy rates, and weaning weights (Kay, Edwards, and Duffy, 2012). Price risk is associated with the changes in beef and feed ration ingredient prices from year-to-year and month-to-month (Kay, Edwards, and Duffy, 2012).

When production and price risk are considered in a cow-calf operator's decision-making framework, the optimal calving season will be a function of expected net returns along with the variability of net returns (Kay, Edwards, and Duffy, 2012). This changes the producer's decision-making framework from profit-maximization to utility maximization. A producer's utility function is defined as $U_{ik}(\pi_{ik}, r)$ where *r* is the producer's risk preference level (Hardaker et al., 2004). The utility function is used to find the certainty equivalent (CE), which is defined as the guaranteed return a person is willing to take rather than taking a gamble for a higher, but uncertain, return. A rational decision maker who is risk averse has a CE that is less than the expected value of the uncertain return. That is, a cow-calf producer who is risk averse would be willing to take a lower return with certainty instead of the expected returns with uncertainty.

The calving season and feed ration with the highest CE at a given level of risk aversion is the optimal calving season (or maximizes utility). A cow-calf producer will follow a spring-calving season if the expected utility for the spring-calving season is higher than the expected utility of the fall-calving season:

$E[U_{Sk}(\pi_{Sk}, r)] > E[U_{Fk}(\pi_{Fk}, r)]$ where *S* is the spring-calving season and *F* is the fall-calving season. Conversely, a cow-calf producer will follow a fall-calving season if the expected utility for the fall-calving season is higher than the expected utility of the spring-calving season: $E[U_{Sk}(\pi_{Sk}, r)] < E[U_{Fk}(\pi_{Fk}, r)]$.

CHAPTER IV: MATERIALS AND METHODS

Data

Animal Production

The data for the spring- and fall-calving cows comes from Ames Plantation Research and Education Center, near Grand Junction, Tennessee, over a 19-year time period from 1989 to 2008. The spring- and fall-calving cows consisted of both commercial and purebred Angus cattle. The purebred Angus herd was established in 1913 by the American Angus Association, making it the fourth oldest herd in the United States. The commercial cattle were predominantly Angus with Simmental and Hereford influence. Bulls and replacement heifers for the purebred Angus herd were developed at the Ames Plantation; however, bulls were purchased to maintain the genetic diversity of the herd. The bulls for the commercial cattle were purebred Angus origin. These herds were true spring- and fall-calving herds, meaning cows were not switched between the herds. The spring-calving herd calved from mid-February through mid-April. The fall-calving herd calved from mid-September through mid-November.

Both herds primarily grazed on endophyte-positive tall fescue and were supplemented with free choice mineral and corn silage year-round as needed. The quantity of corn silage and choice mineral fed to cattle in each herd was not recorded. Cows were primarily culled due to failure to rebreed; however, poor calf performance and old age also factored into the decision to cull a cow. Poor calf performance was based on total weight gain compared with the other calves of the same age. Over the 19-

year period, the spring herd totaled 478 individual cows with 1,534 individual calves born, and the fall herd totaled 474 individual cows with 1,727 calves born. These cow and calf totals reflect the number of cows and calves that were included in the herd at some point over the 19- years.

The cow data included identification number, breed, calving herd, sire, dam, and date of birth. Unfortunately, records were not kept for cows that did not calve; thus, percent calf crop could not be directly calculated. Data for the calves included calf number, date of birth, sex, sire, number of calves, average daily gain, birth weight, and weaning weight. Birth weights for the calves were collected at the closest day of birth using a portable scale. Weaning weight is a common measure for calf growth potential and the mothering ability of the dam. Actual weaning weights, however, are influenced by the age of the calf at weaning, sex of the calf, and age of the dam. Therefore, a common practice is to calculate the 205-day adjusted weaning weights, which gives an adjusted weaning weight for calves of different ages. The adjusted 205-day weaning weight was calculated following the guidelines of the Beef Improvement Federation (2010). Table 1 includes the average birth weight and adjusted 205-day weaning weight by steer and heifer calves in the spring- and fall-calving herds.

Ration Development

As previously stated, data on the quantity of corn silage and choice mineral provided to the two calving herds was not recorded. Therefore, rations were developed to meet the nutrient requirements for cows in the spring- and fall-calving herds for December, January, February, and March. Rations were only developed for the winter months because the cows had adequate nutrition available through grazing tall fescue pastures the remaining months of the year. The nutritional needs will be different by month and by calving season due to different gestation cycles (George, Nader, and Dunbar, 2001), impacting the quantity of feed needed by month.

All rations were built to meet the pre-determined nutritional needs for cows in each calving herd using the National Research Council (NRC) Nutrient Requirements of Beef Cattle 1996 program (NRC, 1996). The NRC program determined the minimal nutritional needs for a cow based on animal description, environmental factors, pasture management, and feed diet evaluation. The animal description variables included were age, body weight, body condition score, calf birth weight, peak milk production, milk fat, milk protein, days pregnant, and days in milk. Pasture management variables included additives, pasture unit size, pasture mass, and days on pasture. The environmental factors contained night cooling, hair depth, and monthly average temperature. Table 3 shows the parameter values used in the NRC program for the animal description, pasture management, and environmental factors variables by month.

In the diet evaluation section, the NRC program focuses on balancing a cow's monthly needs of dry matter intake (DMI), energy (NEm), and metabolizable protein (MP) using the available feed ration ingredients specified in the program. The size of the cow, time in gestation, and milk production influences the minimal nutrient intake needed per cow per day. Energy and protein requirements increased approximately sixty days into lactation, known also as the peak lactation period after calving (George, Nader, and Dunbar, 2001). There was also a rise in energy and protein requirements during the last sixty days of gestation (George, Nader, and Dunbar, 2001). Table 4 shows the minimal DMI, NEm, and MP needs used for the diet evaluation section in the NRC program (1996) by calving season and month.

Ingredients for feed rations can be selected by producers based on several criteria. The accessibility of the ingredients and the price of the ingredients are likely two of the most important criteria for selecting feed rations. Therefore, feed rations were developed for commonly used and accessible ingredients by Tennessee producers and for the combination of accessible ingredients that result in the least-cost feed ration to producers. The common feed ration scenario included two rations consisting of: (1) 20 lb/day orchardgrass hay, corn gluten feed, and soybean hulls; and (2) 20 lb/day of orchardgrass hay, corn silage, and soybean hulls. The least-cost rations were constructed by selecting from eight commonly available feed ration ingredients in Tennessee, including corn gluten feed, corn silage, dried distillers grains, soybean hulls, whole cottonseed, rice bran, and wheat middlings feeds. A linear programming model was constructed to select across the eight ingredients to build two least-cost feed rations: (1) a ration when at least 20 lb/day of orchardgrass hay was fed; and (2) when orchardgrass hay was not required to be fed. Table 5 shows the MP and NEm for one pound of dry matter for each of the ingredients.

Budgets

Budgets were constructed to calculate the net returns above variable cost for spring- and fall-calving seasons on a per head basis following the University of Tennessee Livestock

Extension Budgets (University of Tennessee, 2015). The beef price data for the steers, heifers, and culled cows were collected from 1989 to 2013 (USDA-NASS, 2013). Prices for the ingredients of the feed rations were also collected from USDA-NASS (2013); however, the prices were only available from 2000-2013. All beef and feed ingredient prices were adjusted into 2013 dollar values using the U.S. Bureau of Labor Statistics Consumer Price Index (BLS-CPI) (BLS-CPI, 2013). Table 6 shows the real monthly average and standard deviation for price of steers, heifers, and culled cows. Table 7 shows the real monthly average and standard deviation for prices of orchardgrass hay, corn gluten feed, corn silage, dried distillers grains, soybean hulls, whole cottonseed, rice bran, and wheat middlings (USDA-AMS, 2013).

Calf death loss, cow death loss, weaning percentage, cull percentage, and culled cow weights were assumed from the literature since these data were not collected. The cull percentage of 16%, cow death loss of 1%, weaning percentage of 90%, and culled cow weight of 1,100 lb were assumed for both the spring- and fall-calving seasons (University of Kentucky, 2008; University of Tennessee, 2015). Death loss for calves were assumed to be 5% for the spring-born calves and 3% for the fall-born calves, which was within the range found in the literature (Bagley et al., 1987).

Spring-born calves were commonly sold in September or October, and fall-born calves were commonly sold in April and May. Budgets were developed when spring-born calves were weaned and sold in September and October. Similarly, budgets were developed when fall-born calves were weaned and sold in April and May. Eight budgets were developed for the commonly used feed rations scenario (two rations x two weaning months x two calving seasons), and eight budgets were developed for the least-cost feed ration scenario (two rations x two weaning months x two calving seasons), giving a total of 16 budget scenarios.

Methods

Ration Modeling

In the common feed ration scenario, the NRC program found the smallest combination of ingredients required to satisfy the cow's minimal nutritional requirements for the ration that consisted of 20 lb/day of orchardgrass hay, corn gluten feed, and soybean hulls feed and the ration that consisted of 20 lb/day orchardgrass hay, corn silage, and soybean hulls. A linear programming model was created to build balanced least-cost feed rations with a constraint of at least 20 lb/day of orchardgrass hay being fed and when no constraint of orchardgrass hay was fed. Unlike the NRC program, the linear programming model takes into consideration the price of each ingredient. The objective was to find the combination of the eight ingredients that minimized costs while providing a cow the minimum amount of DMI, MP, and NEm per month. The objective function was:

$$
\begin{aligned}
&\mathrm{Min}(FC_{imk}) = \sum_{n=1}^{8} \phi_{imkn} I_{imkn} z_{imkn} \\
&s.t. \quad \phi_{imkn} \geq 0, I_{imkn} \geq 0, z_{imkn} \geq 0 \\
&\qquad DMI_{imk} = \sum_{n=1}^{8} \delta_n z_{imkn} \geq MinDMI_{im} \quad \forall i\text{'s}, m\text{'s, and } k\text{'s} \\
&\qquad MP_{imk} = \sum_{n=1}^{8} \lambda_n z_{imkn} \geq MinMP_{im} \quad \forall i\text{'s}, m\text{'s, and } k\text{'s} \\
&\qquad NEm_{imk} = \sum_{n=1}^{8} \tau_n z_{imkn} \geq MinNEm_{im} \quad \forall i\text{'s}, m\text{'s, and } k\text{'s}
\end{aligned} \qquad (5)
$$

where DMI_{imk} is the dry matter intake (lb/day) in the *m*th month of the *k*th ration for the *i*th herd; δ_n is the percentage of ingredient *n* that is dry matter; $MinDMI_{im}$ is the minimum level of dry matter intake (lb/day) needed by a cow; MP_{imk} is the metabolized protein (grams/day); λ_n is the percentage of ingredient *n* that is metabolized protein; $MinMP_{im}$ is the minimal metabolized protein (grams/day) needed by a cow; NEm_{imk} is the energy (mcal/day); τ_n is the percentage of ingredient *n* that is energy; and $MinNEm_{im}$ is the minimal energy (mcal/day) needed by a cow.

