Breed trends and effect of breed on sale price of lots of beef calves marketed via video auction

by

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Abstract

The United States beef cattle industry is continuously evolving and changing to meet buyer demands while considering environment factors for production. Cow-calf producers make decisions within their herds that impact their profitability. Previous research shows producers can add value to beef calves through management and marketing decisions in areas such as genetics, herd health, and nutrition. It is well documented that there are numerous factors that influence the sale price of beef calves, no matter the venue through which they are sold. Historically, steer calves sold for a greater price compared to heifer calves. Apparent breed composition also influences value of lots of beef calves. Black-hided calves recently sold for a greater sale price than calves of other hide colors due to perceived differences in potential performance. Calves with Bos *indicus* influence usually sell for a lower price than other breed types. Marketing of beef calves through video auction allows sellers to market lots of calves to a buyer basis nationwide. A national market provides a basis for buyer preferences and potential national trends for changes in characteristics valued by buyers. Evaluation of national breed composition trends can indicate potential changes in the industry. The opportunity to evaluate if and how breed description as described by producers influenced calf sale price from 1995 through 2016 was available through a livestock video auction service. Chapter 1 is a review of the literature and an overview of the beef industry and factors affecting sale price of lots of beef calves. Chapter 2 is an analysis of breed composition influencing sale price for lots of steer calves and lots of heifer calves. Chapter 3 investigates national and regional breed description and sire breed trends over a 23-year period.

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I am thankful for the faculty, staff, and students in the Animal Science Department at Kansas State University for providing a challenging and fun learning environment. Also, thank you to Dr. David Grieger for including me in your research projects, classes, and being a great mentor.

Finally, thank you to my family, Randy and Varee McCabe, Flinton, Ashley, and Krease McCabe, Ethan, Kyla, and Hudson McCabe, and Hannah and Alex Tolbert, who are always there for support and encouragement in everything I do.

Dedication

As a fourth-generation cattle enthusiast, there is a constant reminder of being thankful for those who came before and laid the foundation for the next generation. I am thankful for the endless opportunities growing up on the farm, actively involved in the beef industry, specifically the American Angus Association, provided. I dedicate my thesis to my family for the opportunities taken that have shaped my life.

Chapter 1 - Literature Review

Beef Industry Overview

The beef industry in the United States includes multiple segments of production working together to ultimately meet various consumer demands (Speer, 2013). The structure of beef operations in the United States can be described as a large number of small producers. The few large operations in the industry, however, produce the majority of the cattle. Each segment of the beef industry is reliant on those before them to supply a product to meet the needs of those that follow. For example, the operator of a feedlot wants to invest in cattle that packers are willing to purchase, potentially at a premium. The feedlot cattle buyer is dependent on the supply of cattle provided by backgrounders or stockers who depend on cow-calf producers to raise the calves. There is not the extent of vertical integration in beef production as in other industries such as poultry and swine. This is partially a result of areas of land utilized by cattle to graze. Most poultry and swine are raised in a climate controlled facility, thus are not as dependent upon large areas of land as in beef, specifically cow-calf production.

Trends in the United States Cow Herd

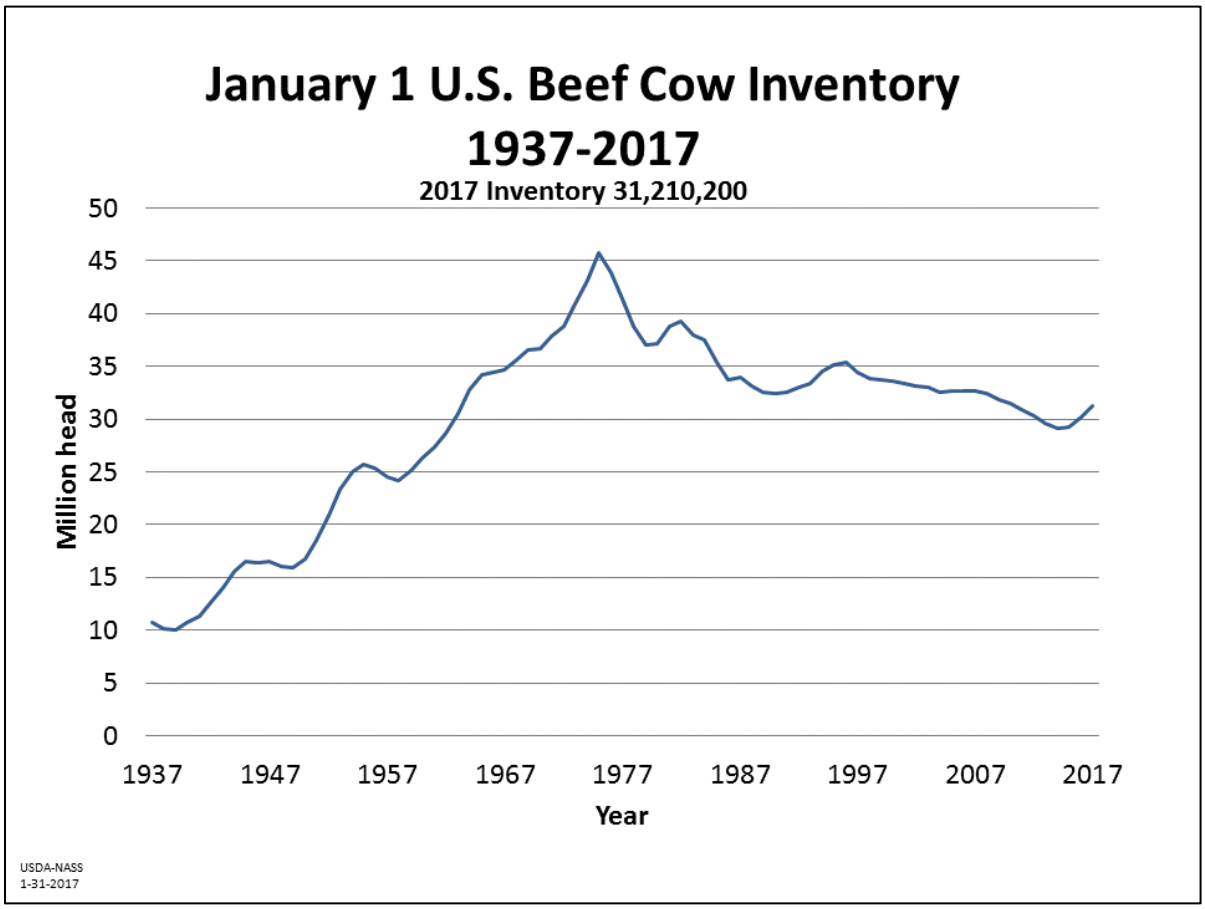
The size of the United States beef cow herd follows a cyclic trend, meaning there are increases and decreases in the herd size as a response to the market supply and demand. The cycle typically lasts ten to twelve years, which is the longest of any meat animal (USDA, ERS, 2017a). The smallest cow herd inventory recorded by the USDA was in 1928 with 8,926,000 head (UDSA, NASS, 2017). In 1971, the largest beef cow inventory in the United States was recorded with

45,711,800 head (UDSA, NASS, 2017). Since 1971, the beef cow inventory in the United States has followed a decreasing trend.

In the last 50 years, the smallest United States January 1 beef cow inventory was in 2014 with 29,042,400 head, which was the smallest inventory since 1962 (Figure 1.1); (Peel, 2016; USDA, NASS, 2017). In the last 21 years, liquidation of the cow herd began in 1996, primarily because of drought. Eight years later, in 2004, the beef industry began to retain more heifers for production to rebuild numbers. The expansion phase lasted until 2007 and was followed by a seven-year liquation phase. A new cow herd cycle started in 2015 (USDA, NASS, 2016). The expansion phase of the current cycle is reflected in the 5% increase in the number of beef cows and 3% increase in the number of heifers being retained for production since 2015 (USDA, NASS, 2016). As of January 1, 2017, beef cows in the United States totaled 31.2 million head, which is a 3% increase from 2016 (USDA, NASS, 2017).

Variability in cattle inventory results from numerous factors such as supply and demand, import and export markets, weather, and input costs such as feed. Market fluctuations (feed cost, land cost, cattle value, etc.) led to producers increasing productivity of the beef cow, ultimately producing more red meat yield with fewer animals slaughtered. United States beef production increased about 80% from 1960 to 2016 with 25.2 billion pounds of beef produced in 2016 (USDA, ERS, 2017b). The average carcass weight in 1960 was 592 pounds versus 829 pounds in 2016 (USDA, ERS, 2017b).

Figure 1.1 - United States January 1 Beef Cow Inventory from 1937 through 2017 from United States Department of Agriculture National Agricultural Statistics Service

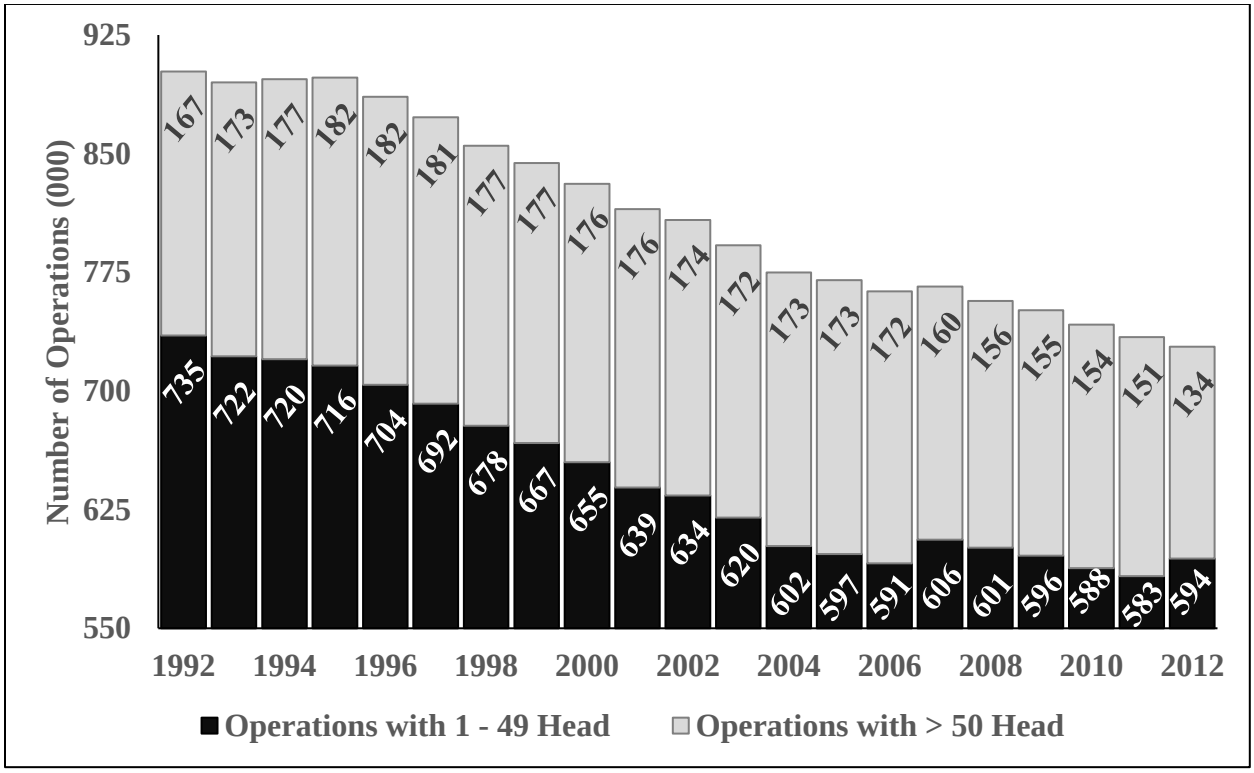


Production Chain

The beef industry in the United States is a result of multiple segments working together. Beef cattle production starts at the cow-calf level and ends with the feedlot phase. The 31.2 million head of beef cows in the United States are divided among operations of various sizes. The average cow herd size in the United States in 2016 was 40 head (USDA, ERS, 2017a). The size and location of the operation can impact the resources available as well as the costs incurred per animal. Economies of size impact how smaller and larger producers manage and market their calves. Smaller producers with fewer calves often have a higher cost per animal versus a larger producer who can spread the fixed costs across more animals.

As in all segments of agriculture, the beef industry has also consolidated since the early 1990's. In the last 25 years, about 175,000 operations have been eliminated. Of those 175,000 operations about 141,000 were producers with 1 – 49 beef cows (Figure 1.2); (USDA, 2014).

Figure 1.2 - United States Beef Cow Operations from 1992 through 2010 based on USDA 2012 Ag Census



Cow-calf

Cow-calf producers start the chain of production. Producers make decisions based on environment, resources available, and production goals. The production environment is an important factor for genetic selection at the cow-calf level. Figure 1.3 depicts locations of beef producers in the United States in 2012 (USDA, 2014). This figure shows cow-calf producers are spread throughout the entire country, which was not necessarily the case in all other segments of

production as feedlots tend to be located in the Plains states, closer to feed resources. The top ten states with the most beef cows in the United States as of January 1, 2017 are listed in Table 1.1 (USDA, NASS, 2017). The top ten states listed account for 58% of the total beef cows in the United States.

The weather in the United States varies from coast to coast. In the Southeast region and gulf of Texas, the environment is hot and humid, subtropical like. Comparing that environment to the northern portion of the United States such as Montana or North Dakota, the environment is drastically different throughout the year. Operations in the southern region may place more emphasis on different traits such as heat tolerance when selecting animals than producers in the northern region of the United States. In the south, the grazing season is longer, which requires less forage supplementation than the northern region. There are also more insects and parasites in the southern region because of the hot, humid climate. Cow-calf producers in the southern region select bos *indicus* breeds or bos *indicus* composite breeds because of their ability to tolerate heat and parasite resistance (Hawkes et al., 2008). In the United States, bos *indicus* influences most often come from the Brahman breed. In the northern region, herds need to tolerate a cold, harsh, long winter. Breeds and breed types utilized will not only vary by region but also within individual herds (Spangler, 2014).