Simulation Model

The two common and two least-cost rations were developed for the fall- and spring-calving scenarios and net returns were simulated for all 16 budgets (two calving season × two selling dates per calving season × four rations) while considering the seasonality of prices for cattle and ingredients in feed rations. The stochastic net returns above variable costs were defined as:

$$E[\tilde{\pi}_{ik}] = E\sum_{m=1}^{12}\begin{bmatrix} \tilde{p}_m^s \tilde{y}_{im}^s q_{im}^s(DL_i) + \tilde{p}_m^h \tilde{y}_{im}^h q_{im}^h(DL_i, CC) + \tilde{p}_m^c y_m^c q_m^c(CC) \\ -\sum_{n=1}^{N} \phi_{imkn} \tilde{I}_{imkn} z_{imkn} - OC \end{bmatrix} \qquad (6)$$

where $\tilde{\pi}_{ik}$ is the uncertain net returns above production costs ($/head) for the *i*th calving season being fed the *k*th ration; $\tilde{p}_m^s$ is the uncertain price of steer calves ($/lb) in the *m*th month; $\tilde{y}_{im}^s$ is the uncertain beef yield of steer calves (lb/head); $q_{im}^s(DL_i)$ is the proportion ($0 \le q_{im}^s(DL_i) \le 1$) of steer calves sold (in head/cow) and is a function of death loss DL_i; $\tilde{p}_m^h$ is the uncertain price of heifer calves (in $/lb); $\tilde{y}_{im}^h$ is the uncertain beef yield of heifer calves (lb/head); $q^h_{im}(DL_i, CC)$ is the proportion ($0 \le q^h_{im}(DL_i, CC) \le 1$) of heifer calves sold (head/cow) and is a function of death loss and the culled cow rate *CC* (heifers were used to replace culled cows); $\tilde{p}^c_m$ is the uncertain price of culled cows ($/lb); y^c_{im} is the beef yield of culled cows (lb/head); $q^c_{im}(CC)$ is the proportion ($0 \le q^h_{im}(DL_i, CC) \le 1$) of cows culled (in head) which is a function of the culled cow rate *CC*; ϕ_{imkn} is the percentage of the *n*th (n=1,…,N) ingredient in the *k*th feed ration; and $\tilde{I}_{imkn}$ is the uncertain price of the *n*th ingredient (in $/lb); z_{imkn} is the quantity (lb) of each ingredient needed to make one lb of the ration; and *OC* are the other production costs such as marketing, trucking, animal health, land, salt, and minerals.

Animal production data were used to make steer calf weight and heifer calf weight. These weights were drawn from a normal distribution using the average and standard deviation of weaning weights. Prices for steers, heifers, culled cows, and ration ingredients were randomly drawn from a multivariate empirical distribution derived from historical price data. Simulation and Econometrics to Analyze Risk (SIMETAR©) was used to develop the distributions and perform the simulations (Richardson et al., 2008). Net returns above variable costs were simulated for a total of eight budgets for the commonly used feed ration scenario and a total of eight budgets for the least-cost feed ration scenario. A total of 5,000 observations were simulated for each of the budgets.

Risk Analysis

A common approach to comparing net returns and variability of net returns for different scenarios is to use stochastic dominance, which compares the cumulative distribution function (CDF) of net returns for all scenarios (Chavas, 2004). In first degree stochastic dominance, the scenario with CDF *F* dominates another scenario with CDF *G* if $F(\pi) \leq G(\pi) \forall \pi$. First degree stochastic dominance often does not find one scenario to clearly be preferred to another; therefore, second degree stochastic dominance adds the restriction that producers are risk averse, which increases the chance of finding a preferable scenario (Chavas, 2004). Second degree stochastic dominance states the scenario with CDF *F* dominates another scenario with CDF *G* if $\int F(r)dR \leq \int G(r)dRG(r) \forall r$.

If there is not a clear dominant calving season and feed ration using first and second degree stochastic dominance, stochastic efficiency with respect to a function (SERF) was used to rank the calving seasons and feed ration scenarios over a range of absolute risk aversion coefficients (Hardaker et al., 2004). SERF analysis requires the specification of a utility function $U(\tilde{\pi}_{ik}, r)$, which is a function of the distribution of net returns for each calving seasons and feed ration scenario along with an absolute risk-preference level *r*. The utility function was used to find the CE. The calving season and feed ration scenario with the highest CE at a given level of risk is preferred by producers.

A negative exponential utility function was used in this analysis, which specifies constant absolute risk-aversion coefficient (ARAC) to calculate the CE (Pratt, 1964). The ARAC represents the ratio of derivatives of the person's utility function

$r_a(r) = -U''(r)/U'(r)$. Following Hardaker et al. (2004), a vector of CEs will be derived bounded by a low and high ARAC. The lower bound ARAC was zero, meaning the producer was risk neutral and the calving seasons and feed ration scenario with the highest expected net returns was preferred. The upper bound ARAC was found by dividing four by the average net returns for all the calving seasons and feed ration scenarios, which was proposed by Hardaker et al. (2004) to find the extremely risk averse decision maker.

In our analysis, ARACs ranged from 0.0 as risk neutral to 0.03 as highly risk averse. This means as the ARAC increased, the decision-maker was becoming more risk averse. Taking the difference between CEs of any two alternatives was defined as the utility weighted risk premium. The risk premium is the minimum amount of money a decision maker would have to be paid to switch from the calving seasons and feed ration scenario with the greatest CE to the alternative calving seasons and feed ration scenario with the lesser CE. The SERF analysis was also conducted in SIMETAR© (Richardson et al., 2008).

CHAPTER V: RESULTS AND DISCUSSION

Ration Development

Commonly Used Rations

Table 8 shows the quantity (lb/day) of each ingredient for the two commonly used rations needed to meet the minimum requirements of DMI, MP, and NEm by month and calving season. For both rations, the spring-calving cows required less feed in December and January than the fall-calving cows. The spring-calving cows were transitioning from a late-gestation and no lactation period into a calving and lactation period in December and January, and the fall-calving cows were moving from breeding and lactation period to early gestation and lactation period, which required higher levels of MP and NEm. During February and March, the fall-calving cows required less daily feed than the spring-calving cows because the spring-calving cows were reaching the peak lactation period. For each calving season, the total amount of feed provided daily was higher for the corn gluten feed ration than the corn silage ration.

Budgets were constructed to show the net returns per head for the spring- and fall-calving seasons for each ration and weaning month. Tables 9 and 10 show the expected net returns for the spring-calving herd when calves were weaned and sold in September while fed the corn gluten ration (Table 9) and the corn silage ration (Table 10). Tables 11 and 12 show the expected net returns for the spring-calving herd when calves were weaned and sold in October while fed the corn gluten ration (Table 11) and the corn silage ration (Table 12). For both weaning months, the corn silage ration had higher expected net returns than the corn gluten ration. Steer and heifer prices were higher in September than October, which explains the net returns being higher when weaning in September.

Tables 13 and 14 show the expected net returns for the fall-calving herd when calves were weaned in April while fed the corn gluten ration (Table 13) and the corn silage ration (Table 14). Tables 15 and 16 show the expected net returns for the fall-calving herd when calves were weaned in May while fed the corn gluten ration (Table 15) and the corn silage ration (Table 16). Similar to the spring-calving herd, the corn silage ration had higher expected net returns than the corn gluten ration for both weaning months. Weaning calves in April was more profitable than in May due to higher steer and heifer prices in April.

Comparing between calving seasons, the fall-calving cows had higher expected net returns than the spring-calving cows when fed the commonly used feed rations, which matches what others have found (Caldwell et al., 2013; Campbell et al., 2013; Smith et al. 2012). The spring-calving cows had heavier calves at weaning, and lower feed costs than the fall-calving cows; however, cattle prices at weaning were higher for calves born in the fall. The higher prices of steer and heifer calves captured by fall-born calves were able to cover the higher feed expenses and lighter weaning weights by the fall-born calves.

Least-Cost Rations

Table 17 shows the quantity (lb/day) of each ingredient in the two least-cost feed rations that provided the minimum requirements of DMI, MP, and NEm by month and calving season. For both rations, the model found that a producer would feed orchardgrass, corn gluten, corn silage, rice bran, and wheat middlings. The spring-calving cows required less daily feed in December and January than the fall-calving cows because of differences in the reproductive stages; however, in February and March the spring-calving cows required higher feed intake. For both calving seasons, relaxing the constraint of a minimum of 20 lb/day of orchardgrass hay being fed reduced the total feed required. The model selected feeding corn silage instead of orchardgrass hay.

Budgets were constructed to show the net returns per head for the spring- and fall-calving seasons for each ration and selling month. Tables 18 and 19 show the expected net returns for the spring-calving cow that calves were weaned and sold in September and cows were fed a ration that required a minimum amount of orchardgrass hay (Table 18) and a ration with no minimum amount of orchardgrass hay (Table 19). Tables 20 and 21 show the expected net returns for the spring-calving herd when calves were weaned and sold in October and cows were fed a ration that required a minimum amount of orchardgrass hay (Table 20) and a ration with no minimum amount of orchardgrass hay (Table 21). For both weaning months, the feed ration consisting of no minimum amount of orchardgrass hay resulted in the highest expected net returns. Expected net returns were higher when weaning occurred in September because steer and heifer prices were higher in September than October.

Tables 22 and 23 show the expected net returns for the fall-calving herd when calves were weaned and sold in April and cows were fed a ration that required a minimum amount of orchardgrass hay (Table 22) and a ration with no minimum amount of orchardgrass hay (Table 23). Tables 24 and 25 show the expected net returns for the fall-calving herd when calves were weaned and sold in May and cows were fed a ration that required a minimum amount of orchardgrass hay (Table 24) and a ration with no minimum amount of orchardgrass hay (Table 25). Similar to spring-calving cows, the feed ration with no minimum amount of orchardgrass hay had higher expected net returns for both weaning months. For either feed rations, weaning and selling the calves in April was more profitable than in May due to higher steer and heifer prices.

Comparing between calving seasons, the results were the same as the commonly used feed ration results. The fall-calving cows had higher expected net returns than the spring-calving cows when fed the least-cost feed rations. This matches results from research comparing the profitability of spring- and fall-calving seasons grazing tall fescue (Caldwell et al., 2013; Smith et al., 2012). The spring-calving cows had heavier calves at weaning, and lower feed costs than the fall-calving cows. However, cattle prices at weaning were higher for calves born in the fall. The higher prices of steer and heifer calves captured by fall-born calves were able to cover the higher feed expenses and lighter weaning weights by the fall-born calves.

Simulated Net Returns with Commonly Used Rations

The average and standard deviation of simulated net returns ($/head) under the commonly used rations by calving season and weaning month are shown on Table 26. Feeding a spring-calving cow a corn silage ration resulted in higher expected net returns than feeding a corn gluten ration for both weaning months. Weaning in September was more profitable and had less variable net returns than weaning in October for both rations. A spring-calving cow that was fed a corn silage ration and weaned in September had the highest expected net returns ($6.63/head) and lowest variability in net returns for all spring-calving scenarios.

Similarly, feeding a fall-calving cow a corn silage ration increased expected net returns and reduced variability of net returns relative to feeding a corn gluten ration for both weaning months. Weaning fall-born calves in April had higher expected net returns than weaning in May; however, the variability in net returns was higher when calves were weaned in April. A fall-calving cow that was fed corn silage and weaned in April had the highest expected net returns ($36.20/head), but a fall-calving cow that was fed corn silage and weaned in May had the lowest variability of net returns.