Figure 1.3 - Beef cow inventory in the United States in 2012 according the United States Department of Agriculture Census of Agriculture

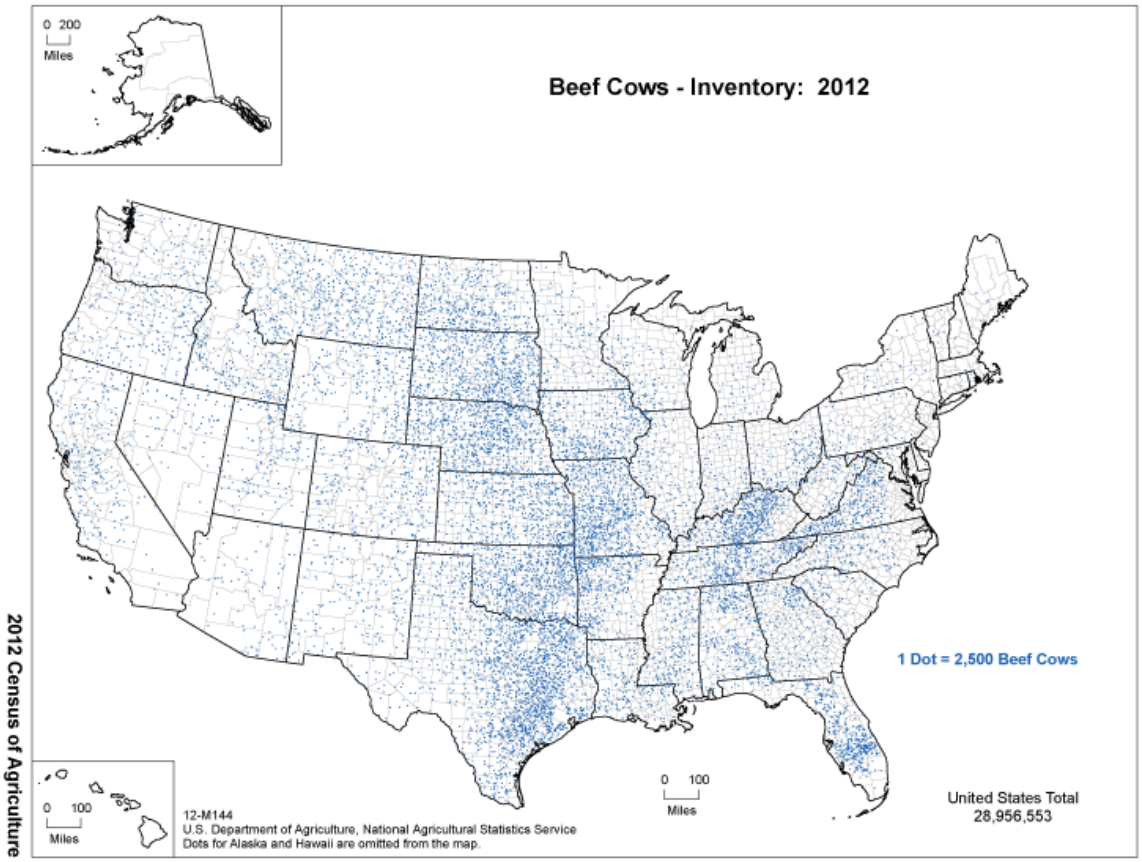


Table 1.1 - Ranking of states by number of beef cows as of January 1, 2017 based on United States Department of Agriculture inventory data

Rank	State	Number of Head	% of United States Total Beef Cow Inventory
1	Texas	4,460,000	14.3
2	Oklahoma	2,095,000	6.7
3	Missouri	2,052,000	6.6
4	Nebraska	1,920,000	6.2
5	South Dakota	1,664,000	5.3
6	Kansas	1,570,000	5.0
7	Montana	1,486,000	4.8
8	Kentucky	1,023,000	3.3
9	Iowa	965,000	3.1
10	North Dakota	954,000	3.1

At the cow-calf level, there are two types of producers; seedstock and commercial. Purebred or seedstock producers are the sector of the production chain that provides the basis for genetic improvement in the entire industry (Rhinehart, 2015). Sire selection is based on buyers' expectations of the bull's ability to pass desirable characteristics to progeny (Vanek et al., 2008). Sires contribute 50% of the genetic makeup of a calf crop and introduce most of the new genetics into a cow herd. Siring multiple calves each year, if females are retained in the cow herd, the sire is contributing more overall genetic influence by the females used as replacements. Sire selection is a critical part of improvement in the cow herd. Commercial cow-calf producers use genetics from seedstock operations, often purchasing bulls to naturally breed females. The offspring might be sold at weaning or ownership retained through the feedlot phase. A USDA survey for operations with more than 20 beef cows found about 60% of cow-calf producers sell their calves at weaning and 80% are sold within sixty days of weaning (McBride and Mathews, 2011). These were commonly the smaller operations located in the Southeast and southern plains. Typically, these producers were not relying on their cow herd as their primary source of income (McBride and Mathews, 2011) and generally market their calves locally because they do not have a large enough lot of calves to receive the premiums associated with a large lot size (Nyamusika et al., 1994). Smaller operations also may not have access to the feed and facility resources to retain calves after weaning. Local auctions provide a convenient option for producers to sell their calves. If the cow herd is a secondary source of income, producers may not be as interested in "marketing" their calf crop to try and obtain premiums. Instead, they are willing to take the market price on the day the calves are sold and not incur more input expenses.

McBride and Mathews (2011) also found more than a third of producers retain ownership of their calves for a 30 to 90-day window after weaning. These were generally larger operations

located in the northern and western regions of the United States that retained calves for a period after weaning. The size and location of a cow-calf operation has an influence in the decisions producers make and accessibility to resources. Operations with enough resources or inputs have flexibility to choose when to sell calves. Cow-calf producers ultimately want to select cattle and management practices that optimize their operation and maximize the price their cattle will sell for (Hawkes et al., 2008). The costs incurred at the cow-calf segment must be repaid when the calves are sold, or it is not economically feasible for the producer to have additional input costs (Bulut and Lawrence, 2007; Hawkes et al., 2008). All segments of production are affected by the decisions made at the cow-calf level. If producers do not properly vaccinate and manage calves before they are sold, the calves are at a disadvantage when exposed to new health risks in a new environment. Unless increased management of calves is valued by buyers with a higher sale price, producers may not have enough incentive to incur extra input costs in calves.

Backgrounder/Stocker

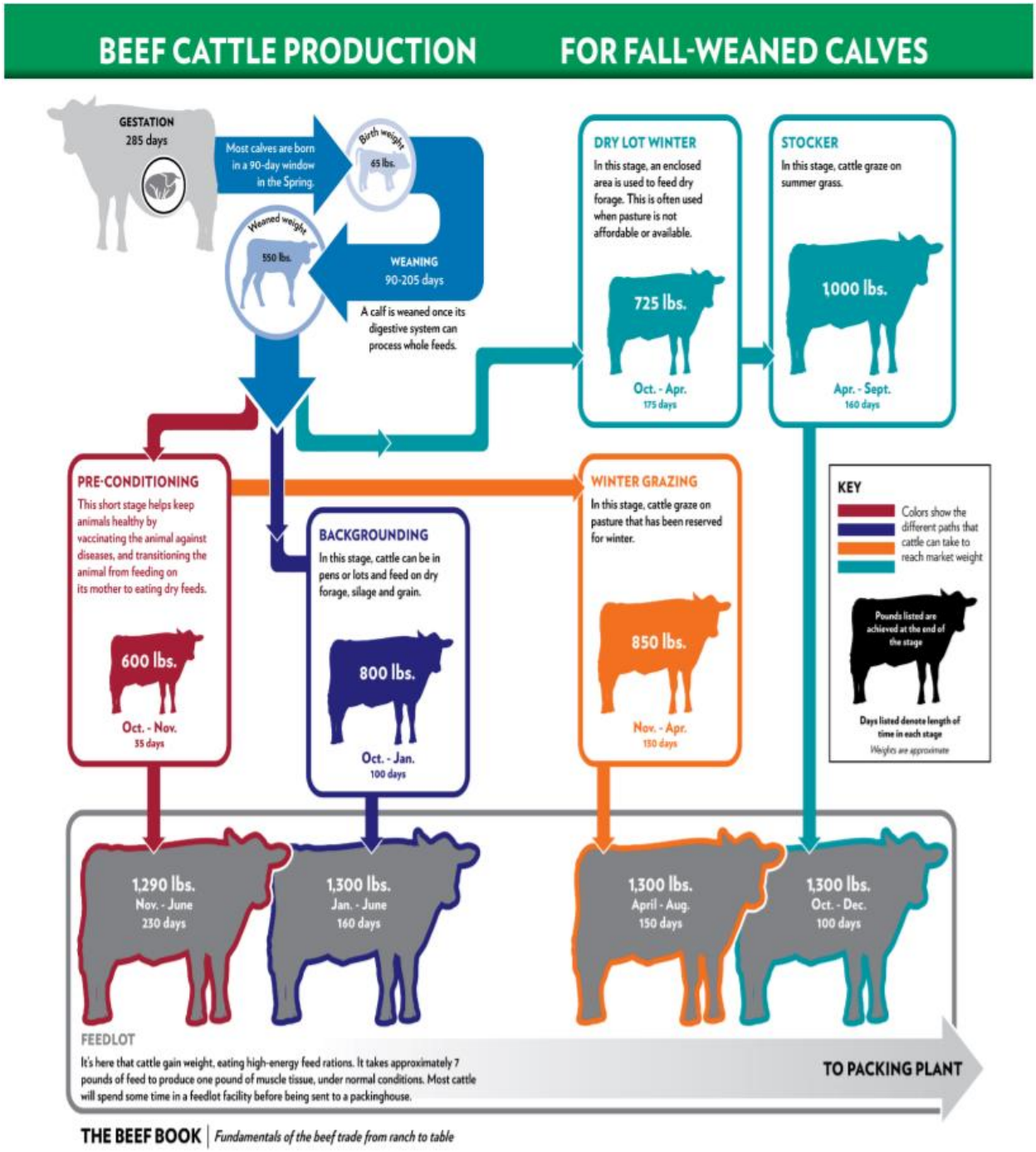
At the age of weaning, typically six to seven months, cow-calf producers either sell the calves or retain ownership. Some operations will retain ownership and the calves will either graze forage or be fed a high forage diet to allow for the calves to grow frame and muscle. Other producers will sell their calves at weaning. The calves sold at weaning may be purchased by other cow-calf or stocker operations with available forage for the calves to consume.

The use of backgrounding allows for calves to grow frame and muscle with economically efficient resources, such as grass for grazing. Available resources and the program used for backgrounding calves depends on the time of year. Calves born in the fall and weaned in the spring are often grazed on pasture during the summer months then sold during the late summer or early

fall months as yearlings to feedlot operations. In contrast, calves born during the spring months will be weaned in the fall and may be backgrounded in a more confined setting but still receiving a high forage diet. These calves will either enter the feedlot or graze during the following spring and summer months as yearlings and enter the feedlot later. Figure 1.4 depicts various options for calves weaned in the fall months (USDA, NASS, 2016).

Calves that are preconditioned before leaving the cow-calf operation are ready to enter the next segment. Preconditioning programs often include vaccinations protocols, weaning, and other management practices such as castration and dehorning/tipping. Calves with little management or poor vaccination programs are commonly known as high-risk cattle. These calves are often sold at a discount compared to preconditioned calves because of the increased health risk and decreased immunity of the calves and will enter a backgrounding operation to begin a preconditioning program before entering the feedlot.

Figure 1.4 - Beef cattle production for fall weaned calves provided by the United States Department of Agriculture (USDA, NASS, 2016)



Feedlot

Unlike the cow-calf segment of production, feedlots are more centrally located in the United States. The majority of feedlots in the United States are located in the Great Plains but there are also feedlots located in the Corn Belt, Southwest, and Pacific Northwest (USDA, ERS, 2017a). Feedlots are typically located near feed resources and packing plants to reduce the cost of transportation.

Feedlot sizes are often described as having less than 1,000 head or more than 1,000 head, in part because of confined animal feeding operations regulations associated with a capacity of 1,000 or more head. About 95% of feedlots in the United States have less than 1,000 head (USDA, ERS, 2017a). While there is a larger number of feedlots with less than 1,000 head capacity, they have a small market share of total cattle fed. Feedlots with greater than 1,000 head capacity account for less than 5% of the total number of feedlots, but they have 80-90% of the fed cattle inventory (USDA, ERS, 2017a).

The feedlot stage of production typically is 140 days but can range from 90 to 300 days. In feedlot, cattle are fed grains and high concentrate diets. The level of concentrate in a feedlot diet can range from about 70 to 90%. The length of time cattle spend in a feedlot is dependent upon their frame score and weight when they enter the feedlot. Lighter weight cattle with less condition will take longer to reach their finished weight, thus might be in the feedlot for 300 days. Cattle with more flesh and weight will reach their end point faster and may only be in a feedlot about 90 days (USDA, ERS, 2017a).

Buyers who purchase cattle for feedlots determine the lot characteristics for which they will pay premiums. Characteristics valued by buyers are those the buyer believes will help the cattle to be more productive and efficient or profitable for their particular operation. For example,

some buyers will pay premiums for weaned calves with respiratory vaccinations that appear healthy and have incurred basic management practices already such as castration and dehorning/tipping (Wirak et al., 1976; King et al., 2006; Zimmerman, 2010). Characteristics valued by buyers indicate to producers at the cow-calf level the managements and types of cattle that may provide a higher sale price because they are demanded at the feedlot. Cow-calf producers often want to maximize the traits valued by buyers while also considering operational goals, environment, and available resources (Hawkes et al., 2008).

Calf Marketing Venues

There are numerous avenues sellers can choose to market their calves. Producers can market their calves via private treaty, sale barns, internet listings, and video auctions. In 2004, according to Gillespie and others (2004), 91% of producers in the United States used sale barns or sale barn auctions for marking cattle. In 2012, it was reported that 90% of beef operations in the United States sold beef calves via sale barns (USDA, APHIS, 2009), while video auction accounted for 3% of the producers selling method (Gillespie et al., 2004).

Private Treaty

Private treaty marketing is also known as direct marketing. The seller has direct contact with the buyer and the seller has more control over the sale price and terms of sale. Sellers can show positive aspects of livestock and traits the buyer values (Parish, 2013). Private treaty marketing allows for a more personal sale compared to other methods. However, this method of selling requires more work from the seller to find interested buyers versus selling through an auction format. The buyer and seller can negotiate not only on the price but also on the terms and

conditions of the sale. The buyer can view aspects of the operation such as facilities and the cow herd (Parish, 2013). It allows for the calves to originate from the ranch and not be co-mingled with other calves at sale barns. By not being exposed to new health risks at sale barns, the calves are exposed to less disease and may undergo less stress (Parish, 2013). However, to attract buyers to look at calves, producers typically need to have a large quantity of animals for sale (Gillespie et al., 2004) as well as knowledge of management and marketing. Producers with a few calves for sale may not have the same level of interest from buyers compared to producers with a large group of calves. If buyers can source a semi-load of calves from one operation, it decreases transportation cost and health risk of the calves.

Sale Barn

Sale barn marketing of calves brings cattle together at a central location where various types of buyers can bid on the lots of cattle (Gillespie et al., 2004). Sale barns typically hold one weekly auction and sell calves, feeders, cows, cull bulls, etc. based on what producers bring to the sale barn. Sale barns also hold specialized auctions if there are large quantities of similar types of cattle to sell (ie. calf sales, feeder sales, retention female sales, etc.). The specialized sales attract the interest of buyers from a larger area because of the large number of similar lots.

Selling cattle through a local or regional sale barn can benefit some producers. Producers have weekly options for selling cattle. Depending on location, they may be near multiple sale barns, which allows for multiple options available throughout the week. Small operations cannot offer a semi-load sized lot of cattle to buyers. However, producers may group similar calves together to collectively offer a larger group of calves. The health risk of a lot of calves increases as the number of calf sources increase. Co-mingling cattle at community sales exposes naive cattle

to new diseases. Stress from transportation, weaning, and co-mingling causes the immune function of cattle to decrease, thus increasing their susceptibility to illness.

There are other drawbacks to selling cattle via sale barns other than co-mingling of cattle. There is no way to predict how many buyers will be present to bid from sale to sale. Smaller producers with excellent management and high-quality cattle for sale may not receive premiums from buyers due to lack of numbers of cattle as well as buyer competition. Without competition among buyers for similar cattle, there is not the demand present to increases prices paid (Gillespie et al., 2004). The sale price paid for a lot is dependent on the buyers present and the local market. For example, if an area is in a drought and producers do not have the feed resources for the cattle, there likely will be a drastic increase in the number of producers selling cattle. The local market then becomes over supplied and decreases sale prices when demand is static.

Internet

Cattle can be sold via internet listings or auctions. Internet listings commonly include a description of the lot selling and include a video or picture of the lot of cattle. Cattle can also be sold via Internet sales, where the bidding is done strictly through the computer. Internet sales begin and end at a set time but allow flexibility for buyers to watch the bidding activity on lots during the duration of the sale.