A profit-maximizing beef cattle producer would select a fall-calving season over a spring-calving season regardless of the feed ration and weaning month. Caldwell et al. (2013) and Smith et al. (2012) also found fall-calving season to have higher net returns than the spring-calving season in Arkansas. The spring-calving cows had heavier calves at weaning, and lower feed costs than the fall-calving cows; however, cattle prices at weaning were higher for calves born in the fall. The higher prices of steer and heifer calves captured by fall-born calves were able to cover the higher feed expenses and lighter weaning weights by the fall-born calves. This suggests that seasonality of feed and beef prices, the forage growth cycle of tall fescue (Bagley et al., 1987), and the negative impacts of fescue toxicosis on spring-calving cows (Smith et al., 2012) impacted the results.

Risk Analysis of Net Returns with Commonly Used Rations

Figure 1 presents the CDF of net returns for each calving season and weaning month when feeding the corn gluten feed ration. Figure 2 presents the CDF of net returns for each calving season and weaning month when feeding the corn silage feed ration. The CDFs show that first- and second-degree stochastic dominance does not exist since the CDFs cross.

SERF was used to determine the combination of calving season, feed ration, and weaning month that was preferred by cattle producers at different levels of absolute risk aversion. Figure 3 displays the results of the SERF analysis for the commonly used feed ration scenario by calving season and weaning month, which ranks the CEs. Fall-calving was the preferred calving season regardless of the producer’s risk aversion level. Figure 4 shows the risk premiums for each scenario for the commonly used feed rations. A risk neutral to slightly-risk averse (0.0 ≤ ARAC ≤ 0.004) producer would select a fall-calving season that weans calves in April and feeds a corn silage ration (Fall_Apr_CS). A producer with these risk preferences would have to be paid approximately $30/head to switch from fall-calving that weans in April and feeds a corn silage ration (Fall_Apr_CS) to the best spring-calving season scenario (i.e., spring-calving that weans in September and feeds a corn silage ration (Spring_Sept_CS)).

However, as risk aversion increases (ARAC ≥ 0.004), the most preferred scenario was a fall-calving season, feeding a corn silage ration and weaning in May (Fall_May_CS). A highly risk averse producer (ARAC = 0.03) would have to be paid approximately $33/head to switch fall-calving that weans in May and feeds a corn silage ration to the spring-calving season that weans in September and feeds a corn silage ration

(Spring_Sept_CS), and $8.52/head to take on the additional risk associated with switching from feeding corn silage and weaning in May to weaning in April.

Simulated Net Returns with Least-Cost Rations

The average and standard deviation of simulated net returns (in $/head) under the least-cost rations by calving season and weaning month are shown in Table 27. For spring-calving season, expected net returns were higher when there was not a restricted amount of orchardgrass hay fed for both weaning months. Weaning in September was more profitable than weaning in October. A spring-calving cow that was fed a ration without a minimum amount of orchardgrass hay required and weaned in September had the highest expected net returns ($10.03/head) but this scenario also had the highest variability in net returns.

Similarly, feeding a fall-calving cow a ration with no minimum amount of orchardgrass hay had higher expected net returns and higher variability of net returns than feeding a ration with a minimum amount of orchardgrass hay. Weaning fall-born calves in April resulted in higher expected net returns and higher variability in net returns than weaning in May. A fall-calving cow that was not fed a minimum amount of orchardgrass hay and weaned in April had the highest expected net returns ($37.92/head) but also had the most variability in net returns. A fall-calving cow that was fed a minimum amount of orchardgrass hay and weaned in May had the lowest variability of net returns but also had the lowest expected net returns.

Similar to the commonly used rations scenarios, a profit-maximizing cattle producer would choose a fall-calving season regardless of the feed ration and weaning month. The increase in revenue received from higher cattle prices in April and May for fall-born calves was able to make up for the higher feed costs and lighter calves. Again, this result seems to match what Caldwell et al. (2013) and Smith et al. (2012) observed. Also, that the seasonality of feed and beef prices, the forage growth cycle of tall fescue more closely matching nutritional needs of fall-calving cows (Bagley et al., 1987), and the negative impacts of fescue toxicosis on spring-calving cows (Smith et al., 2012) impacted the results.

Risk Analysis of Net Returns with Least-Cost Rations

Figure 5 presents the CDF of net returns for each calving season and weaning month when feeding a ration with the orchardgrass hay constraint. Figure 6 presents the CDF of net returns for each calving season and weaning month when feeding a ration without the orchardgrass hay constraint. The CDFs show that first- and second-degree stochastic dominance does not exist since the CDFs cross.

SERF was used to determine the combination of calving season, feed ration, weaning month preferred by beef cattle producers at different levels of absolute risk aversion by calculating CEs (Figure 7). Figure 8 shows the risk premiums for each scenario for the least-cost feed rations. The fall-calving season regardless of the ration and weaning month was preferred to the spring-calving season for all levels of risk aversion. Within the fall-calving season, a risk-neutral (ARAC = 0) to moderately-risk averse (ARAC = 0.016) producer would prefer to wean in April and feed a ration that does not require a minimum amount of orchardgrass hay (Fall_April_NHC). However, a producer who was moderately-risk averse (ARAC = 0.016) to highly-risk averse (ARAC

0.03) would select a fall-calving season that weans in May and does not feed a minimum amount of orchardgrass hay (Fall_May_NHC).

CHAPTER VI: CONCLUSION AND IMPLICATIONS

The objective of this study was to evaluate the profitability and variability of profits for spring- and fall-calving seasons for beef production in Tennessee while considering the seasonality of feed costs and cattle prices under various feed rations. Data used came from spring- and fall-calving cows located at Ames Plantation, which is near Grand Junction, Tennessee, over a 19-year time period from 1989 to 2008. This research will help Tennessee beef cattle producers make better economic decisions about optimal calving seasons.

Feed rations were developed for two commonly used rations by Tennessee producers and two least-cost feed rations available to producers. Enterprise budgets were established for each of the rations and calving seasons as well as two weaning dates for each calving season, resulting in 16 scenarios (four rations x two weaning months x two calving seasons). Net returns were simulated for all 16 budgets while considering seasonal prices for cattle and ingredients in feed rations, and used to compare the profitability and risk of each calving season.

Under the commonly used feed ration scenario, a risk neutral- to slightly-risk averse producer would select a fall-calving season that weans in May and fed the corn silage ration. However, a slightly- to highly-risk averse producer would select a fall-calving season that weans in April and fed the corn silage ration. For the least-cost feed ration scenario, a risk neutral to slightly-risk averse producer would select a fall-calving season that weans in April and does not feed a minimum amount of orchardgrass hay. However, a slightly- to highly-risk averse producer would select a fall-calving season that weans in May and does not feed a minimum amount of orchardgrass hay. Overall, the fall-calving season was found to be preferred to the spring-calving season for all scenarios of rations and weaning months.

However, the majority of beef cattle producers in Tennessee who operate with a defined calving season choose to follow a spring-calving season (Campbell et al., 2013). Future research should consider using a producer survey to examine why producers prefer the spring-calving season to the more profitable fall-calving season. Also, further research is needed on the economics of switching a spring-calving herd to a fall-calving herd.

REFERENCES

Anderson, J.R. and J.L. Dillon. 1992. *Risk Analysis in Dryland Farming Systems*. Farm Systems Management Series Vol. 2. Food and Agriculture Organizations of the United Nations, Rome.

Bagley, C.P., J.C. Carpenter, J.I. Feazel, F.G. Hembry, D.C. Huffman, and K.L. Koonce. 1987. Influence of Calving Season and Stocking Rate on Beef Cow-Calf Productivity. *Journal of Animal Science* 64(3):687–694.

Beef Improvement Federation (BIF). 2010. BIF Guidelines for Uniform Beef Improvement Programs. 9th ed. Beef Improvement Federation. Raleigh, NC.

Caldwell, J.D., K.P. Coffey, J.A. Jennings, D. Philipp, A.N. Young, J.D. Tucker, D.S. Hubbell, T. Hess, M.L. Looper, C.P. West, M.C. Savin, M.P. Popp, D.L. Kreider, D.M. Hallford, and C.F. Rosenkrans. 2013. Performance by Spring- and Fall-Calving Cows Grazing with Full, Limited, or No Access to Toxic Neotyphodium Coenophialum-Infected Tall Fescue. *Journal of Animal Science* 91(1):465–476.

Campbell, B.T., W.M. Backus, C.M. Dixon, R.J. Carlisle, and J.C. Waller. 2013. A Comparison of Spring- and Fall-Calving Beef Herds Grazing Tall Fescue. *The Professional Animal Scientist* 29(2):172–178.

Chavas, J.P. 2004. *Risk Analysis in Theory and Practice the Professional.* San Diego, CA: Elsevier Academic Press.

Evans, J.R., M. Sperow, G.E. D'Souza, and E.B. Rayburn. 2007. Stochastic Simulation of Pasture-Raised Beef Production Systems and Implications for the Appalachian Cow-Calf Sector. *Journal of Sustainable Agriculture* 30(4):27–51.

Gaertner, S.J., F.M. Rouquette, Jr., C.R. Long, and J.W. Turner. 1992. Influence of Calving Season and Stocking rate on Birth Weight and Weaning Weight of Simmental-sired Calves from Brahman-Hereford F1 Dams. *Journal of Animal Science* 70:2296-2303.

George, M., G. Nadar, and J. Dunbar. 2001. Balancing Beef Cow Nutrient Requirements and Seasonal Forage Quality on Annual Rangeland. *Department of Agriculture and Natural Resources,* University of California.

Griffith, A.P. 2013. Seasonal Prices for Feedstuffs Commonly Utilized in the Midsouth. *Department of Agricultural and Resource Economics*, University of Tennessee.

Hardaker, J.B., R.B.M Huirne, J.R. Anderson, and G. Lien. 1997. *Coping with Risk in Agriculture.* 1st edition. Pub. Guildford, UK.

Hardaker, B.H, J.W. Richardson, G. Lien., and K.D. Schumann. 2004. Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach. *The Australian Journal of Agricultural and Resource Economics* 48:2 253-270.

Julien, D. J., and M. W. Tess. 2002. Effects of Calving Date, Weaning Date, and Duration of Fall Grazing on Profitability in Range Beef Cattle Enterprises. *Journal of Animal Science* 80:1462–1469.

Kay, R.D., W.M. Edwards, and P.A. Duffy. 2007. *Farm Management.* 6th Edition. R.R. Donnelley Crawfordsville, Indiana.

Keyser, P.D., C.A. Harper, G.E. Bates, J. Waller, and E. Doxon. 2011. Native Warm-Season Grasses for Mid-South Forage Production. *University of Tennessee Center for Native Grassland Management* SP: 731-A.

Khakbazan, M., R. Carew, S.L. Scott, P. Chiang, H.C. Block, C. Robins, O.N. Durunna, and J. Huang. 2014. Economic Analysis and Stochastic Simulation of Alternative Beef Calving and Feeding Systems in Western Canada. *Canadian Journal of Animal Science* 94(2):299–311.

Leesburg, V.L.R., M.W. Tess, and D. Griffith. 2007. Evaluation of Calving Seasons and Marketing Strategies in Northern Great Plains Beef Enterprises: I. Cow-Calf Systems. *Journal of Animal Science* 85(9):2314–2321.

McCarter, M.N., D.S. Buchanan, and R.R. Frahm. 1991. Comparison of Crossbred Cows Containing Various Proportions of Brahman in Spring- or Fall-Calving Systems: IV. Effects of Genotype X Environment Interaction on Lifetime Productivity of Young Cows. *Journal of Animal Science* 69(10):3977–3982.