Internet auctions can also be live sales that also are broadcast over the Internet. Typically, producers photograph cattle and place the pictures on an Internet site for buyers to view (Gillespie et al., 2004). This allows the opportunity for local sale barns to have buyers from all over the country bidding on cattle (Pope, 1993). When used correctly, the Internet can increase sale attendance and build customer base (Cattle Mail USA, 2007). This generates more interest in the

cattle and possibly a higher sale price. Bids can be placed online or via telephone from the buyers' ranch, farm, office or home location (Cattle Mail USA, 2007).

Video Auction

Marketing cattle through video auction is another option for sellers. This method provides options for those who live long distances from auction markets or feedlots (Pope, 1993). Video auctions allow sellers to market their cattle to a buyer base nationwide, which can help to overcome local climate or market conditions (Superior Livestock Auction, 2017).

One of the original developers of video auctions was Jim Odle. He is founder of the world's largest video auction service, Superior Livestock Auction (SLA). Odle had his own electronic marketing service and in 1986; then he merged his company with Amarillo Livestock Video Auction, which created SLA (Bailey and Hunnicutt, 2002). In 1987, SLA sold over 270,000 head of cattle and over 480,000 the following year (Bailey et al., 1991) and within five years of the merger, SLA was the largest video auction service in the United States (Bailey and Hunnicutt, 2002).

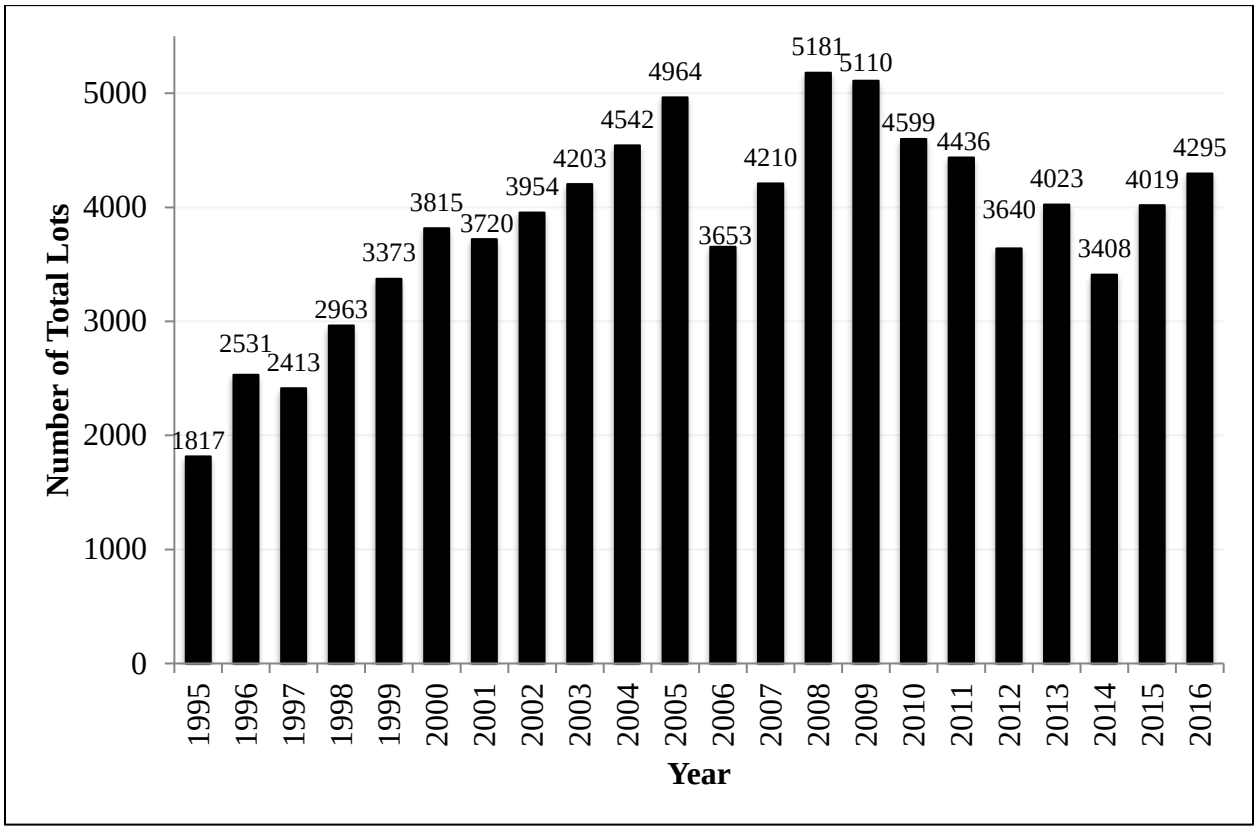
While marketing cattle via a prerecorded video was a new concept for many, Odle was not trying to change the basis of cattle marketing. Cattle marketed through video auction still followed the basic concept of traditional marketing; the buyers viewed the cattle, the cattle were described, and the lot was auctioned to the highest bidder. As in traditional methods of selling cattle, the seller was involved in the entire process. The seller helped to describe the lot selling and maintained control of the cattle until sold (Bailey and Hunnicutt, 2002). Cattle being offered for sale via video auction are video recorded by a company representative and they assist the seller in describing the cattle for sale (Bailey and Hunnicutt, 2002; Pope, 1993; Superior Livestock Auction, 2017).

Characteristics such as calf weight, breed, and vaccinations received are a few of the descriptions the representative assists with to provide the buyer with accurate information about the lot. The information described about the lot can help the buyer determine the price they are willing to pay for the lot. Buyers may be interested in specific qualities of lots and willing to pay premiums for the calves (Gillespie et al., 2004). For example, if a buyer wants a semi-truckload of calves qualifying for a specific vaccination program to reduce the health risk of the lot later, they have the information available to make purchase decisions.

Video auctions have been in existence for nearly 40 years. Gordon (2012) stated video auctions reduced health risks of calves since the calves are not commingled during the selling process, which is often prior to shipment. In the late 1980's, video auctions had participation from both buyers and sellers in large quantities (Bailey and Hunnicutt, 2002). The video auction market, however, did not see the continued increased growth as expected to become the dominant marketing venue producers use to market lots. Bailey and Hunnicutt (2002) speculated it might be a result of video auction transaction costs were similar to other venues of marketing as well as the transportation costs of purchasing a lot from other regions. While growth slowed, many producers do not have large enough operations to meet the demand of semi-load size lots. (Bailey and Hunnicutt, 2002; Griffith, 2015). Figure 1.5 shows the participation of cow-calf producers in the United States that utilize Superior Livestock video auctions to market their calves during the summer months from 1995 through 2016. The calf sales that take place during the summer months, May through October, are the largest video auction sales for the number of lots marketed. These summer video auctions from 1995 through 2016 included 84,869 lots of beef calves (10,199,418 total calves). While Figure 1.5 displays all lots offered for sale, lots of beef calves are recorded in the data base as 1) sold, 2) no sale, or 3) scratched prior to the auction. Only sold lots were recorded

in the database in 1995. From 1996 through 2016, 12.1% of lots of beef calves were "no sale" lots, meaning there was no sale price associated with the lot. The smallest percent of "no sale" lots was 2.1% in 2007. The largest percent of "no sale" lots was 29.1% in 1998. There are numerous reasons for "no sale" lots but the owner of the lot ultimately determines the base sale price of a lot of beef calves.

Figure 1.5 - Number of lots of beef calves marketed via summer video auction from 1995 through 2016



Williams and others (2012) state while cattle sold via video auction may provide insight of calf demand for larger cow-calf producers, they may not represent the lots of similar cattle sold at a traditional sale barn auction. Producers utilizing video auctions typically have larger operations, potentially are early adopters of new technologies, which could also lead to the assumption they

have more intensive management programs to capture increased premiums for their calves (King et al., 2006; Zimmerman, 2010). Reported in a USDA publication from the 2007 census, operations with 200 head of beef cows or more were raising cattle as their primary source of income (USDA, APHIS, 2011). Operations with beef cattle as their primary source of income may manage their calves differently in attempt to capture added premiums (Hawkes et al., 2008; McBride and Mathews, 2011).

Factors Influencing Sale Price

Introduction

Producers have options for the venue to market their calves. While these venues have their differences, it seems as if buyers in all venues place importance on similar lot characteristics such as management practices and breed influence (Bailey et al., 1991; King et al., 2006). Even though similar factors affect the sale price, lots of cattle do not necessarily sell for the same sale price through all methods of sale. Sale barn auctions often are affected by local climate and market conditions where nationwide auctions, such as video auctions, can overcome local market conditions because of marketing to buyers nationwide (Bailey et al., 1991; Superior Livestock Auction, 2017). There are numerous studies that have evaluated factors influencing sale price of calves marketed via sale barns and video auctions. These analyses can provide indications of buyer preferences from beef calf lots. The actual sale price, however, should not be directly compared between different marketing venues. This is because of several differences between sale barns and video auctions such as the number of head in a lot, number of buyers the lot is offered to, lot regional origin, and potentially the progressiveness of producers using a method such as video auctions to market cattle. Bailey et al. (1991) noted sale prices of lots of cattle selling regionally

or across the United States sold through different venues should not be compared because the market prices have different challenges such as local climate or demand. There are several differences that may increase the sale price of lots selling through video auction such as reduced transportation cost, shrink, and lower stressed cattle compared with lots selling through a sale barn (Bailey et al., 1991).

There are numerous factors influencing the sale price of beef calves. Some factors are beyond the producer's control such as weather and market prices. Input costs are one of the factors producers consider when determining the sale price a lot of calves require to breakeven. For example, if feed costs are high, the producers need calves to receive a higher sale price to breakeven than when feed costs are lower. There are factors the producer has control of such as the health program for the calves, the weight and body condition of calves at sale, time of year when calves are sold, and the venue chose for marketing the calves (Schroeder et al., 1988; Ward et al., 2007). Cattle buyers determine the price they are willing to pay based upon market prices and factors such as the lot description provided and physical characteristics the buyers can visually evaluate. Visual evaluation of physical characteristics can indicate how the cattle are expected to perform throughout the feeding phase (Hawkes et al., 2008). Some characteristics can be visually assessed such as breed composition, frame score, fleshing ability, and health status. Other traits are not as readily observable such as health management, vaccinations, weaning status, and nutritional history (Bulut and Lawrence, 2007). Buyers are typically willing to pay more for cattle they think will efficiently grow and utilize feed resources as well as meet packer specifications (Schulz et al., 2010).

The specific factors affecting sale price likely have more or less influence over time as prevalence of management practices, breed influences, or buyer expectations change. At one time,

few producers administered pre-wean vaccinations and buyers paid premiums for those calves vaccinated against respiratory diseases (King et al., 2006). It is more common among producers to vaccinate beef calves and buyers now provide premiums for lots with more intensive management such as vaccinations prior to being sold (King et al., 2006; Bulut and Lawrence, 2007). Similar changes have occurred in breed influences. At one time, Hereford-influenced cattle were the most common breed influence sold. However, Angus have the largest influence in the cowherd currently likely because of specification requirements for branded beef programs prevalent in the United States beef industry (Wessler, 2011; Rutherford, 2014). As the beef industry continues to evolve, the factors influencing the sale price of beef calves will continuously need be reevaluated to account for the changes.

Volatility of Market

Blank et al. (2006) states, "The basic price of an agricultural commodity is determined by the supply of, and demand for, the product in a local market." For many commodities, this is an accurate statement for the price a producer will receive for a commodity. Some of the factors that influence cattle prices are stage in the cattle cycle (expansion/liquidation), input costs, supply and demand, weather patterns (ie. drought), and import/export markets (Norton, 2005; Blank et al., 2006; Zimmerman, 2010). The cattle industry is cyclical and, on average, it takes three years from the time producers receive a signal for expansion before packers have increase in slaughter numbers (Norton, 2005). During liquidation, from drought for example, the liquidation period length may vary based on severance and number of producers impacted. If a drought is limited to one region of the United States while other regions are thriving, producers can utilize a larger market venue with a larger buyer audience (i.e. video auction versus a local sale barn) to overcome

a saturated local market. Cattle buyers are limited on the price they can pay based on the input costs and health risks for the cattle as well as the transportation cost to relocate the calves (Blank et al., 2006).

While the cattle market can change from year to year, even within a year, there are differences in market price. Schulz et al. (2010) found season, spring or fall, to be a factor affecting the sale price of Kansas and Missouri feeder calves. The variation in prices were compared between lots of steers, bulls, and heifers. Their results showed lots of heifer calves had a greater discounted sale price in the spring than the fall compared to lots of steer calves. The amount of the discount narrowed as the weights of the lots increased. Lots of bulls sold for a smaller discount in the spring than the fall when compared with lots of steer calves in the same market.

Region of Origin

The region of origin cattle were raised in affects the price buyers pay for cattle. The environment calves are raised in includes not only the location, but the management practices performed and breed influences (Hawkes et al., 2008). The location of lots for sale impact the price buyers are able to pay because of accounting for transportation costs (Blank et al., 2006). The majority of cattle feeding takes place in the Great Plains of the United States, but is also located close to the Corn Belt (USDA, ERS, 2017). Producers located further from the Great Plains are at a price disadvantage compared to those in close proximity.

Using data from a video auction service called Western Video Market, Blank et al. (2006) analyzed data from 1,979 lots of steer calves sold from 1997 through 2003. They hypothesized lots originating in regions further from the Midwest, where the feedlots are located, would have a lower sale price or a higher discount, compared with lots located closer to the Midwest region. They

evaluated not only the location, but other common factors known to influence the sale price of cattle. The results confirmed their hypothesis that the calves located further from the Midwest were sold for a lower price.

King et al. (2006) included region of origin in the analysis of factors influencing the sale price of beef calves marketed via video auction from 1995 through 2005. They found lots of beef calves from the Southeast region were discounted the most followed by those from the West Coast. Lots in the Rocky Mountain/North Central sold for highest sale price followed by those from the South Central region (King et al., 2006). These results confirm similar findings that region of origin influences sale price (Seeger et al., 2011).

Size of Lot

When calves are marketed in lot sizes to fill a truckload, they receive premiums compared to lots of smaller sizes (Barham and Troxel, 2007; Schulz et al., 2010; Zimmerman, 2010). Larger lot sizes from one producer reduces the need for grouping calves from multiple sources, which increases the health risk of the lot (Nyamusika et al., 1994; Leupp et al., 2007). Buyers may purchase smaller lots of cattle from certain producers with confidence based on past purchases or reputation, but to fill a truck-load, the buyer would have to source calves from multiple producers. Schulz et al. (2010) found lots approaching a truck-load size received the highest premium. However, as lots began to exceed a single truck load, the premium began to decrease. They attributed the decrease of premium to fewer buyers bidding on larger lots, especially those exceeding one truck load (Schulz et al., 2010). If lots are more than one truck load but less than two, transportation costs and risk of co-mingling become an issue for the buyer once again, even

in larger sized lots. When transportation expense is divided among less than a full load, the price per head for transportation cost increases, which decreases the price buyers are willing to pay.

Leupp et al. (2007) analyzed seven factors potentially affecting sale price of feeder calves sold through sale barns in North Dakota, South Dakota, and Montana. One of the factors they found to significantly influence sale price was the lot size in both fall (October and November) and winter (January and February) sales. Feeder calves selling in lots with more than 21 head sold for a greater sale price compared with smaller lots.

Frame Size

The frame score of lots of calves has been reported to affect sale price. The frame score can indicate the finish weight and growth pattern of cattle. Cattle with extremely large frames typically require more feed to reach their end weight and the carcasses may exceed the optimum size for packers and be discounted (Seeger et al., 2011).