McKinley, T.L. 2013. Seasonal Prices for Tennessee Feeder Cattle and Cows. *Department of Agricultural and Resource Economics*, University of Tennessee.

Menard, J., B. English, and K. Jenson. 2013. Economic Impacts of Agriculture and Forestry in Tennessee. *University of Tennessee Department of Agricultural and Resource Economics* SP:13-001.

National Research Council. 1996. *Nutrient Requirements of Beef Cattle*. National Academy Press. Washington, D.C.

Pang, H., M. Makarechian, J.A. Basarab, and R.T. Berg. 1999. Application of a Dynamic Simulation Model on the Effects of Calving Season and Weaning Age on Bioeconomic Efficiency. *Canadian Journal of Animal Science* 79(4):419–424.

Payne, C.A., B.H. Dunn, K.C. McCuistion, S.D. Lukefahr, and D. Delaney. 2009. Predicted Financial Performance of Three Beef Cow Calving Seasons in South Texas. *The Professional Animal Scientist* 25(1):74–77.

Pratt, J.W. 1964. Risk aversion in the small and in the large. *Econometrica* 32:122–36.

Pruitt, J.R., J.M. Gillespie, R.F. Nehring, and Qushim, B. 2012. Adoption of Technology, Management Practices, and Production Systems by U.S. Beef Cow-Calf Producers. *Journal of Agricultural and Applied Economics* 44(2): 203–222.

Richardson, J.W., K.D. Schumann, and P. A. Feldman. 2008. SIMETAR Simulation for Excel to Analyze Risk. Department of Agricultural Economics, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas.

Sirski, T. K. 2012.The Effect of calving Season on Economic Risk and Return in Cow-calf operations in Western Canada. MS.Thesis, *University of Manitoba*.

Smith, S.A., J.D. Caldwell, M.P. Popp, K.P. Coffey, J.A. Jennings, M.C. Savin, and C.F. Rosenkrans, Jr. 2012. Tall Fescue Toxicosis Mitigation Strategies: Comparisons of Cow-Calf Returns in Spring- and Fall-Calving Herds. *Journal of Agricultural and Applied Economics* 44(4): 577-592.

Strauch, B.A., D.E. Peck, and L.J. Held. 2010. A Case Study of Fall Versus Spring Calving for the Rocky Mountain West. *Journal of the American Society of Farm Managers and Rural Appraisers* 74-84.

United States Department of Labor, Bureau of Labor Statistics Consumer Price Index, BLS-CPI. 2013. http://www.bls.gov/cpi/.

United States Department of Agriculture-Agricultural Marketing Services, USDA-AMS. 2013. Livestock and Grain Market News. http://marketnews.usda.gov/portal/lg.

University of Kentucky -Department of Agricultural Economics. 2008. Beef Enterprise Budgets. http://www2.ca.uky.edu/agecon/index.php?p=4.

University of Tennessee-Department of Agricultural and Resource Economics. 2015. Livestock Budgets. http://economics.ag.utk.edu/budgets.html.

Volenec, J. J., and C. J. Nelson. 2007. Physiology of Forage Plants. *Forages: The Science of Grassland Agriculture* (2): 37-52.

APPENDIX

Tables

Table 1. Summary of Studies Evaluating the Animal Performance and Profitability Variables for a Spring-and Fall-Calving Season

			Animal Performance					Profitability		
Study	Location	Pasture Info.	Lower Birth Weight	Higher Calving Rate	Lower Calf Death Loss	Lower Culling Rate	Higher 205-day Weaning Weight	Seasonal Prices	Expected Profit	Risk Analysis
Bagley et al. (1987)	LA	Bermudagrass, Ryegrass, White Clover	Fall†	Fall†	Fall†	Fall†	Fall†	NA	Fall†	NA
McCarter, Buchanan, & Frahm (1991)	OK	Bermudagrass, Bluestem, & Buffalograss	NA	Spring†	NA	Spring†	ND	NA	NA	NA
Gaertner et al. (1992)	TX	Bermudagrass, Ryegrass, Clover	Fall†	NA	NA	NA	Fall†	NA	NA	NA
Campbell et al. (2013)	TN	E+ Fescue	ND	Fall†	NA	Fall†	Spring†	Beef‡	Fall†	NA
Caldwell et al. (2012) & Smith et al. (2012)	AR	E+ Fescue & E- Fescue	NA	Fall†	Fall†	Fall†	Fall†	Beef‡	Fall†	NA
Pang et al. (1999)	Canada	NA	Fall†	Spring†	NA	NA	Spring†	Beef‡ & Feed‡	<200-d =S >200-d =F	NA
Leesburg, Tess, & Griffith (2007)	North Great Plains	NA	NA	Spring†	Fall†	ND	Spring†	Beef‡ & Feed‡	Spring†	NA
Payne et al. (2009)	TX	NA	NA	NA	NA	Fall†	NA	Beef‡	Fall†	NA

Table 1. Continued.

Study	Location	Pasture Info.	Animal Performance					Profitability		
			Lower Birth Weight	Higher Calving Rate	Lower Calf Death Loss	Lower Culling Rate	Higher 205-day Weaning Weight	Seasonal Prices	Expected Profit	Risk Analysis
Evans et al. (2007)	WV	Orchardgrass, Fescue, Clover	NA	ND	NA	NA	Spring†	Beef‡	Spring†	Spring†
Strauch, Peck, & Held (2010)	CO, UT, & WY	NA	NA	NA	NA	NA	NA	Beef‡	Fall†	Fall†
Sirski (2012)	Canada	NA	NA	ND	NA	ND	Spring†	Beef‡	Fall†	Spring†
Khakbazan et al. (2014)	Canada	NA	NA	ND	NA	ND	Spring†	Beef‡	Fall†	Neutral = Fall Averse = Spring

†Indicates whether fall- or spring-calving was higher or lower relative to the comparison calving system.

‡Indicates whether beef prices (Beef) and/or supplemental feed prices (Feed) varied seasonally in the analysis.

NA- Not applicable; ND- No significant difference; 200-d- 200-day weaning; S- Spring-calving herd; F- Fall-calving herd.

Table 2. Average Birth Weight (in lb) and Adjusted 205-day Weaning Weight (in lb) by Calving Season and Calf Sex at Grand Junction, Tennessee from 1990-2008

	Spring-Calving Season		Fall-Calving Season	
Weight	Steer	Heifer	Steer	Heifer
Average Birth Weight (lb)	79.94 (13.54)	73.34 (12.65)	77.72 (15.26)	70.38 (14.23)
Average Weaning Weight (lb)	623.83 (103.13)	562.95 (88.28)	581.24 (93.23)	537.93 (82.12)

Standard deviations are noted in the parenthesis.

Table 3. Parameter Values Used in the Nutrient Requirements of Beef Cattle (NRC) Program for Animal Description, Pasture Management, and Environment Factor by Calving Season and Month

		Spring-Calving Season				Fall-Calving Season			
Variables	Units	December	January	February	March	December	January	February	March
Animal Description									
Age	months	60	60	60	60	60	60	60	60
Body Weight	lb	1100	1100	1100	1100	1100	1100	1100	1100
Body Condition	value	5	5	5	5	5	5	5	5
Calf Birth Weight	lb	73	73	73	73	73	73	73	73
Peak Milk Production	lb/day	25	25	25	25	25	25	25	25
Milk Fat	%	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Milk Protein	%	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Days Pregnant	days	255	0	0	0	15	45	75	105
Days in Milk	days	0	15	45	75	105	135	165	195
Pasture Management									
Additives	Y/N	N	N	N	N	N	N	N	N
Pasture Unit Size	acres/ head	2	2	2	2	2	2	2	2
Pasture Mass – Dry Matter	lb/acre	5000	5000	5000	5000	5000	5000	5000	5000
Environment Factor									
Night Cooling	Y/N	N	N	N	N	N	N	N	N
Hair Depth	inches	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Average Temperature	^{o}F	41	37	42	51	41	37	42	51

Source: NRC (1996).

Table 4. Minimal Levels of Dry Matter Intake (lb/day), Metabolized Protein (grams/day), and Energy (mcal/day) Required for a 1,100 lb Cow by Calving Season and Month

	Spring-Calving Season			Fall-Calving Season		
Months	DMI (lb/day)	MP (g/day)	NEm (mcal/day)	DMI (lb/day)	MP (g/day)	NEm (mcal/day)
January	29.38	771	24.2	31.85	835	25.3
February	31.35	1027	27	30.28	738	23
March	31.38	1031	25.6	29.5	661	20.4
April	30.9	910	21.83	28	575	17.02
May	30	802	19.83	27.6	543	16.25
June	29.2	705	18.05	26.8	468	14.98
July	25.8	628	16.52	24.1	503	15.34
August	25.3	575	15.79	24.1	559	16.54
September	27.6	543	16.07	27.9	738	18.53
October	26.8	468	15.73	30.1	995	22.85
November	27.6	503	17.99	30.9	998	24.23
December	27.55	592	22.2	32.28	943	26.1

Source: NRC (1996).

Table 5. Amount of Metabolized Protein (MP) (grams/day), and Energy (NEm) (mcal/day) in one lb of Dry Matter for each Feed Ration Ingredient

	Spring- and Fall-Calving Herd	
Ingredient	MP (g/day)	NEm (mcal/day)
Orchardgrass Hay	31	0.72
Corn Gluten Feed	47	1.00
Corn Silage	34	0.80
Dried Distillers Grains	97	1.14
Soybean Hulls	35	0.90
Whole Cottonseed	61	1.24
Rice Bran	52	0.80
Wheat Middlings	47	1.04

Source: NRC (1996).

Table 6. Average Real Price (in $/cwt) for 500-600 lb Steers, 400-500 lb Heifers, and 1100-1600 lb Culled Cows from 1989 to 2013 in 2013 Dollars by Month

Month	Average Steer Price ($/cwt)	Average Heifer Price ($/cwt)	Average Culled Cow Price ($/cwt)
January	$125.10	$120.10	$61.37
	(21.06)	(22.08)	(15.26)
February	$130.35	$125.69	$65.22
	(21.92)	(23.49)	(16.13)
March	$133.90	$128.79	$65.30
	(22.56)	(23.75)	(15.85)
April	$134.46	$129.49	$66.42
	(22.62)	(23.92)	(15.53)
May	$132.83	$128.43	$68.22
	(22.15)	(23.63)	(16.02)
June	$131.00	$125.92	$67.57
	(21.50)	(23.19)	(15.76)
July	$129.00	$124.03	$65.34
	(21.00)	(22.33)	(15.72)
August	$129.12	$123.49	$64.91
	(21.47)	(22.38)	(15.44)
September	$125.26	$120.35	$58.37
	(21.34)	(22.28)	(15.81)
October	$122.72	$116.34	$59.70
	(21.39)	(21.94)	(15.31)
November	$121.76	$116.47	$58.65
	(21.35)	(23.33)	(15.44)
December	$123.46	$117.47	$59.85
	(21.92)	(22.92)	(16.26)

Source: USDA-AMS (2013) and BLS-CPI (2013).
Standard deviations are noted in the parenthesis.

Table 7. Average Monthly Real Prices ($/dry ton) for all Feed Ration Ingredients from 2000 to 2013 in 2013 Dollars

Month	Orchardgrass Hay ($/ton)	Corn Gluten Feed ($/ton)	Corn Silage ($/ton)	Dried Distillers Grains ($/ton)	Soybean Hulls ($/ton)	Cottonseed Whole ($/ton)	Rice Bran ($/ton)	Wheat Midds ($/ton)
January	$104.40	$122.45	$40.03	$156.47	$133.34	$197.74	$120.57	$134.68
	(43.76)	(29.37)	(16.50)	(41.69)	(34.59)	(59.09)	(47.23)	(51.80)
February	$111.94	$120.69	$41.32	$156.27	$128.65	$195.81	$115.23	$125.63
	(41.07)	(31.26)	(17.35)	(45.16)	(30.13)	(60.51)	(40.96)	(49.30)
March	$ 115.57	$116.72	$42.13	$156.71	$119.50	$199.72	$103.92	$132.72
	(48.44)	(33.98)	(17.75)	(48.41)	(30.64)	(63.86)	(39.81)	(53.52)
April	$126.26	$113.74	$42.29	$159.27	$116.94	$205.26	$90.75	$118.07
	(36.41)	(36.64)	(18.21)	(49.21)	(32.34)	(67.73)	(40.56)	(48.39)
May	$128.05	$110.52	$42.88	$161.82	$107.85	$219.79	$86.13	$111.11
	(30.39)	(35.13)	(18.11)	(51.18)	(31.60)	(76.33)	(40.15)	(47.09)
June	$113.70	$109.13	$43.13	$162.13	$106.69	$235.30	$88.36	$116.02
	(29.25)	(34.35)	(19.10)	(64.95)	(35.63)	(90.48)	(39.89)	(45.51)
July	$110.86	$113.18	$41.85	$161.25	$118.03	$237.12	$95.00	$120.67
	(20.09)	(45.27)	(19.82)	(76.65)	(55.08)	(87.81)	(43.83)	(58.02)
August	$114.62	$117.47	$40.59	$160.65	$132.13	$239.13	$100.78	$132.44
	(32.79)	(57.13)	(19.57)	(73.68)	(73.43)	(87.79)	(51.94)	(81.60)
September	$111.29	$121.46	$39.12	$162.18	$134.50	$222.71	$105.88	$137.58
	(30.32)	(55.19)	(17.75)	(64.68)	(54.86)	(81.93)	(52.40)	(78.49)
October	$113.30	$123.37	$38.21	$170.20	$135.75	$193.66	$113.27	$132.20
	(29.08)	(50.00)	(16.51)	(59.92)	(46.76)	(66.01)	(55.92)	(58.15)
November	$104.54	$127.77	$39.31	$173.63	$138.22	$193.98	$119.18	$131.75
	(29.55)	(46.10)	(16.05)	(57.39)	(44.86)	(66.54)	(58.03)	(54.71)
December	$121.38	$129.99	$40.12	$159.83	$142.01	$207.22	$125.85	$146.00
	(34.40)	(40.97)	(15.56)	(51.32)	(42.89)	(66.88)	(56.16)	(59.83)

Source: USDA-AMS (2013) and BLS-CPI (2013).
Standard Deviations are noted in the parenthesis.

Table 8. Amount of Ingredients Fed (dry lb/day) in each of the Commonly Used Feed Rations by Month and Calving Season

Ingredients (dry lb/day)	Spring-Calving Season				Fall-Calving Season			
	December	January	February	March	December	January	February	March
				Corn Gluten Ration				
Orchardgrass Hay	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Corn Gluten	3.80	4.70	5.60	5.70	6.10	5.90	5.10	4.70
Soybean Hulls	3.80	4.70	5.60	5.70	6.10	5.90	5.10	4.70
Total	27.60	29.40	31.20	31.40	32.20	31.80	30.20	29.40
				Corn Silage Ration				
Orchardgrass Hay	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Corn Silage	6.90	8.50	7.60	7.60	11.40	10.90	9.50	8.70
Soybean Hulls	-	-	3.0	3.0	-	-	-	-
Total	26.90	28.50	30.60	30.60	31.40	30.90	29.50	28.70

Source: NRC (1996).

Table 9. Enterprise Budget for a Spring-Calving Cow that was Fed a Corn Gluten Ration and Weaned in September

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	125.26	334.05
Heifers	head	1	563	120.35	155.83
Cull Cows	head	1	1100	58.37	101.70
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	588.58
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Gluten Feed	ton	0.297		142.54	42.33
Soybean Hulls	ton	0.297		148.38	44.07
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.31
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Replacement Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	590.60
				Returns to Variable Expenses	(1.69)

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 10. Enterprise Budget for a Spring-Calving Cow that was Fed a Corn Silage Ration and Weaned in September

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	125.26	334.05
Heifers	head	1	563	120.35	155.83
Cull Cows	head	1	1100	58.37	101.70
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		588.58
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Silage	ton	0.459		116.84	53.63
Soybean Hulls	ton	0.09		143.09	12.88
Pasture & Feed Costs - Bull[c]	au	1.7		-	24.96
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
			Total Variable Expenses		569.03
			Returns to Variable Expenses		19.55

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 11. Enterprise Budget for a Spring-Calving Cow that was Fed a Corn Gluten Ration and Weaned in October

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	122.72	327.28
Heifers	head	1	563	116.34	150.64
Cull Cows	head	1	1100	59.70	104.02
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	578.94
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Gluten Feed	ton	0.297		142.54	42.33
Soybean Hulls	ton	0.297		148.38	44.07
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.31
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	590.60
				Returns to Variable Expenses	(11.66)

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 12. Enterprise Budget for a Spring-Calving Cow that was Fed a Corn Silage Ration and Weaned in October

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	122.72	327.28
Heifers	head	1	563	116.34	150.64
Cull Cows	head	1	1100	59.70	104.02
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	578.94
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Silage	ton	0.459		116.84	53.63
Soybean Hulls	ton	0.09		143.09	12.88
Pasture & Feed Costs - Bull[c]	au	1.7		-	24.96
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	569.03
				Returns to Variable Expenses	9.91

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 13. Enterprise Budget for a Fall-Calving Cow that was Fed a Corn Gluten Ration and Weaned in April

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	134.46	341.14
Heifers	head	1	538	129.49	174.14
Cull Cows	head	1	1100	66.42	115.73
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		628.01
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Gluten Feed	ton	0.327		143.61	46.96
Soybean Hulls	ton	0.327		150.24	49.13
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.97
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
			Total Variable Expenses		602.17
			Returns to Variable Expenses		25.84

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 14. Enterprise Budget for a Fall-Calving Cow that was Fed a Corn Silage Ration and Weaned in April

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	134.46	341.14
Heifers	head	1	538	129.49	174.14
Cull Cows	head	1	1100	66.42	115.73
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		628.01
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Silage	ton	0.608		116.60	70.89
Pasture & Feed Costs - Bull[c]	au	1.7		-	25.26
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
			Total Variable Expenses		575.26
			Returns to Variable Expenses		52.75

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 15. Enterprise Budget for a Fall-Calving Cow that was Fed a Corn Gluten Ration and Weaned in May

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	132.83	337.01
Heifers	head	1	538	128.43	172.72
Cull Cows	head	1	1100	68.22	118.87
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		625.60
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Gluten Feed	ton	0.327		143.61	46.96
Soybean Hulls	ton	0.327		150.24	49.13
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.97
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
		Total Variable Expenses			602.17
		Returns to Variable Expenses			23.43

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 16. Enterprise Budget for a Fall-Calving Cow that was Fed a Corn Silage Ration and Weaned in May

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	132.83	337.01
Heifers	head	1	538	128.43	172.72
Cull Cows	head	1	1100	68.22	118.87
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		625.60
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		125.08	150.10
Corn Silage	ton	0.608		116.60	70.89
Pasture & Feed Costs - Bull[c]	au	1.7		-	25.26
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
			Total Variable Expenses		575.26
			Returns to Variable Expenses		50.34

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 17. Amount of Ingredients Fed (dry lb/day) in each of the Least-Cost Feed Rations by Calving Season and Month

Ingredients (dry lb/day)	Spring-Calving Season				Fall-Calving Season			
	December	January	February	March	December	January	February	March
	Minimum of 20 lb/day of Orchardgrass Hay Fed							
Orchardgrass Hay	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Corn Gluten Feed	-	-	-	10.48	-	-	-	-
Corn Silage	9.75	-	-	-	14.63	5.93	8.71	-
Rice Bran	-	-	-	0.90	-	-	-	9.50
Wheat Middlings	-	9.42	12.11	-	-	5.92	1.57	-
Total	29.75	29.42	32.11	31.38	34.63	31.86	30.28	29.50
	No Minimum of Orchardgrass Hay Fed							
Orchardgrass Hay	-	-	-	-	-	2.25	15.30	-
Corn Gluten Feed	-	-	-	2.48	-	-	-	-
Corn Silage	27.75	26.48	23.35	-	32.63	29.60	14.98	-
Rice Bran	-	-	-	28.90	-	-	-	29.50
Wheat Middlings	-	2.90	8.00	-	-	-	-	-
Total	27.5	29.38	31.35	31.38	32.63	31.85	30.28	29.50

Source: NRC (1996).

Table 18. Enterprise Budget for a Spring-Calving Cow that was Fed a Ration with 20 lb/day of Orchardgrass Hay and Weaned in September

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	125.26	334.05
Heifers	head	1	563	120.35	155.83
Cull Cows	head	1	1100	58.37	101.70
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	588.58
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		130.05	156.06
Corn Gluten Feed	ton	0.157		144.96	22.76
Corn Silage	ton	0.146		127.48	18.61
Rice Bran	ton	0.014		119.80	1.67
Wheat Middlings	ton	0.323		150.66	48.66
Pasture & Feed Costs - Bull[c]	au	1.7		-	27.08
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	602.30
				Returns to Variable Expenses	(13.72)

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 19. Enterprise Budget for a Spring-Calving Cow that was Fed a Ration with no Minimum Level of Orchardgrass Hay and Weaned in September

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	125.26	334.05
Heifers	head	1	563	120.35	155.83
Cull Cows	head	1	1100	58.37	101.70
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	588.58
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Corn Gluten Feed	ton	0.0372		144.96	5.39
Corn Silage	ton	1.1635		128.43	149.43
Rice Bran	ton	0.4335		119.80	51.93
Wheat Middlings	ton	0.1635		151.31	24.74
Pasture & Feed Costs - Bull[c]	au	1.7		-	25.97
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	584.92
				Returns to Variable Expenses	3.66

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 20. Enterprise Budget for a Spring-Calving Cow that was Fed a Ration with 20 lb/day of Orchardgrass Hay and Weaned in October

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	122.72	327.28
Heifers	head	1	563	116.34	150.64
Cull Cows	head	1	1100	59.70	104.02
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
			Total Revenue		578.94
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		130.05	156.06
Corn Gluten Feed	ton	0.157		144.96	22.76
Corn Silage	ton	0.146		127.48	18.61
Rice Bran	ton	0.014		119.80	1.67
Wheat Middlings	ton	0.323		150.66	48.66
Pasture & Feed Costs - Bull[c]	au	1.7		-	27.08
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
			Total Variable Expenses		602.30
			Returns to Variable Expenses		(23.36)

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 21. Enterprise Budget for a Spring-Calving Cow that was Fed a Ration with no Minimum Level of Orchardgrass Hay and Weaned in October