Factors influencing the sale price of beef calves that sold from 1995 through 2005 and 1995 through 2009 via video auction were evaluated by King et al. (2006). King et al. (2006) did not specifically report price differences due to frame size in lots of beef calves; however, did state that in 1997, 2001, 2003, and 2004, frame influenced sale price. Other studies showed larger framed beef calves were valued more by buyers compared to smaller framed calves (Bailey et al., 1991; Smith et al., 2000; Bulut and Lawrence, 2007; Seeger et al., 2011).

Schulz et al. (2010) analyzed data from lots of feeder cattle in Kansas and Missouri sold through a sale barn. Small framed lots of cattle were discounted $5.98/cwt and premiums of $0.75/cwt were given for lots of large framed feeder cattle compared to average framed lots. Schulz et al. (2014) evaluated lots of preconditioned calves selling through markets in Iowa for the effect

of market and sale conditions. One of the factors included in their model describing a lot of calves was frame score. Lots of preconditioned calves with medium to large frames had a premium of $4.91/cwt compared to medium framed calves.

Flesh

The amount of flesh, also known as condition, "can be influenced by transportation, handling, and weighing conditions associated with the selling process" (Ward et at., 2007). Ward et al. (2007) also attributes buyer preferences for the flesh condition of feeder calves to the expectation of the buyer for realization of compensatory gains from thinner lots. Schulz et al. (2010) speculated moderately conditioned calves showed the ability convert feed to flesh but were not overly conditioned, which would limit compensatory gain.

Smith et al. (2000) reported factors affecting feeder calf sale price in eastern Oklahoma in 1997 and 1999. One of those factors included the flesh score of the lots. In eastern Oklahoma markets in 1997 and 1999, buyers preferred lots of averaged conditioned calves. Lots of thin or fat feeder calves were discounted by buyers.

Ward et al. (2007) evaluated buyer preferences of feeder calf traits of feeder calves selling through Oklahoma Beef Quality Network sales. One of the traits included in the analysis was condition of lots. Buyers at these sale, based on the three-year averages, provided premiums for thin calves ($1.36/cwt) while discounting fleshy calves $1.78/cwt.

Weight

A survey by United States Department of Agriculture, National Animal Health Monitoring System revealed calf weight and age were the most important factors for 49.9% of producers when

determining when to wean calves (USDA, APHIS, 1998). Typically, sale price per pound and calf weight have an inverse relationship. Buyers can pay more per pound for calves at lighter weights and less per pound as the calf weight increases likely because of potential feeding performance and profitability (Schulz et al., 2010).

As weight increases, the price paid per hundredweight decreases but the price-weight slide is dependent on the sex of the lot and the season of the year lots are sold (Schulz et al., 2010; Schulz et al., 2014). Hawkes et al. (2008) analyzed data from 428 lots of feeder calves sold through Superior Livestock Auction video auctions from 2000 through 2006. These lots originated from Arizona, New Mexico, and Texas. The results revealed that for every one-hundred-pound increase in body weight, the sale price decreased $6.00/cwt. Hawkes et al. (2008) results are applicable to feeder cattle selling via video auction but the actual price may change for other venues.

King et al. (2006) and Seeger et al. (2011) included weight in the model when determining factors that influence the sale price of lots of beef calves sold via video auction. Both studies found lots of beef calves that were described as fairly even in weight sold for a greater sale price most years than lots described as uneven or very uneven in weight variation (King et al., 2006; Seeger et al., 2011).

Calf Sex

Steer calves grow faster, have improved feed efficient, and can be fed to heavier weights. These are the primary reasons that steer calves sell for a greater sale price than heifer calves (Zimmerman, 2010). Heifers purchased for eventual harvest have potential for more management issues such as pregnancy, estrous cycles, and reduced feed efficiency. Buyers are willing to pay a higher price for steers because they do not biologically have the same potential management issues

as heifers. Steers are more efficient in feed conversion. Heifers also are less efficient in converting feed to weight gain and typically produce carcasses with poorer yield grades (Sewell, 1993) and sell for a lower price to the packer.

The price differences observed between lots of steers and heifer calves is also impacted by the current stage of the cattle cycle. When the liquidation phase is occurring, the discounts for heifer calves compared to steer calves increases; there are more heifers in the market because there are fewer being retained for production in the cow herd. As the rebuilding phase takes place, heifer calves may not be discounted to the same extent as steer calves because producers are retaining heifers for breeding purposes. Heifers also are discounted when sold as calves because if producers are retaining heifers, they are keeping, in theory, the highest quality heifers of the group for breeding purposes. Meaning the heifers entering the market from operations retaining heifers are not the highest quality replacement type heifers of the group.

King et al. (2006) analyzed factors influencing the sale price of lots of beef calves selling via video auction and included sex of lot in the model. They found the sex of lot influenced sale price every year from 1995 through 2005. Lots of steers sold for a premium of $9.04/cwt compared to lots of heifer calves in 2005 (King et al., 2006). Seeger et al. (2011) performed a similar study analyzing various factors influencing lots of beef calves sold through a video auction service and included sex of lot in the model. Their results showed sex of calf influenced sale price in all years from 1995 through 2009 and steer lots sold for a greater sale price every year compared to lots of heifer calves (Seeger et al., 2011).

Leupp et al. (2007) analyzed calf sex as one of seven factors influencing sale price of feeder calves sold through auction markets in North Dakota, South Dakota, and Montana. They found calf sex affected sale price ($P<0.0001$) in both fall (October and November) and winter (January

and February) sales. Steer calves sold for a greater sale price than heifer calves in both fall and winter ($117.11/cwt and $107.33/cwt; $101.82/cwt and $93.42/cwt, respectively); (Leupp et al., 2007).

Schulz et al. (2010) analyzed factors impacting sale price of feeder cattle selling in Kansas and Missouri and found similar results but they also separated bulls, steers, and heifers into varying weight categories. As others have reported, steer calves sold for the highest sale price at all weights. Different than other studies, Schulz et al. (2010) included lots of bulls in their analysis, representing approximately 10% of the lots. At lower weights, lots of bulls were discounted between $5.00 and $6.00/cwt compared to lots of steer calves and as the weight of the calves increased, the discounts associated with bulls compared to lots of steer calves were greater. Conversely, heifer calves were discounted less than bull calves compared to steer calves at lower weights, but the discount decreased as weight increased (Schulz et al., 2010). This means as steers increased in weight compared to bulls, buyers were willing to pay more per hundred weight for heavier steer calves. The same applies as heifers increase in weight but the price difference between bulls and heifers at similar weights is less than that of steers and bulls.

In 1991, Jim et al. compared the costs of feeding non-pregnant, aborted, and pregnant heifers in the feedlot. Pregnant heifers in the feedlot increased costs of labor, death loss from calving difficulties, and complications. They noted the pregnant heifers were also discounted by packer buyers because of the potential reduced dressing percentage compared to open heifers. The economic analysis showed non-pregnant heifers returned $66.35 more per head than pregnant heifers (Jim et al., 1991). This study showed the expense of feedlots managing previously mismanaged heifers and why, in part, cattle buyers tend to discount lots of heifers relative to steers.

Preconditioning/Vaccinations

Preconditioning was first developed to reduce the risk of calves contracting bovine respiratory disease after weaning by boosting each calf's immune system with vaccinations and to reduce the amount of stress around the time of weaning. (Speer et al., 2001). Preconditioning of beef calves has evolved over time and tends to add value to calves selling around the age of weaning if buyers are willing to pay a premium equal to or greater than the cost of the preconditioning program (Lacy et al., 2017). There are numerous preconditioning programs available for producers to follow for their calves. While specific programs vary, commonly programs include weaning for approximately 30-45 days before selling, vaccinations to prevent respiratory diseases and build immunity, eating from a feed bunk, as well as castration of bull calves, and dehorning if horns are present (Wirak et al., 1976; Speer et al., 2001; Bulut and Lawrence, 2007). The actual premium associated with preconditioning is dependent upon how much buyers value the preconditioning program at the time of sale. Without verification of preconditioning from the seller or a third-party verification program, the prices paid for lots are based on the average market value of the qualities, which may or may not fully cover the input cost by the seller (Bulut and Lawrence, 2007). Preconditioned calves reduce the risk associated with respiratory sickness in the feedlot but cannot guarantee the calves will stay healthy (King et al., 2006).

Early research for the value based on premiums from buyers of preconditioning of beef calves prior to sale included a study by Wirak et al. (1976). In Washington state, Wirak et al. (1976) analyzed the value of preconditioning beef calves in nine herds, which included 431 calves. The preconditioning program included: calves be weaned a minimum of three weeks prior to being sold, wounds from dehorning and castration were healed, vaccinated for blackleg and malignant

edema after four months of age and prior to sale date, vaccinated with PI_3 for shipping fever, a systemic pour-on applied, and the calves were identified with an ear tag. They found in the fall of 1969, this preconditioning program had a net return of $10.72 per steer and $7.84 per heifer, when averaged to a 30-day preconditioning window. While this study was exclusive to Washington producers, they noted the results were confirming other studies performed in other states (Wirak et al., 1976).

Blank et al. (2006) analyzed data from a video auction service, evaluating lots in the Western region of the United States offered for sale from 1997 through 2003. While their primary objective to quantify the price differences of lots located closer to the Midwest and those lots further away, they also evaluated "value-added" programs. Their study defined preconditioned calves as having received viral respiratory vaccinations prior to shipping. Throughout the seven years of this study, beef producers selling calves through this video auction service responded to the opportunity to gain premiums as great as $1.57/cwt in 2003 offered from buyers by preconditioning calves. In 1997, there were less than 10% of the lots receiving viral respiratory vaccinations prior to shipment. That percentage increased to over 50% of the lots by 2003. They concluded beef producers were trying to meet the demands of buyers who would pay extra for preconditioned calves. Preconditioned calves that were once a niche market, became the normal expectation of the market (Blank et al., 2006).

King et al. (2006) also used video auction data from 1995 through 2005 to evaluate the effects of certified health programs on the sale price of beef calves. Their analysis represented 26,205 lots of beef calves. Factors evaluated were sale date, sex, breed, frame, flesh, region the calves originated from, if calves were home raised or purchased, variation of body weight within the lot, presence of horns, implant status, certified health program status, lot enrolled in a natural

program (2004 and 2005), age and source verified (2005), linear and quadratic terms of lot size, linear and quadratic term of base weight, and difference of days between sale and delivery date. The specifications for each of the Value-Added Health programs can be found in (Table 1.2). The data were analyzed using a backwards selection, where at each step the largest nonsignificant *P* value was removed from the model until all factors were significantly influencing price at a $P<0.05$.

King et al. (2006) found beef calves qualifying for VAC 34 and VAC 45 programs sold for a greater price than beef calves not qualified for a certified health program, non-weaned, and not vaccinated against respiratory tract viruses. In 1995, 44.7% of the lots were not vaccinated for respiratory diseases prior to marketing. Throughout the course of 11 years, the number of lots not vaccinated against respiratory diseases decreased, and in 2005, only 3.9% of the lots sold were not vaccinated against respiratory diseases (King et al., 2006). These results agree with Blank et al. (2006) and show a similar participation by producers in administering at least one dose of a vaccination against respiratory diseases. Buyers were providing premiums for calves with viral vaccinations and producers responded to the demand. King et al. (2006) reported a price premium in all 11 years of the study for lots of calves qualifying for the VAC 34 or VAC 45 programs when compared to lots not in a certified health program, not vaccinated against respiratory diseases prior to shipment, and not weaned. The premiums ranged from \$2.47/cwt to \$7.91/cwt for lots in the VAC 45 program and \$0.99/cwt and \$3.47/cwt for the VAC 34 program, when all other variables were held constant.

Table 1.2 - Superior Livestock Auction Valued-Added health protocol descriptions

Value-Added Protocol	Vaccination Requirements	Timing
VAC 24	– 1 dose: 7-way, 8-way, 9-way Clostridial – 1 dose: Viral 5-way[ab] – 1 dose: Mannheimia Haemolytica and/or Pasturella Multocida – Internal and external parasite control recommended	Calves are vaccinated 2 to 4 months of age while on cow.
VAC 34	– 2 doses: 7-way, 8-way, 9-way Clostridial[c] – 1 dose: Viral 5-way[ab] – 1 dose: Mannheimia Haemolytica and/or Pasturella Multocida – Internal and external parasite control recommended	Calves are vaccinated 2 to 4 weeks prior to shipping.
VAC 34+	– 2 doses: 7-way, 8-way, 9-way Clostridial[c] – 2 doses: Viral 5-way[abc] – 1 dose: Mannheimia Haemolytica and/or Pasturella Multocida[d] – Internal and external parasite control recommended	Calves vaccinated on cows at branding and 2 to 4 weeks prior to shipping.
VAC 45	– 2 doses: 7-way, 8-way, 9-way Clostridial[c] – 2 doses: Viral 5-way[abc] – 1 dose: Mannheimia Haemolytica and/or Pasturella Multocida[e] – Internal and external parasite control recommended	Calves vaccinated twice: 2 to 4 weeks prior to shipping and at weaning OR at weaning and boostered to label instructions. Calves must be home raised and weaned minimum of 45 prior to delivery.
VAC 45+	– 2 doses: 7-way, 8-way, 9-way Clostridial – 3 doses: Modified Live Viral 5-way – 2 doses: Mannheimia Haemolytica and/or Pasturella Multocida – Internal and external parasite control required	Calves vaccinated three times: At branding, prior to or at weaning, and boostered according to label instructions. Home raised and weaned minimum of 45 days prior to delivery.
VAC PreCon	– 2 doses: 7-way, 8-way, 9-way Clostridial[f] – 2 doses: Modified Live Viral 5-way[f] – 1 dose: Mannheimia Haemolytica and/or Pasturella Multocida[f] – Internal and external parasite control recommended	Vaccinated twice: At arrival and boostered according to label instruction, minimum 14 days prior to delivery. Purchased cattle weaned minimum 60 days prior to delivery.

[a]IBR and PI_3 must be chemically altered modified live or modified live with veterinarian's approval.
[b]BVD and BRSV can be modified live or killed vaccine.
[c]One dose administered at branding and one dose administered 2 to 4 weeks prior to shipping.
[d]Administered 2 to 4 weeks prior to shipping.
[e]Administered prior to weaning or at weaning and boostered according to label instructions.
[f]Administered on arrival and boostered according to label instructions.
Table adapted from Superior Livestock Vaccination Programs Designed for Your Management Practices (Superior Livestock Auction, 2017) and (Zimmerman, 2010).

Horns

During the 1970's, many studies indicated horns could have been the major cause of bruising of carcasses (Strappini et al., 2009). Today, a common practice within the cattle industry is disbudding or dehorning to remove horns from cattle to prevent the perceived bruising from horns. This helps to prevent injury to people and other cattle, potentially reducing bruising of carcasses. Shaw et al. (1976) reported that trim loss on carcasses due to bruising nearly doubles in lots with horned cattle compared to lots with no horns present. These findings likely contributed to buyers discounting lots of calves with horns present. Numerous studies show price discounts for lots with horns, indicating horns are an undesired trait in calves and feeders (King et al., 2006; Bulut and Lawrence, 2007; Ward et al., 2007; Schulz et al., 2010; Zimmerman, 2010). The National Beef Quality Audit has evaluated the prevalence of horns on hide-on carcasses since 1991 (Eastwood et al., 2017). Price discounts associated with the presence of horns may have led to the 14.4% decrease of cattle harvested with horns since 1991. The percent decreased to 16.7% in 2016 (Eastwood et al., 2017). During this time, the use of polled genetics increased, likely as a response for potential qualification for various branded beef programs (Eastwood et al., 2017; USDA-AMS, 2017a), as well as discounts from buyers for horned cattle, which decreased the percent of genetically horned cattle.

A recent case study, however, found contradictory results from previous literature such as Shaw et al. (1976) that indicated horns were the largest contributor of bruising on beef carcasses (Youngers et al., 2017). Youngers et al. (2017) evaluated carcass bruising on 4,287 carcasses at a commercial packing plant. The percentage of cattle in a lot with horns averaged 7.7 ± 7.4% with an average horn spread from tip to tip of 39.6 cm. Their results indicated there was not a significant relationship between the presence of horns and bruises in a lot. Based on the locations of the

bruising, most prevalent location being along the midline thoracic cavity, there may be other sources contributing to the bruising than horns such as handling facility design or animal handling practices. Carcass bruising results in increased trimming of damages on the rail and decreases profitability (Youngers et al., 2017).

Implants

Growth-promoting implants in beef calves increase feed efficiency, which reduces feed costs (Stewart, 2013). Implants administered to nursing beef calves increase weaning weights. If calves are destined for the feedlot, meaning the heifers will not be retained for breeding purposes, implants are an effective technology to improve performance when administered at any stage of production. Heifers that are being retained for breeding purposes, however, should not be implanted as the implants contributed to decreased pregnancy rates (Stewart, 2013).

Seeger et al. (2011) evaluated data from 41,657 lots of beef calves sold via video auction from 1995 through 2009. They found in 1995, lots that received a growth promoting implant sold for a premium of $0.34/cwt. In no other years of the study did growth promoting implant usage impact sale price. In 1995, 64.3% of the lots were implanted. By 2009, that number decreased to 26.5% of lots.

Rogers et al. (2015) used the same livestock video auction service as Seeger et al. (2011) but analyzed the effect of growth promoting-implants on the sale price of beef calves sold through video auction from 2010 through 2013. Their study found similar results as previous research from the data; the use of growth-promoting implants did not increase sale price of beef calves selling through video auction. They also reported the percentage of lots of steer calves implanted were significantly higher than lots of heifer calves each year. The percent of lots of steer calves and lots

of heifer calves implanted remained relatively constant during the study (31.0% to 33.6% and 23.4% to 26.1%, respectively). Lots of calves in their analysis were also evaluated by region. Of lots originating from the Southeast region (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, and North Carolina), 64.9% were implanted. No other regions had more than 28% of lots of calves implanted. The authors were not able to determine a reason for the large regional difference in the percentage of calves implanted.

Implants are proven to improve growth performance of calves. Rogers et at. (2011) and Seeger et al. (2015) both indicated the decrease in percentage of implanted lots may have been because of the potential premiums associated with natural value-added programs. Calves receiving growth-promoting implants would not be eligible for natural, hormone free programs such as Non-Hormone Treated Cattle, Never-Ever-3, and Verified Natural Beef, which require cattle to be free of growth promotants (Superior Livestock Auction, 2017).

Value Added Programs

Value added programs are intended to help producers potentially capture premiums for their calves. Many include third party verification of management practices on cow-calf operations so buyers can purchase lots of calves with confidence of factors they cannot confirm visually such as vaccinations and age.

Programs such as Non-Hormone Treated Cattle (NHTC), Certified Natural, Certified Natural Plus, or Verified Natural Beef were designed to help provide verification and garner potential premiums for producers not using products such as antibiotics or growth promotants (Superior Livestock Auction, 2017; USDA, AMS, 2017b). Each of these programs have their own specific rules and regulations for lots of calves to qualify.

The NHTC program requires an on-farm or ranch verification before cattle can be sold under the program. Non-Hormone Treated Cattle is a USDA approved, third-party audit. It verifies the age, source, and non-hormone treated status of the calves selling. Lots of calves qualifying for NHTC be marketed in the program but it also qualifies the calves for potential export to the European Union, which may interest a niche market of buyers (Superior Livestock Auction, 2017; USDA, AMS, 2017b). Certified Natural and Certified Natural Plus programs validate calves in a lot have not received hormones, antibiotics, or animal by-products. Certified Natural Plus program verifies the cattle are free of ionophores, antibiotics, growth promoting hormones, beta agonists or animal by-products (Superior Livestock Auction, 2017). Verified Natural Beef is a program audited by a third party that the cattle are free of antibiotics, growth promotants, or any animal by-products (Superior Livestock Auction, 2017). These programs were created to target a niche market of producers who were already producing or willing to produce cattle that meet the requirements.

Seeger et al. (2011) included various natural programs as potential factors influencing the sale price of beef calves sold through video auction from 1995 through 2009. The Certified Natural program was introduced into their data in 2004. Initially, calves qualifying for the program received premiums but not in all years of the study, indicating lots of beef calves in this program were not consistently valued by buyers. They also included NHTC in their analysis. The program began being recorded in their data in 2008. Results indicate premiums were provided in 2008 but not in 2009. Another valued-added program included in their analysis but not for naturally produced lots, were lots identified as bovine viral diarrhea virus persistently infected (BVD-PI) free. This program certified calves were tested negative for BDV-PI. Introduced in 2008, the program did not significantly influence sale price (Seeger et al., 2011).

In 2003, the United States had a case of bovine spongiform encephalopathy (BSE). This event drastically decreased United States beef exports and ceased trade agreements with many countries such as Japan and South Korea. Beef export markets to Japan and South Korea slowly began to reopen, with age restrictions of beef exported from cattle harvested at a maximum of 20 and 30 months, respectively (USDA, Trade, 2017).

After nearly 14-years of market closure following the BSE case in 2003, the United States has most recently signed a trade agreement again with China. While there are stipulations with the trade agreement, one of the requirements for beef exported includes age and source verified cattle to ensure they are less than 30 months of age (Inouye, 2017). What does this mean for cow-calf beef producers? Cow-calf beef producers can enroll their calves in an age and source verification program. Age and source verification programs differ in the details and process of enrolling cattle in them, but the programs are important for export market qualifications. Others have evaluated the effect of age and source verification cattle on sale price of calves. In an analysis from feeder cattle sold in Oklahoma through sixteen feeder calf sales in 2010, feeder calves qualifying for Oklahoma Quality Beef Network value added program, age and source verification did not impact the sale price of beef calves. They attribute this to only 5% of the cattle in the analysis were age and source verified and buyers looking for cattle to export may go to larger markets with more cattle offered for sale (Williams et al., 2012).

Seeger et al. (2011) included age and source as a potential factor influencing the sale price of lots of beef calves sold via a video auction service. Age and source status was first identified in their data in 2005 and was included each year after. From 2005 through 2009, lots of beef calves age and source verified sold for a greater sale price than lots not verified. The premiums for age and source verified lots ranged from $0.52/cwt in 2005 to $2.14/cwt in 2008 (Seeger et al., 2011).

Breed

Certain breeds or breed-type also influenced the sale price based on how the expectation of how calves will perform in the feedlot (Hersom and Thrift, 2012; Lacy et al., 2017). In a 2010 Arkansas Livestock Auction survey, industry perception of a breed or breed type rather than knowing the actual breed composition affected the sale price (Troxel et al., 2011). This price difference was because of how the calves were expected to perform (Troxel et al., 2011). Bos *taurus* breeds reach their end weight and finish quicker than Bos *indicus* breeds of cattle (Hawkes et al., 2008). Bos *taurus* breeds include breeds such as Angus, Red Angus, Hereford, Charolais, and Simmental for example. English-type breeds, Angus and Hereford for example, historically are known for their maternal attributes. Of the English-type cattle, the Angus breed is often utilized to increase quality (marbling) of carcasses. In contrast, Continental-type cattle, Charolais and Simmental for example, historically are known for their high yield of red meat or more terminal type traits. Often in commercial cattle production, producers will cross British and Continental cattle, hoping to produce calves that will produce a high quality, heavier carcass. A study from USDA in 2007 reported approximately 50% of the operations surveyed reported English-type breeds were the basis of their calf crop while almost 18% of operations reported Continental-type breeds as the basis (USDA, APHIS, 2009). While Bos *indicus* breeds of cattle, Brahman influenced cattle for example, can tolerate a hot, humid climate, they are commonly known for producing lower quality, less tender, cuts of meat (Hawkes et al., 2008).Of the operations surveyed by USDA, nearly 80% of the cow-calf operations had no with Brahman influence animals in the 2007 calf crop (USDA, APHIS, 2009).

Schulz et al. (2010) analyzed approximately 8,200 lots of feeder calves selling in Kansas and Missouri markets during November and December of 2008 and March and April of 2009. Data

collected on the lots selling was similar to that of other studies including the hide color and breed. Through the use of a hedonic pricing model, all lots were analyzed in a single model. They found buyers were willing to pay the highest premium for Angus-influenced cattle compared to the base, Hereford-influenced cattle. Black-hided, white, and mixed colored lots also received premiums compared to red colored lots (Schulz et al., 2010). Seeger et al. (2011) which analyzed factors affecting the price of beef calves and stated Angus influenced calves sold for a greater sale price than other breeds of lots of beef calves.

Changes in breed compositions are partially a result of the increase of branded beef programs. Branded beef programs were first introduced in the 1970's with Certified Angus Beef. During the next 20 years, there were 10 more programs started. Since then, there have been 129 additional branded beef programs introduced (Speer, 2013). Companies saw the opportunity to capture premiums from a niche market of branded beef. "The evolution of branded beef programs and international trade restrictions has led to market demand for calves with specific genetic and management characteristics" (Zimmerman, et al., 2012). "About 70% of the certified beef programs utilize phenotypic characteristics for claiming live animal Angus influence or predominately black-hided" (Eastwood et al., 2017; USDA, AMS, 2017c). Producers aiming to receive premiums associated with the branded beef programs must first meet the requirements of the specific program they are targeting, which may start with hide color.

The National Beef Quality Audit has recorded the predominant hide color or breed type for cattle harvested in each audit since 2000. Black hided or predominantly black hided beef cattle harvested increased from 45.1% in 2000 to 61.1% in 2011. In 2016, the percent decreased to 57.8% (Table 1.3). All other hide colors (red, yellow, gray, brown, and white) have decreased since the 2011 audit. Holstein (black and white) hided cattle increased since the 2011 audit from 5.5% to

20.4%. They attribute the increase in Holstein colored cattle in the fed beef market to a possible shift in the beef supply and stage in the cattle cycle of the United States cow herd rebuilding (Eastwood et al., 2017).

Table 1.3 - National Beef Quality Audit (NBQA): Percentages of cattle harvested with predominant hide colors or breed type evaluated in NBDA-2000, NBQA-2005, NBQA-2011, and NBQA-2016*

Item	NBQA-2000	NBQA-2005	NBQA-2011	NBQA-2015 (± SEM)
Black	45.1	56.3	61.1	57.8 ± 0.3
Holstein (black and white)	5.7	7.9	5.5	20.4 ± 0.3
Red	31.0	18.6	12.8	10.5 ± 0.2
Yellow	8.0	4.9	8.7	4.8 ± 0.1
Gray	4.0	6.0	5.0	2.9 ± 0.1
Brown	1.7	3.0	5.0	1.3 ± 0.1
White	3.2	2.3	1.4	1.1 ± 0.1

*Adapted from Eastwood et al. (2017) Table 4.

Williams et al. (2012) collected data from sixteen feeder auctions in Oklahoma to primarily quantify the effect of a state-wide preconditioning program. They evaluated 2,913 lots of cattle (22,363 head). Lots of calves qualifying for their preconditioning program were comprised of 77% black or black mixed hided cattle. Of lots selling but that were not qualified for the preconditioning program, 67% were black or black mixed hide. “As expected, black-hided lots received a higher price/cwt than all other hide colors because of potential for acceptance in the Certified Angus Beef program” (Williams et al., 2012).

Feeder calf sale prices, when evaluated based on hide color, differ among various color patterns because of the potential to distinguish between breeds (Leupp et al., 2007; Troxel et al., 2011; Williams et al., 2012). In 2010, survey data showed black-white face feeder calves sold for the greatest premium. Black hided calves, yellow, and yellow-white face calves did not differ in the sale price. Other color patterns were also evaluated but spotted or striped pattern calves, which

would indicate dairy or Brahman influence, had the greatest discount on average from other hide colors selling (Troxel et al., 2011). Dairy and Brahman influenced calves are typically discounted when sold through sale barns and are commonly used as the base when comparing other breed compositions for sale price premiums and discounts (King et al., 2006; Lacy et al., 2017; Seeger et al, 2011; Troxel and Barham, 2007; Troxel and Barham, 2012; Zimmerman, 2010).

Brahman influenced calves are commonly discounted when sold, even though approximately 35 to 40% of the calves that enter the production chain have Brahman influence (Riley, 2012). If lots of beef calves selling are commonly discounted for the Brahman influence, why do producers utilize Brahman or Brahman influenced cattle in their herds? The Brahman breed has advantages over other breeds because of the ability to tolerate hot climates, offer disease and parasite resistance, as well as reproduce in a "stressful environment" (American Brahman, 2017). Approximately 40% of the beef cows in the United States are in a hot and humid climate (Cundiff et al., 2012; Spangler, 2012). In the southern portion of the United States, Brahman crossbred cows comprise a large percent of the cow-calf segment (Riley, 2012). Producers commonly crossbreed English or Continental breeds with Brahman cattle to capture heterosis. The Brahman influenced females in crossbreeding add hardiness, longevity, and maternal traits (Russell et al., 2014). Commonly, Brahman females or Brahman crossed females are mated with Angus or Hereford bulls to add quality to the meat to the calves ultimately going to the feedlot but the calves are still able to tolerate the southern climate. The Angus crosses result in calves with black hides and can add price premiums when sold (Williams et al., 2012). Russell and others (2014) collected information on females selling for breeding purposes in south Texas. The information collected on each lot included the number of head, color, frame size, flesh score, percent of Brahman influence by lot, physiological state (open, bred, exposed, pairs, three-in-one),

presence of horns, weight, and sale price. They found in 96% of the lots selling in south Texas, Brahman influence was present. Purebred Brahman females sold for the highest sale price followed by more than 50% Brahman compared to females with no Brahman influence (Russell et al., 2014). Traits valued by producers in females retained for the cow herd are based on their production goals, available resources, and environment. In south Texas, the Brahman influenced females can withstand the hot climates and still fulfill their intended purpose as a breeding female and reproduce efficiently.

Superior Livestock Auction Database History and Description

The opportunity to evaluate potential breed trends and the effect of breed on the sale price of lots of beef calves was available through a livestock video auction service. The data used in Chapters 2 and 3 were from lots of beef calves sold through Superior Livestock Auction. Introduction to the database and explanation of evolvement over the course of more than two decades is important to understand the research presented.

Superior Livestock Auction (SLA) is the largest video auction service in the United States, marketing more than 2 million head of cattle annually. Introducing satellite video marketing in 1987, SLA changed the way producers could market load-lots of cattle by creating a national livestock market (Superior Livestock Auction, 2017). They market calves originating from all across the nation to buyers everywhere in the United States. Calves, feeders, dairy influenced, Mexican cattle, and breeding stock are all offered within SLA. Producers can market their calves via private treaty, Internet auction, or video auction. A representative works with the producer to describe the lot selling as well as take a video of cattle for potential buyers to view (Figure 1.6). The contract is submitted to Brush, Colorado for catalog preparation. The catalog for video and

Internet auctions are available for viewing one week prior to the sale date. The video is sent to Fort Worth, Texas to be uploaded for viewing prior to the auction. On the sale day, there is a live auction as well as a nationwide satellite broadcast and internet viewing. Delivery of cattle is managed by a Superior representative. The cattle are delivered directly from the seller to the buyer, which reduces transportation stress and health issues. The sales representative works with both the buyer and the seller after calves are purchased to arrange delivery. Lots of cattle can be sold on forward contracting. The seller can sell calves during times when prices are high and the calves can be arranged for delivery when the buyer wants them (Zimmerman, 2010; Superior Livestock Auction, 2017).