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	624	122.72	327.28
Heifers	head	1	563	116.34	150.64
Cull Cows	head	1	1100	59.70	104.02
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		5%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	578.94
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Corn Gluten Feed	ton	0.0372		144.96	5.39
Corn Silage	ton	1.1635		128.43	149.43
Rice Bran	ton	0.4335		119.80	51.93
Wheat Middlings	ton	0.1635		151.31	24.74
Pasture & Feed Costs - Bull[c]	au	1.7		-	25.97
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.79		38.83	30.68
				Total Variable Expenses	584.92
				Returns to Variable Expenses	(5.98)

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 22. Enterprise Budget for a Fall-Calving Cow that was Fed a Ration with 20 lb/day of Orchardgrass Hay and Weaned in April

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	134.46	341.14
Heifers	head	1	538	129.49	174.14
Cull Cows	head	1	1100	66.42	115.73
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	628.01
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		130.05	156.06
Corn Silage	ton	0.439		128.45	56.39
Rice Bran	ton	0.1425		119.80	17.07
Wheat Middlings	ton	0.1125		151.31	17.02
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.99
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
				Total Variable Expenses	602.54
				Returns to Variable Expenses	25.47

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 23. Enterprise Budget for a Fall-Calving Cow that was Fed a Ration with no Minimum Level of Orchardgrass Hay and Weaned in April

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	134.46	341.14
Heifers	head	1	538	129.49	174.14
Cull Cows	head	1	1100	66.42	115.73
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	628.01
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	0.263		127.57	33.55
Corn Silage	ton	1.158		129.82	150.33
Rice Bran	ton	0.4425		119.80	53.01
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.34
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
				Total Variable Expenses	592.24
				Returns to Variable Expenses	35.77

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 24. Enterprise Budget for a Fall-Calving Cow that was Fed a Ration with 20 lb/day of Orchardgrass Hay and Weaned in May

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
<u>*Revenue*</u>[a]					
Steers	head	1	581	132.83	337.01
Heifers	head	1	538	128.43	172.72
Cull Cows	head	1	1100	68.22	118.87
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	625.60
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	1.2		130.05	156.06
Corn Silage	ton	0.439		128.45	56.39
Rice Bran	ton	0.1425		119.80	17.07
Wheat Middlings	ton	0.1125		151.31	17.02
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.99
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	1		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
				Total Variable Expenses	602.54
				Returns to Variable Expenses	23.06

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).

[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.

[c]University of Kentucky (2008); University of Tennessee (2015).

Table 25. Enterprise Budget for a Fall-Calving Cow that was Fed a Ration with no Minimum Level of Orchardgrass Hay and Weaned in May

Description	Unit	Quantity	Weight (lb)	Price ($/cwt)	Amount ($/head)
Revenue[a]					
Steers	head	1	581	132.83	337.01
Heifers	head	1	538	128.43	172.72
Cull Cows	head	1	1100	68.22	118.87
Cow Weaning Percentage		90%	-	-	-
Calf Death Loss		3%	-	-	-
Cow Death Loss		1%	-	-	-
Beef Checkoff	head	3	-	1.00	(3.00)
				Total Revenue	625.60
Variable Expenses	Unit	Quantity		Price	Amount
Feed Costs - Cow[b]					
Fescue Pasture	au	1.2		125.37	150.44
Orchardgrass Hay	ton	0.263		127.57	33.55
Corn Silage	ton	1.158		129.82	150.33
Rice Bran	ton	0.4425		119.80	53.01
Pasture & Feed Costs - Bull[c]	au	1.7		-	26.34
Salt & Mineral - Cows, Bulls, Repl. Heifers[c]	lb	91		0.34	30.94
Vet & Medicine - Cows, Bulls, Repl. Heifers[c]	head	1		28.80	28.80
Labor - Cows, Bulls, Repl. Heifers[c]	hour	8		8.50	68.00
Interest – Cow & Sire[c]	head	6%		619.99	18.60
Marketing[c]	head	0.83		38.83	32.23
				Total Variable Expenses	592.24
				Returns to Variable Expenses	33.36

[a]Steer Revenue ($/head) = ((weight * price * (1 – calf death loss) / 100) * weaning percentage); Heifer Revenue ($/head) = ((weight * price / 100 * (weaning & cull percentages – total death loss); and Culled Cow Revenue ($/head) = ((weight * price * (1 – cow death loss) / 100) * cull percentage).
[b]Prices for each ingredient were found by weighting the monthly price by the quantity fed in each month.
[c]University of Kentucky (2008); University of Tennessee (2015).

Table 26. Summary Statistics of Simulated Net Returns by Calving Season, Commonly Used Feed Ration, and Weaning Month

Ration	Weaning Month	Estimated Returns ($/head)	Standard Deviation
		Spring-Calving Season	
Corn Gluten	September	-15.08	85.27
	October	-7.50	87.78
Corn Silage	September	6.63	84.30
	October	-5.01	86.48
		Fall-Calving Season	
Corn Gluten	April	8.32	90.09
	May	6.27	87.88
Corn Silage	April	36.20	91.31
	May	33.79	84.81

Table 27. Summary Statistics of Simulated Net Returns by Calving Season, Least-Cost Feed Ration, and Weaning Month

Ration	Weaning Month	Estimated Returns ($/head)	Standard Deviation
	Spring-Calving Season		
Minimum Hay	September	-19.95	83.81
Constraint	October	-30.89	86.07
No Minimum Hay	September	10.03	93.72
Constraint	October	-1.01	92.37
	Fall-Calving Season		
Minimum Hay	April	14.76	87.75
Constraint	May	12.16	86.03
No Minimum Hay	April	37.92	90.99
Constraint	May	35.52	90.55

Figures

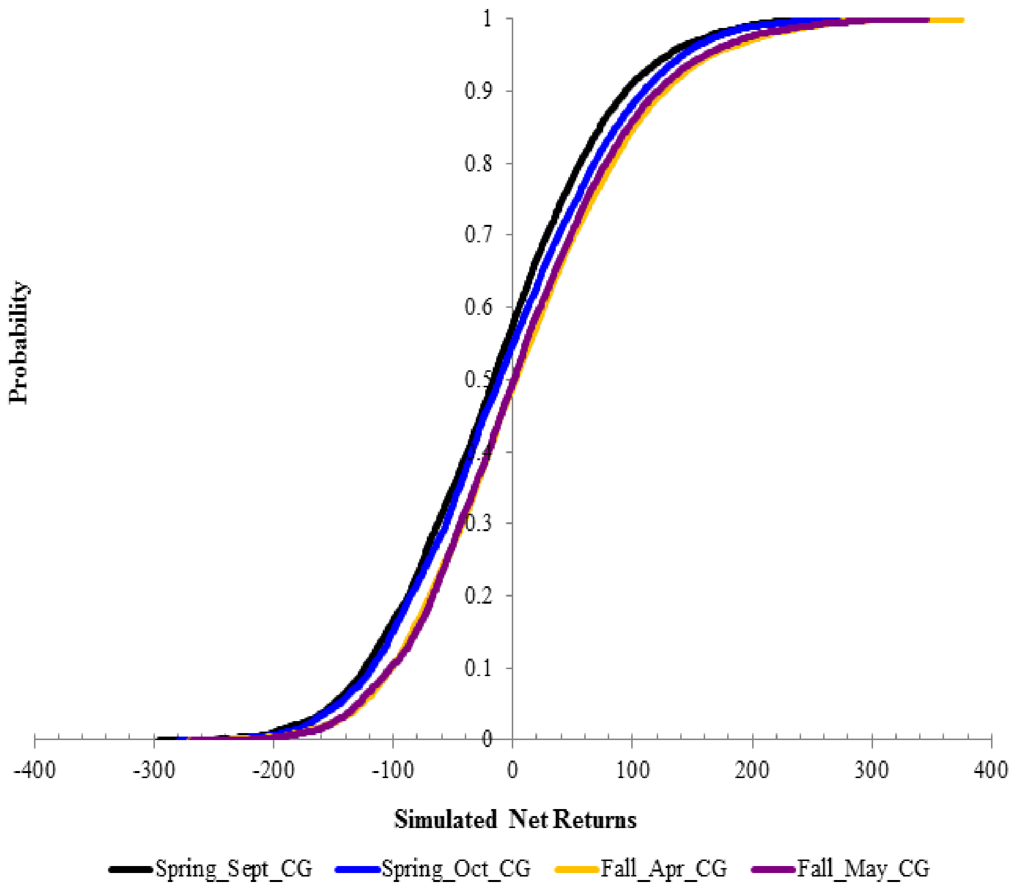

Figure 1. Cumulative Distribution Function of Net Returns of Spring- and Fall-Calving with the Commonly Used Ration Feeding Corn Gluten Ration

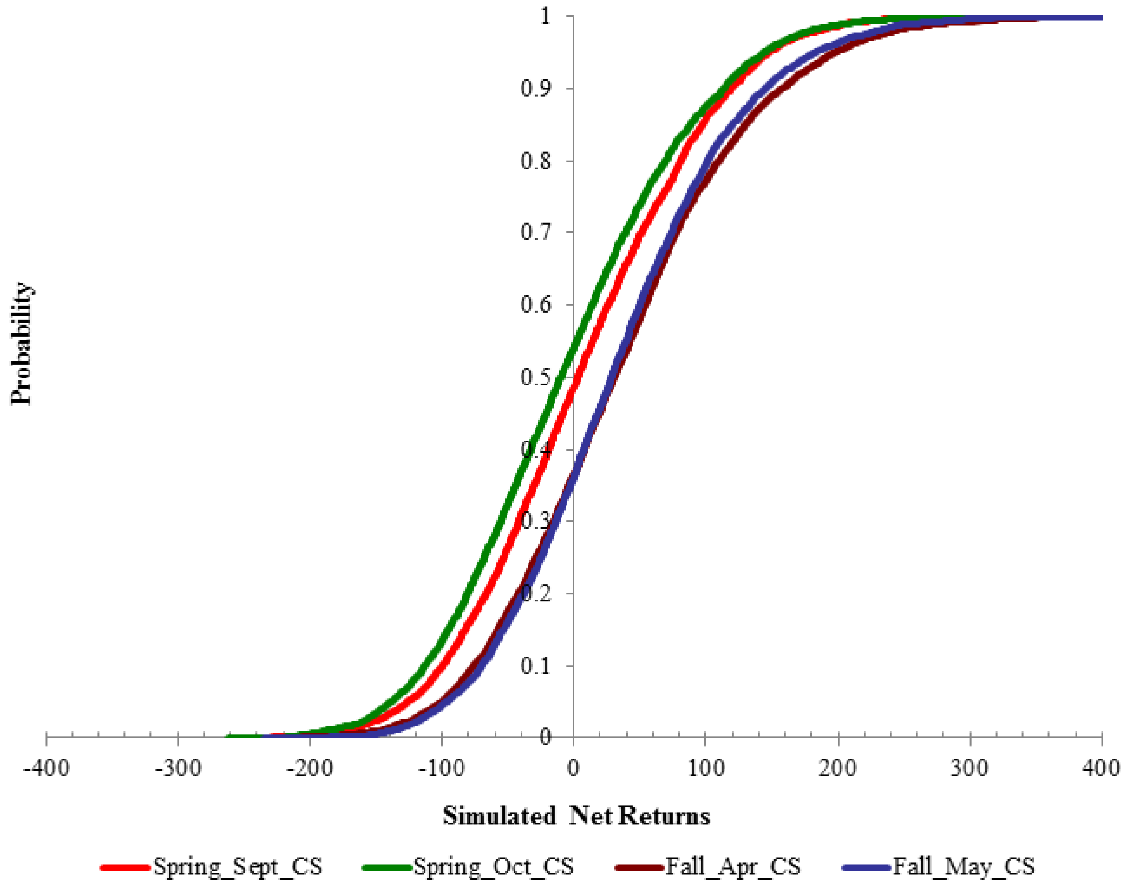

Figure 2. Cumulative Distribution Function of Net Returns of Spring- and Fall-Calving with the Commonly Used Ration Feeding Corn Silage Ration