Figure 1.6 - Example lot from Superior Livestock Auction

Lot # 5915 — Rodewald Ranch

Add to my lots

110 STEER CALVES		**BASE WT:**	**450#**
ORIGIN:	Home Raised		
SLIDE:	15 cents Over the base weight		
CURRENT LOCATION:	Ranch, 15 mile(s) W of Rawlins , WY which is 150 mile(s) W of Cheyenne , WY		
BREED TYPE:	Angus & Angus cross by reg. Angus bulls.		
FRAME:	Medium	**FLESH:**	Medium
EST. WT. VAR.:	Uneven	**HORNS:**	None
FEED:	On cows & native desert pasture.		
DELIVERY DATE:	Oct. 19-31, 2017 Rep's option		
WEIGHING COND:	Gather early a.m., trail 6 miles, sort off cows, sort, load on buyers truck & weigh on truck w/a 2%.		
COMMENTS:	Knife cut or banded. Nice set of light desert calves. Sort 1 load from 125 hd.		
VACCINATIONS:			
IMPLANTED:	No	**TOTAL EST PAY WEIGHT:**	49500 #
AGE/SOURCE VERIFIED:	No		
REPRESENTED BY:	Producers Livestock Marketing Assn (970) 353-4121 Brad Jones (970) 590-9583		

SLIDE 15¢ **ANGUS**

Most producers who utilize SLA as a marketing tool have sufficient numbers of beef calves to fill a load from their operation. The lots of beef calves in the database represent larger operations in the United States. Calves marketed via SLA are sold in "load-lots". A load of cattle on a semi is typically 50,000 pounds. If a lot of beef calves average 500 pounds per head, it would take 100 calves to fill a load. The average sized United States beef operation does not have a large enough cow herd to fill a load of calves. The lot size of beef calves marketed via SLA summer video auction from 1995 through 2016 was 120 head, on average. The average beef cow herd size in the United States is 40 head (USDA, ERS, 2017a). These smaller operations are typically part of multi-enterprises or serve as a secondary source of income for producers. Over half of the beef cow inventory in the United States is derived from only 9% of operations with more than 100 head of beef cows (USDA, ERS, 2017a). Beef operations marketing calves through SLA video auctions most likely have at least 200 head cow herds in order to fill a load of single gender calves. The lots in the database may also represent more progressive operations who utilize technology such as video auctions to potentially gain more premiums for their calves.

Since the start of the database in 1995, the six to eight largest sales for beef calves were recorded in the database every year, these sales typically take place from the end of May through the end of September and will be referred to as "summer sales". Total percentage of lots of beef calves marketed via SLA summer video auction are represented in Figure 1.7, divided by regional representation with the Northeast region excluded due to few lots of beef calves originating from this region.

Table 1.4 lists the number of lots and the total number of head from each region of the United States. Figure 1.8 illustrates the states included within each region. Using lots of beef calves offered for sale during the summer months from 1995 through 2016, the Rocky Mountain/North

Central region (Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming) represented 49% of the total lots. The West Coast included the states of Alaska, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington. The Rocky Mountain/ North Central region included Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming. The South Central region included the states of Arizona, Kansas, Missouri, New Mexico, and Oklahoma. Texas was a separate region due to the large number of lots originating from the state. Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina comprised the Coastal region. The Subcoastal region included the states of Arkansas, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia. Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont were in the Northeast region. The Northeast region has been excluded in analyses from this database due to the few number of lots of beef calves originating from this region.

Figure 1.7 - Percent of lots of beef calves marketed from each region of the United States via summer video auction from 1995 through 2016

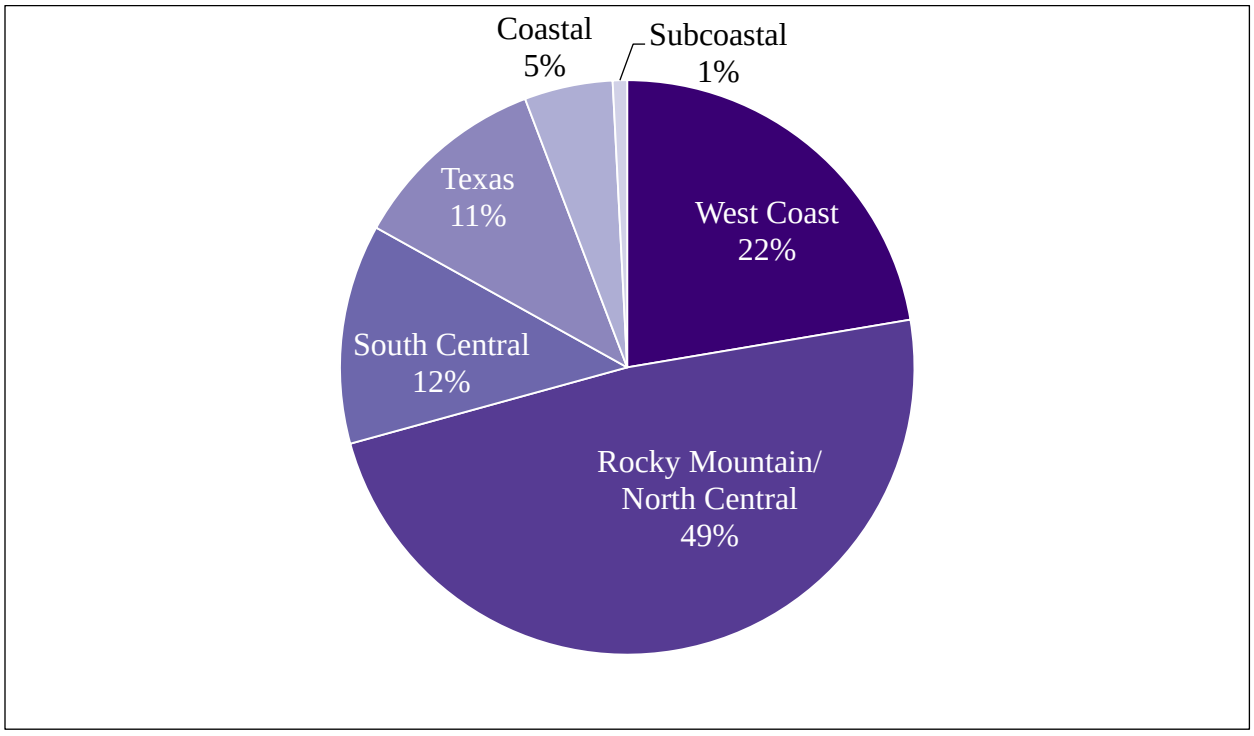
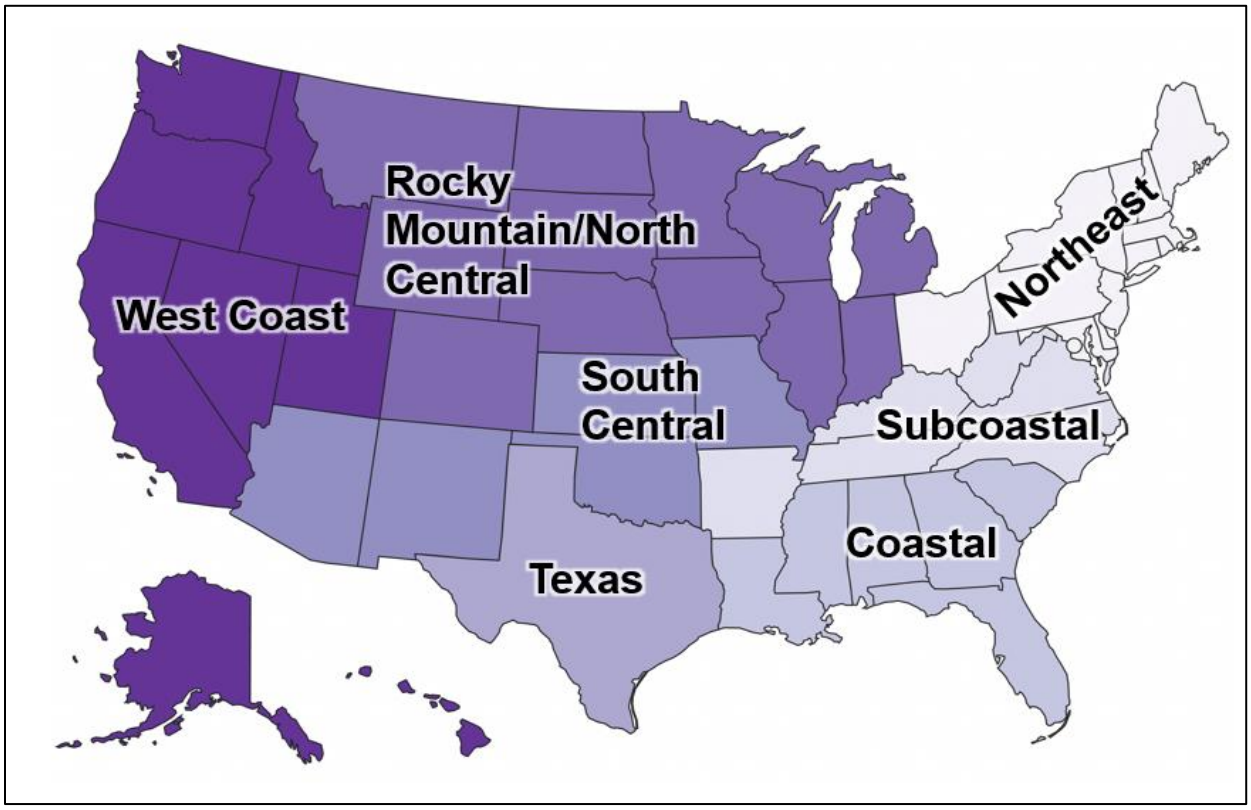


Table 1.4 - Number of lots and total head marketed from each region via summer video auction from 1995 through 2016

Region	Total Number of Lots	Total Head
West Coast	18,962	2,213,826
Rocky Mountain/ North Central	41,059	5,080,328
South Central	10,492	1,248,858
Texas	9,448	1,105,248
Coastal	4,221	486,877
Subcoastal	687	64,677

Figure 1.8 - Map of regions within the United States for analysis



Development Since 1995

Pfizer Animal Health, in cooperation with Colorado State University, began collecting and storing data describing lots of beef calves sold via video auction through Superior Livestock Auction starting in 1995. These data were obtained through the video auction catalogs and manually entered into a computer database, Microsoft Access®, each year. In 1995, seven summer sales were recorded in the database. The lots that sold were recorded and were single-gender lots of beef calves and feeders, both weaned and non-weaned. The primary objective of the project at that time was to quantify the effects of the health protocols of SLA's Value-Added Health program on the sale price of beef cattle while adjusting for all other factors that significantly affected the price of cattle. At the time, preconditioning programs for calves around the age of weaning were of interest to the beef industry. Preconditioning calves helps to boost immunity to respiratory

diseases through vaccination and lower stress when the calves transitioned from the cow-calf producers to a backgrounder/stocker operation or feedlot. Initially, there were four health protocols used by producers: VAC 24, VAC 34, VAC 45, and VAC PreCon. Table 1.2 summarizes the requirements for each health protocol offered by SLA.

With the development of the database, the reference population for the health protocols changed as producer management practices changed. In 1995, the reference population lots were compared with were the non-weaned, non-viral vaccinated lots of beef calves. This reference population remained until 2010. Based on the findings of King et al. (2006) in 1995, 44.7% of the lots had not received vaccinations against respiratory diseases and that number reduced to 3.9% in 2003. In 2010, the reference population was changed to the non-weaned, respiratory disease vaccinated calves. These were lots of calves that were not weaned at the time of sale but had received at least one dose of a viral respiratory vaccination. Based on changes in the beef industry and producers vaccinating their calves prior to selling, in 2013, the reference population in this database were lots of calves qualifying for the VAC 24 program. Within this database for calves selling via video auction, in 2016, there were 31 lots of non-weaned, non-viral vaccinated calves out of 6,838 lots or 0.45% of the total lots. Also in 2016, there were only 18 lots of weaned, non-viral vaccinated calves from a total of 6,838 lots or 0.26% of the total lots. In 2006, Blank et al. (2006) speculated, referring to calf health programs, what was once a niche market was becoming the normal basis expected by buyers. Based on the lots of beef calves marketed via video auction through SLA in 2014, there are very few producers who do not administer at least one viral vaccination to their calves, and the normal expectation of buyers has shifted.

From 1996 through 2005, data from all video auctions were manually recorded into the database. As time passed, more variables describing the lots were added to the database. In 1996,

more characterized variables were added such as specific implants administered to calves, if described by the seller in the written lot description. Until 1999, breed descriptions of lots of calves were categorized as English and English-crossed, English and Continental-crossed, or Brahman influenced based on the breed description provided by the seller. In 1999, the breed descriptions in the database began to be more categorized more specifically. Lots described as English and English-crossed that are at least 90% black or black white face and lots described as being at least 90% Angus were classified. The creation of this breed description was to provide information for the branded beef program, Certified Angus Beef. Beginning in 2010, specific sire breeds were also included as a variable in the database for a lot of beef calves. The sire breed of a lot was determined based on the breed description of the lot provided by the seller and sales representative.

In 2000, among lots of beef calves that did not qualify for a value-added health protocol, those lots that received two doses of a viral respiratory disease vaccination were identified. The percentage of black-hided cattle in a lot were also identified. Beginning in 2004, SLA also began to recognize outside value-added programs and they were identified in the database. The Certified Natural program was introduced into the database in 2004. This program verifies that cattle have not received hormones, antibiotics, or animal by-products (Superior Livestock Auction, 2017). Age and Source Verified programs were identified starting in 2005. Until this point, Bang's, or brucellosis vaccination, was recorded on lots of heifers but was never quantified previously so the status was not recorded in 2005, 2006, or 2007. This is a vaccination administered typically to females being retained in the breeding herd.

Starting in 2006, only the six to eight largest sales of the year for lots of beef calves were recorded in the database. The six to eight largest sales typically took place the end of May through the end of September. The summer sales are the largest sales for lots of beef calves because of

summer grazing. Buyers need to purchase calves to graze grass during the summer and at the end of the summer, after the grazing period has ended, lots of beef calves enter the market. Also in 2006, lots qualifying for the value-added program, Angus Source® were identified.

The Pfizer SelectVAC vaccination protocols were added to SLA value-added health program, thus were recognized starting in 2007. In 2008, the VAC 34+ health protocol was added (Table 1.2). Also in 2008, two new value-added programs were added, which included: Bovine Viral Diarrhea virus Persistently Infected Free (BVD-PI) program and the Non-Hormone Treated Cattle (NHTC) program. Lots qualifying for these programs were identified. Identifying lots of heifers that were spayed ended in 2008 because of few lots being identified in this category. Bang's status of lots of heifers was recorded again starting in 2008. Superior Livestock Auction began a new program called the Superior Progressive Genetics Program. The status for this program was recorded for each lot beginning in 2009.

In 2010, data were provided electronically for all sales and animal types. These data were then imported into the Microsoft Access® database. Both single-gender and mixed-gender lots marketed were included and identified. As stated previously, the reference population for vaccinations also changed in 2010 from non-weaned, not vaccinated for respiratory diseases to lots non-weaned, vaccinated against respiratory disease calves. The previous reference population, non-weaned, not vaccinated for respiratory diseases, was excluded from analysis because of few lots in this category. This means that while producers had not moved away from marketing non-weaned calves, there was value to having at least one viral respiratory disease vaccination in lots of calves and producers recognized it. There was an additional heath protocol added in 2010; weaned, respiratory disease vaccinated calves. The Verified Natural Beef program was also first identified in 2010 in the database. In 2012, the VAC 45+ health protocol was added (Table 1.2).