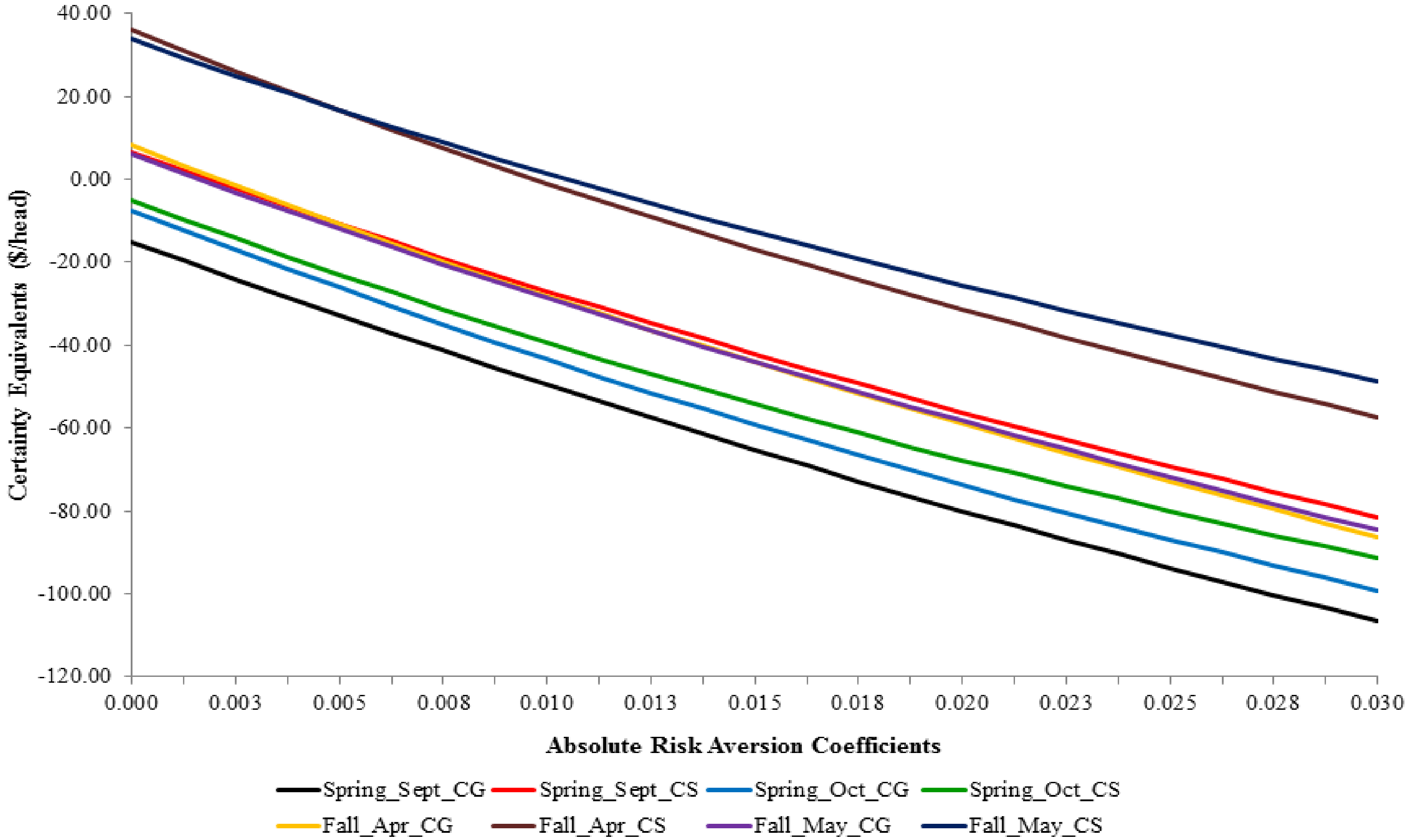

Figure 3. Certainty Equivalents Ranked Using SERF Analysis for Spring- and Fall-Calving Herds Under Commonly Used Rations

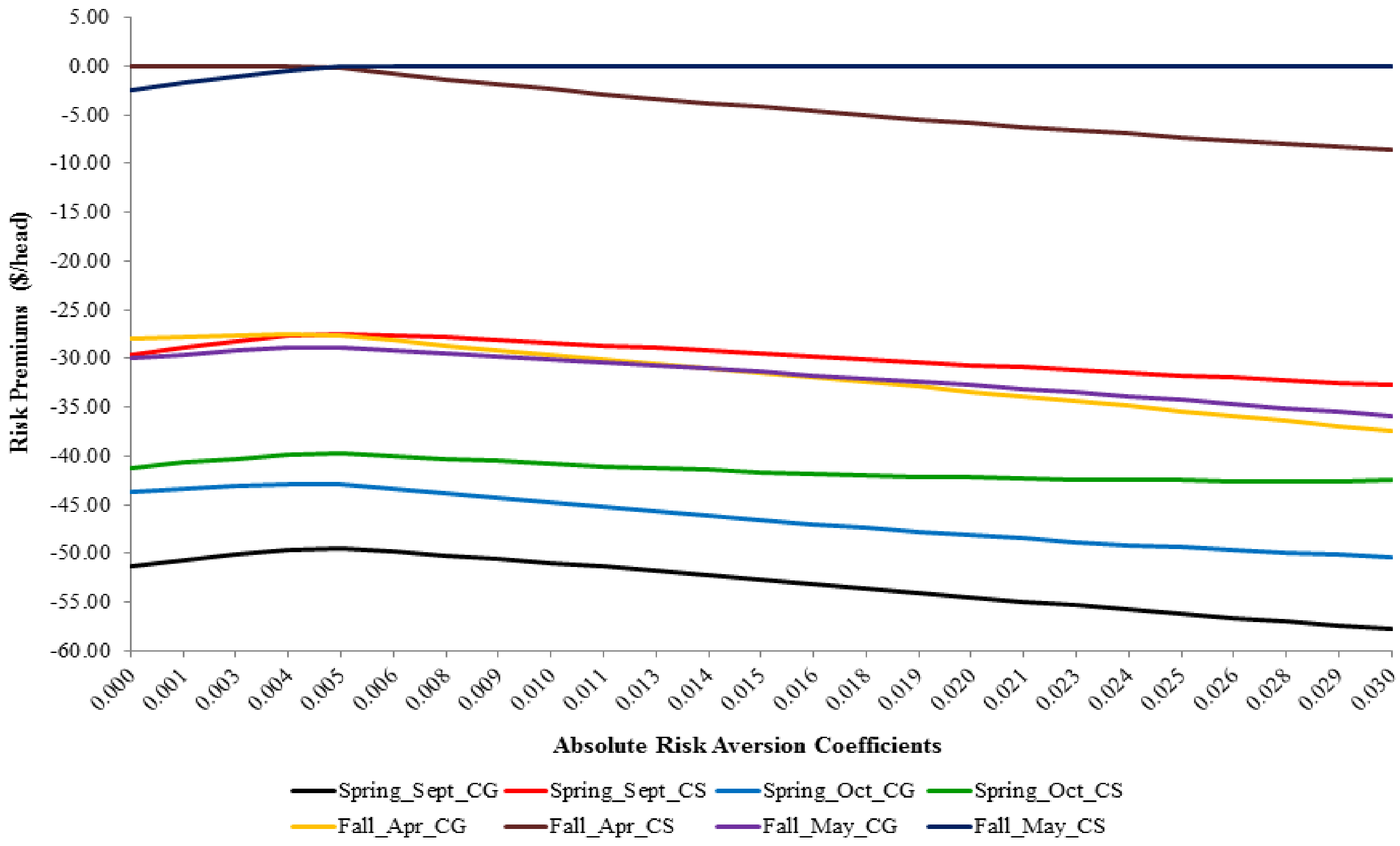

Figure 4. Utility Weighted Risk Premiums for Spring- and Fall-Calving Herds Under Commonly Used Ration

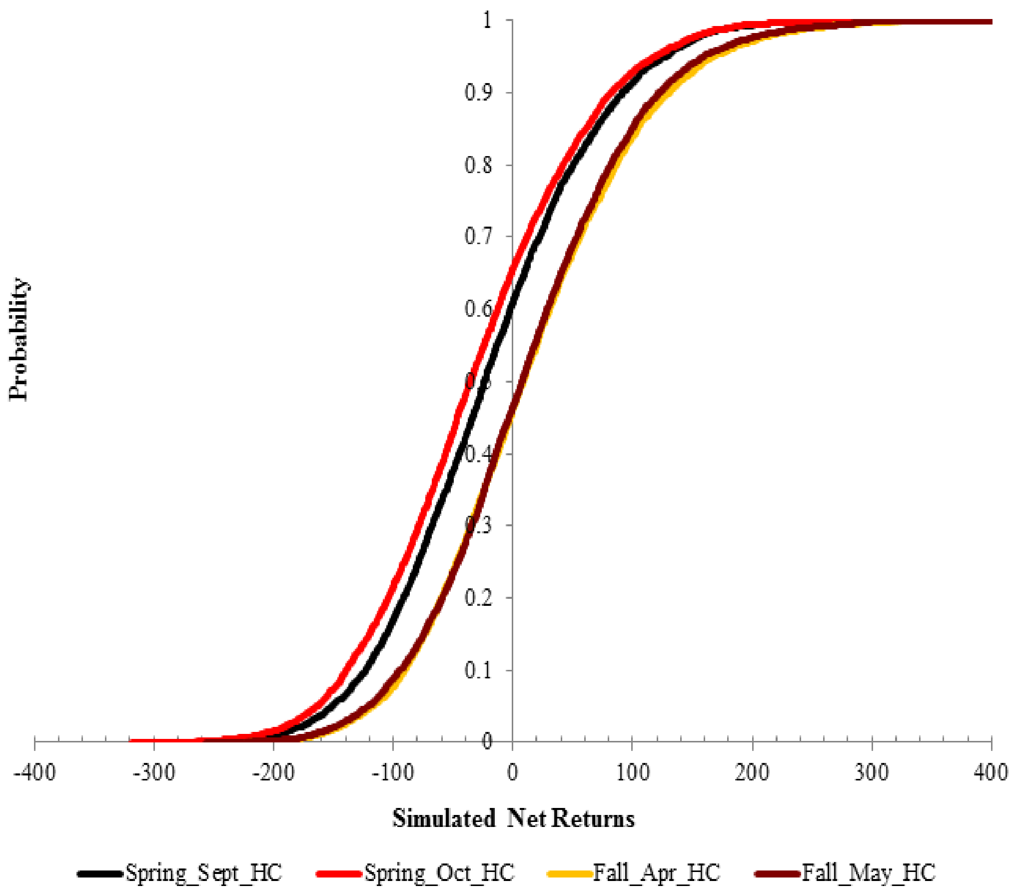

Figure 5. Cumulative Distribution Function of Net Returns of Spring- and Fall-Calving with Least-Cost Ration Feeding Ration with Hay Constraint