The reference population was once again changed from non-weaned, respiratory vaccinated calves, to the VAC 24 health protocol (Table 1.2) in 2013. In 2014, other programs introduced to the database included the Certified Natural Plus program, the Global Animal Partnership program, and the Merck Prime VAC program. The BVD-PI free lots tested by the Gold Standard Lab were also identified. Also in 2014, Superior began a new sale called Superior Select. Superior Select is a video auction for breeding cattle. Breeding cattle lots added new variables including: projected calving period, age, description of teeth condition, GeneMax score, HD50K score, and the type of breeding program. There were also new programs added in 2015 including Reputation Feeder Cattle, Top Dollar Angus, and Superior RightSlide.

With changes in buyer expectations as seen previously with management practices, vaccinations, and breed influences, factors influencing the sale price of beef calves needs to be analyzed. Evaluation of video auction data from lots of beef calves can provide a nationwide perspective of trends in the cowherd and buyer preferences.

References

American Brahman. 2017. Why use Brahman? Accessed 12 July 2017. http://brahman.org/about/benefits-of-brahman/.

Bailey, D., M.C. Peterson, and B.W. Brorsen. 1991. A comparison of video cattle auction and regional market prices. American Journal of Agricultural Economics. 73(2):465-475.

Bailey, D. and L. Hunnicutt. 2002. The role of transaction costs in market selection: Market selection in commercial feeder cattle operations. Annual Meeting of the American Agricultural Economics Association in Long Beach, CA. July 28-31.

Barham, B.L. and T.R. Troxel. 2007. Factors affecting the selling prices of feeder cattle sold at Arkansas livestock auctions in 2005. Journal of Animal Science. 85:3434-3441.

Blank, S.C., H. Boriss, L. Forero, and G. Nader. 2006. Western cattle prices vary across video markets and value-adding programs. University of California, Division of Agriculture and Natural Recourses. California Agriculture. 60(3):160-165.

Breimyer, H.F. 1955. Observations on the cattle cycle. Agricultural Economics Research. 1:1-11.

Bulut, H. and J.D. Lawrence. 2007. The value of third-party certification of preconditioning claims at Iowa feeder cattle auctions. Journal of Agricultural and Applied Economics. 39(3):625-640.

Cattle Mail USA. 2007. Cattle auctions on the internet. Cattle Mail USA. Accessed 01 July 2017. http://www.cattlemailusa.com/cattle-auctions-on-the-internet.php

Chvosta, J., R.R. Rucker, and M.J. Watts. 2001. Transaction costs and cattle marketing: The information content of seller-provided presale data at bull auctions. American Journal of Agricultural Economics. 83(2):286-301.

Cundiff, L.V., R.M. Thallman, and L.A. Kuehn. 2012. Impact of Bos *indicus* genetics on the global beef industry. Beef Improvement Federation Research Symposium, Houston, TX. Accessed 01 July 2017. http://www.brahman.org/PDFs/CundiffBIF.pdf

Dhuyvetter, K.C., T.C. Schroeder, D.D. Simms, R.P. Bolze, and J. Geske. 1996. Determinants of purebred beef bulls price differentials. Journal of Agricultural and Resource Economics. 21(2):396-410.

Eastwood, L.C., C.A. Boykin, M.K. Harris, A.N. Arnold, D.S. Hale, C.R. Kerth, D.B. Griffin, J.W. Savell, K.E. Belk, D.R. Woerner, J.D. Hasty, R.J. Delmore, J.N. Martin, T.E. Lawrence, T.J. McEvers, D.L. VanOberbeke, G.G. Mafi, M.M. Pfeiffer, T.B. Schmidt, R.J. Maddock, D.D. Johnson, C.C. Carr, J.M. Scheffler, T.D. Pringle, and A.M. Stelzleni. 2017. National Beef Quality Audit-2016: Transportation, mobility, and harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and by-products. Translation Animal Science. 1:229-238.

Gillespie, J., A. Basarir, and A. Schuup. 2004. Beef producer choice in cattle marketing. Journal of Agribusiness. 22(2):149-161.

Gordon, B.L. 2012. Selling cattle on video auctions continues to grow. Drovers. Accessed 01 July 2017. http://www.cattlenetwork.com/cattle-news/Selling-cattle-on-video-auctions-continues-to-grow-164299386.html

Griffith, A.P. 2015. Marketing feeder cattle via video auction. University of Tennessee Extension. Accessed 15 July 2017. http://utbfc.utk.edu/Content%20Folders/Beef%20Cattle/Beef-Economics%20and%20Marketing/Publications/W335%20Marketing%20Feeder%20Cattle%20Via%20Video%20Auction.pdf

Hawkes, J.M., J.M. Lillywhite, and J. Simonsen. 2008. Breed influence on feeder calves. New Mexico State University, College of Agriculture and Home Economics, Cooperative Extension Service. Circular 634.

Hersom, M. and T. Thrift. 2012. Factors that affect calf selling price at marketing. Institute of Food and Agricultural Sciences. University of Florida. Accessed 15 July 2017. https://edis.ifas.ufl.edu/pdffiles/AN/AN27800.pdf

Inouye, A. 2017. Procedures for exporting U.S. beef to China. United States Department of Agriculture, Foreign Agricultural Service. Global Agricultural Information Network. Accessed 23 July 2017. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Procedures%20for%20Exporting%20U.S.%20Beef%20to%20China_Beijing_China%20-%20Peoples%20Republic%20of_7-13-2017.pdf

Jim, G.K., C.S. Ribble, P.T. Guichon, and B.E. Thoralkson. 1991. The relative economics of feeding open, aborted, and pregnant feedlot heifers. Canadian Veterinary Journal. 32:613-617.

King, M.E., M.D. Salman, T.E. Wittum, K.G. Odde, J.T. Seeger, D.M. Grotelueschen, G.M. Rogers, and G.A. Quakenbush. 2006. Effect of certified health programs in the sale price of

beef calves marketed through a livestock video auction service from 1995 through 2005. JAVMA 229:1389-1400.

Lacy, R.C., C.H. Knight, and J.C. Mckissick. 2017. Profitable cattle marketing for the cow-calf producer. University Cooperative Extension Bullentin 1087. University of Georgia Extension. Accessed 23 July 2017. https://secure.caes.uga.edu/extension/publications/files/pdf/B%201078_4.PDF.

Leupp, J.L., G.P. Lardy, R. Daly, C.L. Wright, and J.A. Paterson. 2007. Factors influencing price of North Dakota, South Dakota, and Montana feeder calves. North Dakota State University Agriculture Experiment Station Beef Cattle and Range Research Report. Pg. 36-39.

McBride, W.D. and K. Mathews. 2011. The diverse structure and organization of U.S. beef cow-calf farms. USDA, ERS. EIB-73.

Parish, J. 2013. Prepping for private treaty. Cattle Business in Mississippi. Mississippi State University Extension. Accessed 05 July 2017. https://extension.msstate.edu/sites/default/files/topic-files/cattle-business-mississippi-articles/cattle-business-mississippi-articles-landing-page/mca_may2013.pdf

Peel, D.S. 2016. Status of the US Beef Herd Expansion. IFAS Extension University of Florida. Panhandle Ag e-News. Accessed 03 October 2017. http://nwdistrict.ifas.ufl.edu/phag/2016/11/04/status-of-us-beef-herd-expansion/

Norton, M. 2005. Factors affecting beef and cattle producer price movements. Monthly Labor Review. 32-40.

Nyamusika, N., T.H. Spreen, O. Rae, and C. Moss. 1994. A bioeconomic analysis of bovine respiratory disease complex. Review of Agricultural Economics. 16:39-53.

Pope, A. 1993. Marketing beef cattle via satellite, video auction proves successful in areas distinct from markets. Research brief. University of Wisconsin-Madison. Accessed 23 July 2017. http://cias.wisc.edu/marketing-beef-cattle-via-satellite-video-auction-proves-succesful-in-areas-distant-from-markets/

Riley, D. 2012. Brahman crossbred performance in distinct segments of the United States beef industry. Beef Improvement Federation Conference proceedings. Texas A&M University, Department of Animal Science. 14-31.

Rhinehart, J. 2015. How it works: The U.S. beef industry. Drovers. Accessed 07 July 2017. http://www.cattlenetwork.com/news/industry/how-it-works-us-beef-industry.

Rogers, G.M., M.E. King, K.L. Hill, T.E. Wittum, and K.G. Odde. 2015. The effect of growth promoting implant status on the sale price of beef calves sold through a livestock video auction service from 2010 through 2013. Prof. Anim. Sci. 31:443-447.

Russell, L.A., M.T. Bochat, B.D. Yanta, D.P. Anderson, J.C. Paschal, and A.M. Young. 2014. Impact of Brahman influence on breeding female prices in South Texas: Results from a special sale in Bee county, Texas. Texas A&M AgriLife Extension. Accessed 02 July 2017. https://brahman.org/PDFs/ImpactofBrahmanInfluenceonBreedingFemalePricesinSouthTexas.pdf

Rutherford, Burt. 2014. U.S. beef herd is mostly black but changing slightly. BEEF Magazine. Accessed 15 July 2017. http://www.beefmagazine.com/cattle-genetics/us-beef-herd-mostly-black-changing-slightly

Seeger, J.T., M.E. King, D.M. Grotelueschen, G.M. Rogers, and G.S. Stokka. 2011. Effect of management, marketing, and certified health programs on the sale price of beef calves sold through a livestock video auction service from 1995 through 2009. JAVMA 239:451-466.

Sewell, H.B. 1993. Heifers versus steers in feedlot. University of Missouri-Columbia, Department of Animal Sciences. Agricultural publication G02082. http://cattle.rfitz.com/heifersvssteers.txt

Schulz, L., K. Dhuyvetter, K. Harborth, and J. Waggoner. 2010. Factors affecting feeder cattle prices in Kansas and Missouri. Kansas State University, Department of Agricultural Economics. Accessed 06 July 2017. https://www.researchgate.net/publication/265935740_Factors_Affecting_Feeder_Cattle_Prices_in_Kansas_and_Missouri

Schulz, L.L., K.C. Dhuyvetter, and B. Doran. 2014. Factors affecting preconditioned calf price differentials: How much do market and sale conditions matter? Paper presented at Agricultural and Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN. July 27-29. http://ageconsearch.umn.edu/bitstream/170570/2/AAEA%205043.pdf

Schulz, L.L., K.C. Dhuyvetter, and B.E. Doran. 2015. Factors affecting preconditioned calf price premiums: Does potential buyer competition and seller reputation matter? Journal of Agricultural and Resource Economics. 40(2):220-241.

Schroeder, T., J. Mintert, F. Brazle, and O. Grunewald. 1988. Factors affecting feeder cattle price differentials. Western Journal Agriculture Economics. 13:71-81.

Shaw, F.D., R.I. Baxter, and W.R. Ramsay. 1976. The contribution of horned cattle to carcass bruising. Veterinary Record. 98:255-257.

Smith, S.C., D.R. Gill, T.R. Evicks, and J. Prawl. 2000. Effect of selected characteristics on the sale price of feeder cattle in eastern Oklahoma: 1997 & 1999 summary. Animal Science Research Report – Agricultural Experiment Station, Oklahoma State University. P-980:14-19.

Spangler, M.L. 2012. Utilizing Brahman germplasm in crossbreeding systems. Beef Improvement Federation Research Symposium, Houston, TX. Accessed 17 July 2017. http://www.brahman.org/PDFs/Utilizing-Brahman-Germplasm-in-Crossbreeding-Systems.pdf

Spangler, M. 2014. Genetic considerations for the cowherd. University of Nebraska-Lincoln. Accessed 19 January 2017. http://beef.unl.edu/genetic-considerations.

Speer, N.C., C. Young, and D. Roeber. 2001. The importance of preventing bovine respiratory disease: a beef industry review. Bovine Practitioner. 35:189-196.

Speer, N. 2013. Industry at a glance: Growth of USDA-Certified beef programs. BEEF Magazine. Accessed 10 July 2017. http://www.beefmagazine.com/retail/industry-glance-growth-usda-certified-beef-programs

Stewart, L. 2013. Implanting beef cattle. The University of Georgia, UGA Cooperative Extension Bulletin. 1302.

Strappini, A.C., J.H.M. Metz, C.B. Gallo, and B. Kemp. 2009. Origin and assessment of bruises in beef cattle at slaughter. Animal Consortium. 3(5):728-736.

Superior Livestock Auction. 2017. “Superior Livestock Auction.” Accessed 15 January 2017. http://www.superiorlivestock.com.

Troxel, T.R. and B.L. Barham. 2007. Comparing the 2000 and 2005 factors affecting the selling price of feeder cattle sold at Arkansas livestock auctions. J. Anim. Sci. 85:3425-3433. https://www.animalsciencepublications.org/publications/jas/pdfs/85/12/0853425

Troxel, T.R and B.L. Barham. 2012. Phenotypic expression and management factors affecting the selling price of feeder cattle sold at Arkansas livestock auctions. Prof. Anim. Sci. 28(1):64-72.

Troxel, T., B. Barham, S. Cline, J. Foley, D. Hardgrave, R. Wiedower, W. Weidower. 2011. Improving the value of feeder cattle. Agricultural and Natural Resources. University of Arkansas. https://www.uaex.edu/publications/PDF/FSA-3056.pdf.

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 1998. Part IV: Changes in the U.S. beef cow-calf industry 1993 – 1997. Accessed 14 December 2017. https://www.aphis.usda.gov/animal_health/nahms/beefcowcalf/downloads/beef97/Beef97_dr_PartIV.pdf

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 2009. Beef 2007-08. Part II: Reference of beef cow-calf management practices in the United States, 2007-08. USDA-APHIS-VS, CEAH. Fort Collins, CO.

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 2011. Small-scale U.S. cow-calf operations. USDA-APHIS-VS, CEAH. Fort Collins, CO. 564.0411.

United States Department of Agriculture, Agriculture Marketing Service (USDA, AMS). 2017a. Certified beef programs. UDSA, AMS, Washington, DC. Accessed 09 August 2017. https://www.ams.usda.gov/services/auditing/certified-beef-programs

United States Department of Agriculture, Agriculture Marketing Service (USDA, AMS). 2017b. Non-Hormone Treated Cattle program. Accessed 08 January 2018. https://www.ams.usda.gov/services/imports-exports/nhtc

United States Department of Agriculture, Agriculture Marketing Service (USDA, AMS). 2017c. Official listing of approved USDA process verified programs for service producers. Accessed 23 July 2017. https://www.ams.usda.gov/sites/default/files/media/Official%20Listing%20of%20Approved%20Process%20Verified%20Programs%20for%20Sevice%20Providers.pdf

United States Department of Agriculture, Census of Agriculture. 2014. 2012 census publication. Accessed 23 July 2017.

United States Department of Agriculture, Economic Research Service (UDSA, ERS). 2017a. Cattle and Beef: Background. Accessed 01 July 2017. https://www.ers.usda.gov/topics/animal-products/cattle-beef/background/

United States Department of Agriculture, Economic Research Service (UDSA, ERS). 2017b. Livestock and meat domestic data. Accessed 15 December 2017. https://www.ers.usda.gov/data-products/livestock-meat-domestic-data/

United States Department of Agriculture, National Agricultural Statistics Service (USDA, NASS). 2016. Overview of the United States cattle industry. Agricultural Statistics Board, United States Department of Agricultural. Accessed 15 July 2017. http://usda.mannlib.cornell.edu/usda/current/USCatSup/USCatSup-06-24-2016.pdf

United States Department of Agriculture, National Agricultural Statistics Service (USDA, NASS). 2017. Cattle. Agricultural Statistics Board, United States Department of Agricultural. Accessed 05 July 2017. http://usda.mannlib.cornell.edu/usda/current/Catt/Catt-01-31-2017.pdf

Vanek, J.K., M.J. Watts, and G.W. Brester. 2008. Carcass quality and genetic selection in the beef industry. Journal of Agricultural and Resource Economics. 33(3): 349-363.