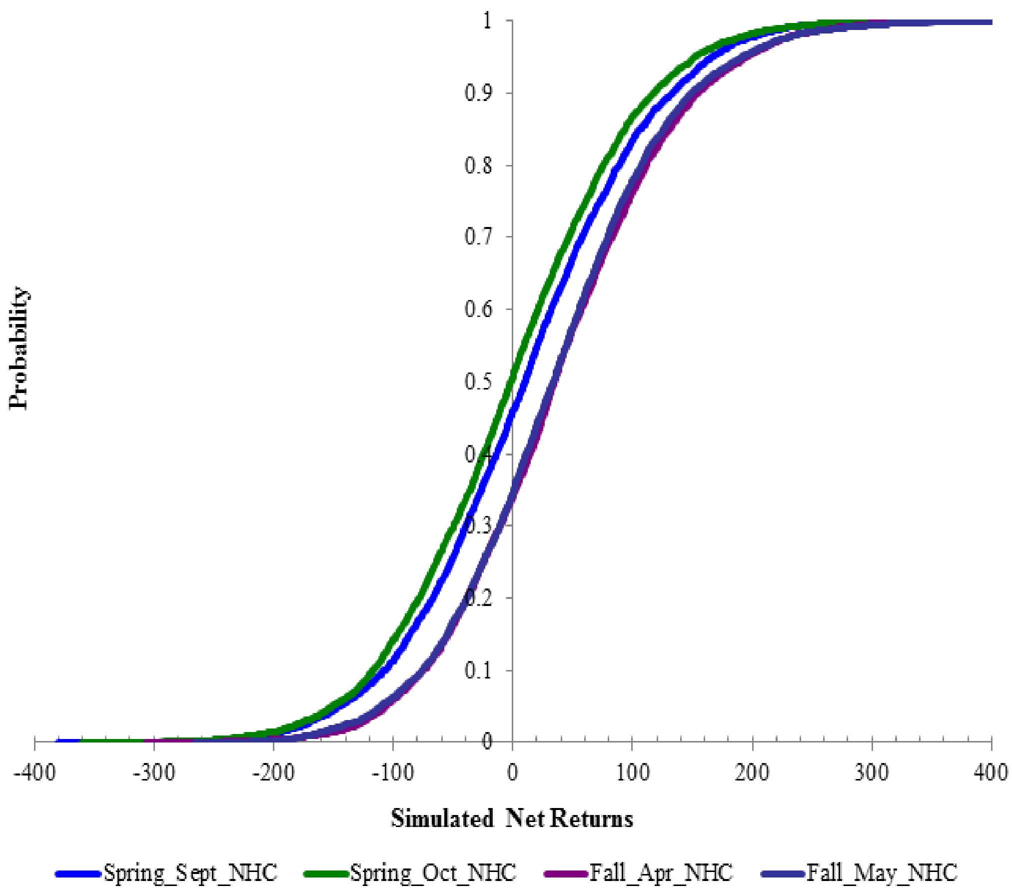

Figure 6. Cumulative Distribution Function of Net Returns of Spring- and Fall-Calving with Least-Cost Ration Feeding Ration without Hay Constraint

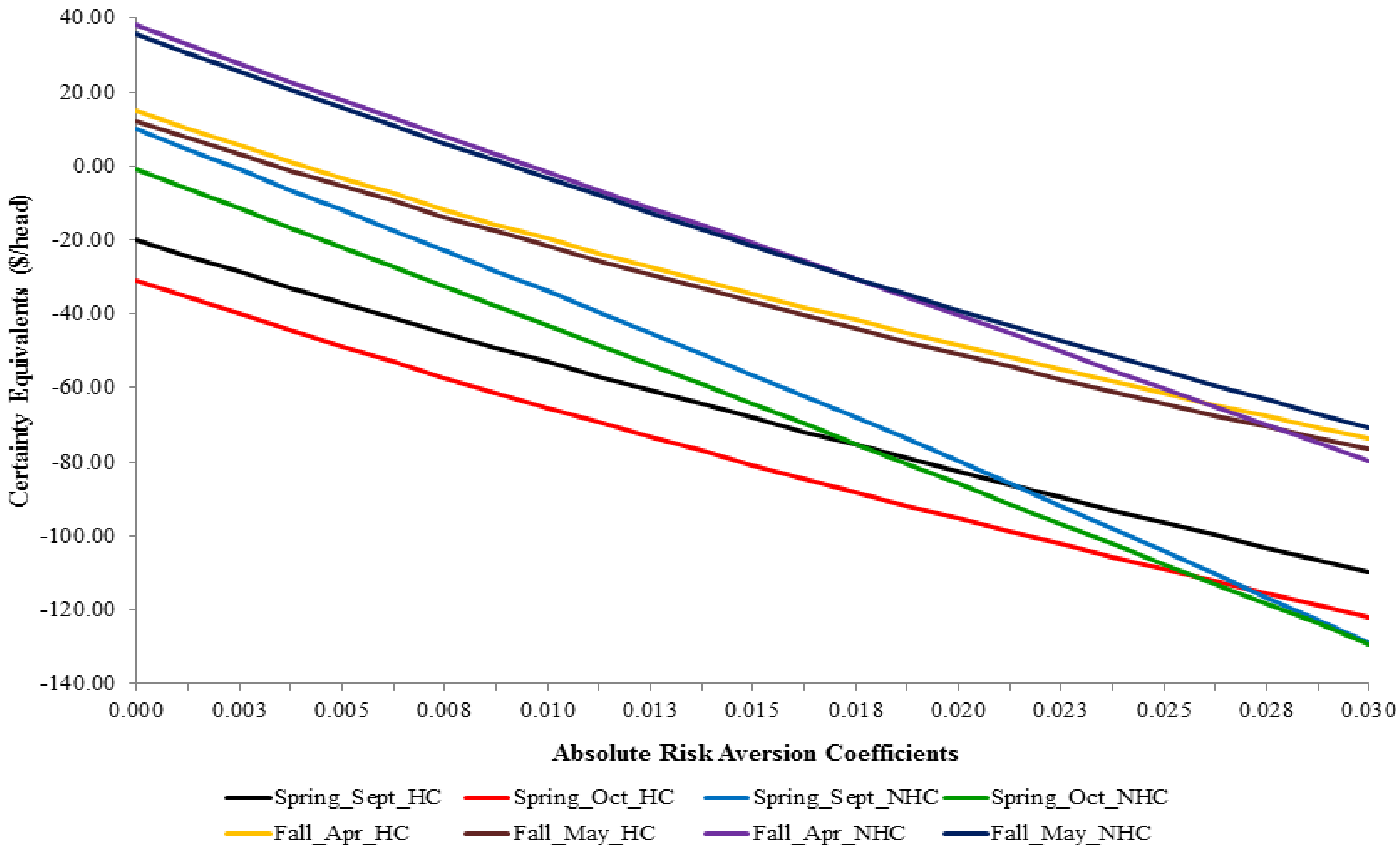

Figure 7. Certainty Equivalents Ranked Using SERF Analysis for Spring- and Fall- Calving Herds Under Least-Cost Ration

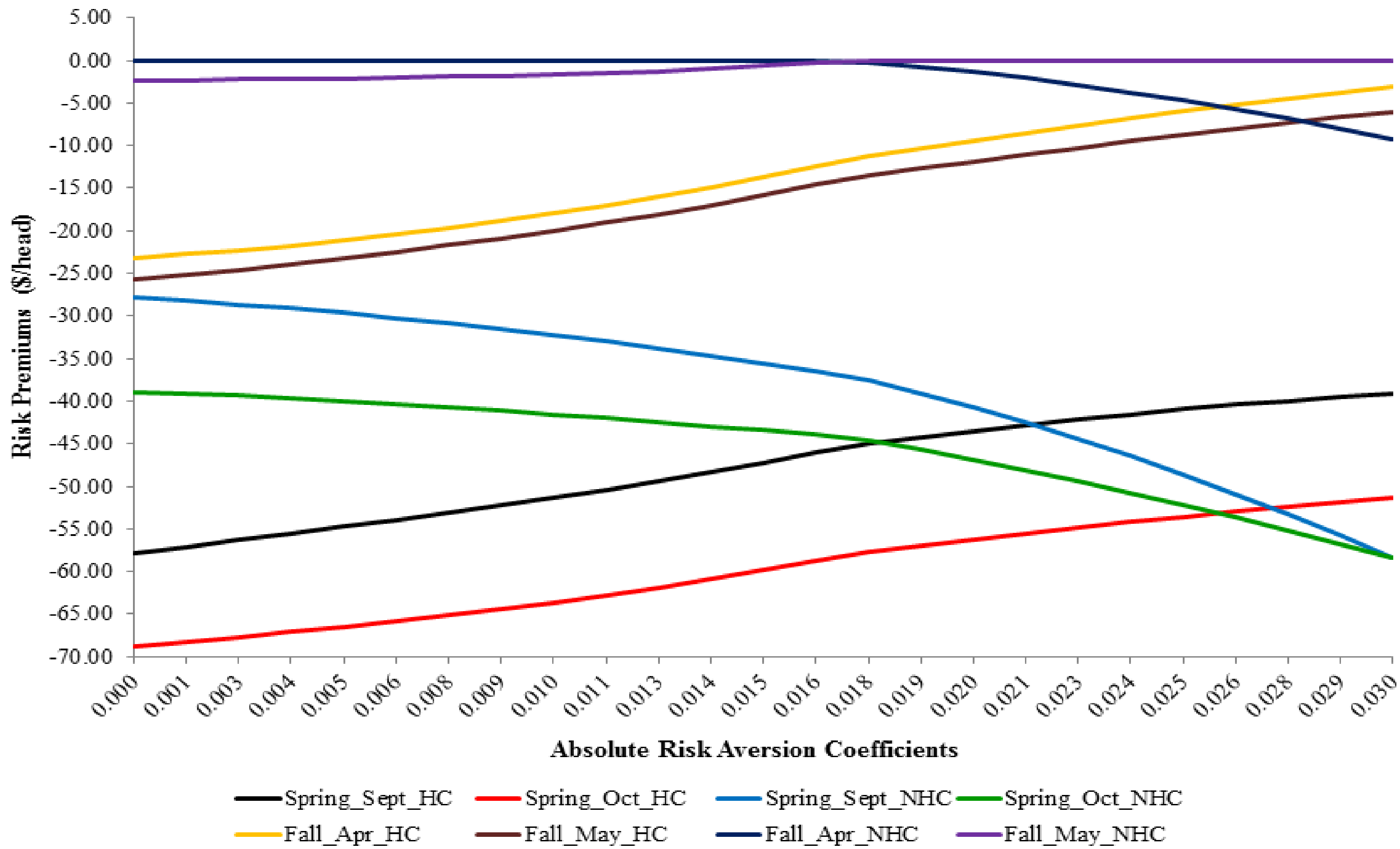

Figure 8. Utility Weighted Risk Premiums for Spring- and Fall Calving Herds Under Least-Cost Ration

VITA

Gavin Henry was born in Nashville, Tennessee to Nancy and William Henry. He grew up in Springfield, TN, living and working on his family's century farm. He attended East Robertson High School in Cross Plains, TN. He stayed in-state to pursue a Bachelor of Science in Agriculture and Resource Economics at the University of Tennessee in Knoxville. Gavin continued his education to pursue a Master of Science degree in Agricultural Economics at the University of Tennessee at Knoxville, TN. He graduated in August, 2015.