Ward, C.E., C.D. Ratcliff, and D.L. Lalman. 2007. Buyer preferences for feeder calf traits. Oklahoma State University, Oklahoma Cooperative Extension Service. AGEC-602.

Wessler, B. 2011. Trends in hide color. Drovers. Accessed 10 July 2017. http://www.cattlenetwork.com/drovers/markets/Trends-in-hide-color-125028789.html

Williams, G.S., K.C. Raper, E.A. DeVuyst, D. Peel, and D. McKinney. 2012. Determinants of price differentials in Oklahoma value-added feeder cattle auctions. J. Agricultural and Resource Economics. 37(1):114-127.

Wirak, O.S., R. Hostetler, W.E. McReynolds, and W.D. Warnock. 1976. Preconditioning of beef calves before sale. Washington State University, Cooperative Extension Service. EM 3415 (Reprint) June.

Youngers, M.E., D.U. Thompson, E.F. Schwandt, J.C. Simroth, S.J. Bartle, M.G. Siemens, and C.D. Reinhardt. 2017. Case Study: Prevalence of horns and bruising in feedlot cattle at slaughter. Professional Animal Scientist. 33:135-139.

Zimmerman, L.C. 2010. Factors influencing the price of value-added calves at Superior Livestock Auction. Master's Thesis. Kansas State University, Manhattan, KS.

Zimmerman, L.C., T.C. Schroeder, K.C. Dhuyvetter, K.C. Olson, G.L. Stokka, J.T. Segger, and D.M. Grotelueschen. 2012. The effect of value-added management on calf prices at Superior Livestock Auction video markets. J. Agricultural and Resource Economics. 37(1):128-143.

Chapter 2 – Breed composition affects the sale price of steer and heifer calves sold through video auctions from 2010 through 2016

Abstract

The objective was to quantify the effect of breed composition on the sale price of steer and heifer calves sold through Superior Livestock video auctions in all sales from 2010 through 2016 while adjusting for all other independent factors that significantly affect the sale price. Information on descriptive characteristics of lots of beef calves were obtained from a livestock video auction service. Data were available on 29,103 lots of steer calves and 18,955 lots of heifer calves that sold in 164 video auctions from 2010 through 2016. Effect of breed composition was evaluated within a single gender. All lot characteristics that could be accurately quantified or categorized were used to develop a multiple regression model that evaluated the effects of independent factors on sale price using a backwards selection procedure. A value of $P<0.05$ was used to maintain a factor in the final model. Breed description of calves in the lots was 1 of 20 factors included in the original model and was used to categorize the lot into one of six groups: English and English-crossed, English and Continental-crossed, Black Angus-sired out of dams with no Brahman influence, Red Angus-sired out of dams with no Brahman influence, Charolais-sired out of dams with no Brahman influence, and Brahman influenced. Breed description of lots of both steer and heifer calves affected sale price ($P<0.0001$). Lots of Charolais-sired and Red Angus-sired steer calves brought the greatest sale prices ($P<0.05$) as compared to steers in all other breed categories at $179.09 and $177.86/cwt, respectively. Lots of Black Angus-sired steer calves sold for a similar price as Red Angus-sired lots ($P=0.29$; $177.23/cwt). English and English-crossed and English and Continental-crossed steer calves had similar sale prices but that were greater ($P<0.05$) than

Brahman influenced steer calves at $175.54/cwt and $175.36/cwt, respectively. Brahman influenced lots of steer calves brought the lowest sale price (P<0.05; $170.97/cwt). Among heifer calves, lots of Red Angus-sired heifers sold for the greatest price (P<0.05) compared to heifers in all other breed descriptions at $173.88/cwt. Lots of Charolais-sired and Black Angus-sired heifer calves sold for less than Red Angus-sired heifer lots but did not differ from each other in sale price (P<0.05; $168.47 and $167.66/cwt, respectively). English and English-crossed and English and Continental-crossed lots of heifer calves had similar sale prices but that were greater (P<0.05) than Brahman influenced lots of heifer calves at $165.79/cwt and $165.58/cwt, respectively. Lots of Brahman influenced heifer calves had the lowest sale price (P<0.05, $162.78/cwt) as compared with heifers of all other breed descriptions. Value placed on breed composition of lots of steer and heifer calves may vary based on the purpose of purchasing the lot. Steer calves are purchased to be fed to harvest endpoint. The purposes of purchasing lots of heifer calves, for replacement females or destined for feedlots, may influence the breed compositions valued by buyers.

Introduction

English breeds have been the basis of the United States cow herd for over a century (Drovers, 2014). A study from USDA in 2007 reported approximately 50% of the operations surveyed reported English-type breeds were the basis of their calf crop while almost 18% of operations reported Continental-type breeds as the basis (USDA, APHIS, 2009). Historically, the Hereford breed was dominant in the United States because of early maturity and efficient production. They remained dominant until the 1970's when widespread use of the black Angus breed began to significantly influence breed composition of the United States cow herd. In a 2014 survey of 1,245 beef producers, 89% of crossbred cow-calf producers reported use of black Angus

genetics (Drovers, 2014). Black Angus genetics dominate the cow herd in the United States, partially as a result of numerous branded beef program requirements for primarily black hides of cattle (Zimmerman et al., 2012). Nearly 70% of the certified branded beef programs include a preliminary requirement of Angus influence or predominately black hided cattle (Eastwood et al., 2017; USDA, AMS, 2017). The basis of production decisions made by cattle producers are dependent upon operation goals, available resources, and production environment conditions. Not all breeds are ideal in all locations and environments. The breed composition of a producer's cow herd in a hot, humid climate will vary from a cow herd located in a cold, harsh winter environment. The breed composition of calves marketed are based on breeding decisions cow-calf producers make. Cow-calf producers selling beef calves around the time of weaning ideally want to optimize their production goals with the type of calves for which buyers provide premiums.

King et al. (2006) analyzed the effect of certified health programs on the sale price of lots of beef calves sold through a video auction service from 1995 through 2005. Through the use of multiple regression with backwards selection, King and others found more intensive health management programs for beef calves (VAC 34 and VAC 45) received the greatest premiums. Premiums for calves that qualified for VAC 45 ranged from $2.47/cwt in 1995 to $7.91/cwt in 2004. Lots that qualified for VAC 34 received premiums ranging from $0.99/cwt in 1996 to $3.47/cwt in 2004. Other factors that significantly influenced price at least one year during the study included auction date, sex of lot, base weight (linear and quadratic), lot size (linear and quadratic), difference of days between sale and delivery, region of origin, breed description, presences of horns, uniformity of weight, flesh score, frame score, and age and source verified lots. Seeger et al. (2011) performed a similar study to King et al. (2006) but analyzed the effects of management, marketing and certified health programs on the sale price of beef calves sold

through a livestock video auction service from 1995 through 2009. Seeger and others found similar results as King and others including a difference in sex of lot and breed descriptions. These studies did not, however, analyze whether lot breed description within a gender affected lot sale price.

When analyzing factors influencing the sale price of lots of beef calves, calf gender of the lot is not always considered. Lots of heifer calves commonly sell for a lower price than lots of steer calves (Zimmerman, 2010). Lots of heifers purchased for eventual harvest have more risk associated with management of unwanted pregnancies (Jim et al., 1991). Heifers also are less efficient in converting feed to weight gain and typically produce carcasses with poorer yield grades (Sewell, 1993). Lots of steer calves will eventually end in harvesting those animals. Heifer calves purchased could be used for replacement females instead of for harvesting purposes, which may impact buyer preference and the characteristics that provide premiums.

The objective of this study was to quantify the effect of breed composition on the sale price of steer and heifer calves sold through Superior Livestock video auctions in all sales in 2010 through 2016 while adjusting for all other independent factors that significantly affect sale price.

Material and Methods

Data Collection

Information describing factors that could potentially affect the sale price of lots of beef calves that were marketed through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) was obtained from the auction service in an electronic format. These data were collected for all lots of beef calves that were offered for sale from 2010 through 2016.

Descriptive information available for each lot of calves were date of the video auction, number of calves, sex of the calves (steers, heifers, or both steers and heifers), the base weight,

whether the calves had been weaned before shipment by the current owner, geographical region of the United States where the lot originated, breed description of the calves, frame score of the calves, flesh score of the calves, the vaccination history, a subjective classification indicating the amount of the base weight variation within the lot, whether the calves had horns, whether the calves had been implanted with a growth-promoting implant, whether heifers were Bang's vaccinated, whether the calves were tested bovine viral diarrhea persistently infected free, whether the lot qualified for a United States Department of Agriculture approved Age and Source Verification program, the number of days between the date of the auction and the forecasted delivery date, whether the lot qualified for one or more of the video auction service's special programs: Value Added Calf, Certified Natural, Certified Natural Plus, Non-Hormone Treated Cattle, Superior Progressive Genetics, Verified Natural Beef or Never Ever 3, Certified Natural Plus, Global Animal Partnership, Superior RightSlide, Reputation Feeder Cattle, or Top Dollar Angus, and the sale price of the lot ($/cwt).

The United States was divided into five regions for categorization of region of origin of the lot. The five regions include: West Coast (AK, CA, HI, ID, NV, OR, UT, and WA), Rocky Mountain/North Central (CO, IA, IL, IN, MI, MN, MT, ND, NE, SD, WI, and WY), South Central (AZ, KS, MO, NM, OK, and TX), Northeast (CT, DE, MA, MD, ME, NH, NJ, NY, OH, PA, RI, VT, and WV), and South East (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, and VA). The Northeast region was excluded from the analysis because few lots originated from the region.

Breed description of the lot of calves was 1 of 20 factors included in the original model and each lot was categorized into one of five breed description groups: English and English-crossed with no Brahman influence, English and Continental-crossed with no Brahman influence, Black Angus sired out of dams with no Brahman influence, Red Angus sired out of dams with no

Brahman influence, Charolais sired calves out of dams with no Brahman influence, and Brahman influenced calves.

Statistical Analysis

Analyses were performed within gender and a lot of beef calves was the unit of study. The fixed effects included in the original models were 1) year of sale, 2) whether the lot was a mixed-gender or single-sex lot, 3) geographical location of lot origin, 4) breed description, 5) health protocol, 6) base weight variation within the lot, 7) frame score, 8) flesh score, 9) presence of horns, 10) Certified Natural program nested within implant status, 11) Non-Hormone Treated Cattle program nested within implant status, 12) age and source verified, 13) whether the lot qualified for Superior Progressive Genetics program, 14) size of the lot (linear term), 15) size of the lot (quadratic term), 16) base weight (linear term), 17) base weight (quadratic term), 18) whether the lot qualified for Bovine Viral Diarrhea-Persistently Infected Free program, 19) number of the days between auction and planned delivery, and 20) implant status. Verified Natural Beef was not included in the original model because it was almost totally confounded with Non-Hormone Treated Cattle.

A multiple-regression model was developed for each year using a backwards selection procedure to quantify the effects of factors on the sale price of beef calves (King et al., 2006). At each step of the backwards selection procedure, the variable with the largest nonsignificant *P*-value was eliminated from the model. A value of $P<0.05$ was required for a fixed effect to remain in the model. To prevent multicollinearity between the linear and quadratic terms of base weight for each lot every year was centered at zero by subtracting the mean base weight of each lot. A

similar procedure was used to prevent multicollinearity between the linear and quadratic terms for the number of calves in each lot each year (King et al., 2006).

Results and Discussion

Steer Calves

Data analyzed were collected from 164 livestock video auctions from 2010 to 2016. There were 29,103 lots of steer calves included in the analysis. Of the 20 fixed effects, 16 were significant and included in the final model. Days between sale date and predicted delivery date (P=0.78), implant status (P=0.40), qualification for Bovine Viral Diarrhea-Persistently Infected Free program (P=0.37) and the presence of horns (P=0.34) did not affect the sale price of steer calves.

The fixed effects included in the final model for lots of steer calves were 1) year of sale, 2) whether the lot was a mixed-gender or single-gender lot, 3) geographical origin of lot, 4) breed description, 5) health protocol, 6) base weight variation within the lot, 7) frame score, 8) flesh score, 9) Certified Natural program nested within implant status, 10) Non-Hormone Treated Cattle program nested within implant status, 11) age and source verified, 12) whether the lot qualified for Superior Progressive Genetics program, 13) size of the lot (linear terms), 14) size of the lot (quadratic terms), 15) base weight (linear terms), 16) base weight (quadratic terms).

Lots of steers analyzed averaged a base weight of 581 pounds. The number of steers in a lot averaged 106 head. On average, lots of steers sold for $176.91/cwt from 2010 through 2016 via video auction (Table 2.1).

Table 2.1 - Non-adjusted means, medians, and ranges for factors describing the lots of steer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Mean ± SD	Median	Range
Number of calves in the lot	105.4 ± 75.8	85	5 to 1,450
Base weight of the lot (lb)	581.3 ± 85.3	575	225 to 950
Number of days from auction to forecasted delivery	66.5 ± 47.5	67	0 to 293
Price per 100 pounds ($)	176.91 ± 50.95	161.00	85.85 to 422.00

Charolais-sired and Red Angus-sired steer calves brought the greatest sale prices ($P<0.05$) as compared to steers in all other breed categories at $179.09/cwt and $177.86/cwt, respectively (Table 2.2). Black Angus-sired lots of steer calves sold for a similar price as Red Angus-sired lots of steers ($P=0.29$; $177.23/cwt). English and English-crossed and English and Continental-crossed steer calves had similar sale prices but were greater ($P<0.05$) than Brahman influenced steer calves at $175.54/cwt and $175.36/cwt, respectively. Brahman influenced steer calves brought the lowest sale price ($P<0.05$; $170.97/cwt) (Table 2.2).

Ultimately, lots of steer calves in this analysis are most likely being purchased to enter a feedlot and then harvested. The lot characteristics buyers value in lots of steer calves are those contributing to increased economic efficiency in the feedlot such as average daily gain, and feed efficiency. Evaluation of the breed description of a lot showed lots of steer calves sired by Charolais bulls were valued most by buyers followed by Red Angus and Black Angus-sired lots.

Table 2.2 – Effect of breed description of lot on the sale price of steer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Breed description of the lot				<0.0001
English and English-crossed	2,668	175.54[a]	4.57	
English and Continental-crossed	7,180	175.36[a]	4.39	
Black Angus sired[e]	10,019	177.23[b]	6.26	
Red Angus sired[f]	1,296	177.86[bc]	6.89	
Charolais sired[g]	490	179.09[c]	8.12	
Brahman influenced	7,450	170.97[d]	0.00	

The model was adjusted for the random effect of auction date nested within auction year.
[a,b,c,d]Values within a factor without a common superscript differ (P < 0.05).
[e]Lots of calves in this breed group were sired by Black Angus bulls and out of dams with no Brahman influence.
[f]Lots of calves in this breed group were sired by Red Angus bulls and out of dams with no Brahman influence.
[g]Lots of calves in this breed group were sired by Charolais bulls and out of dams with no Brahman influence.

Heifer Calves

Data analyzed were collected from 164 livestock video auctions from 2010 to 2016. There were 18,955 lots of heifer calves included in the analysis. Of the 20 fixed effects, 18 were significant and included in the final model. The number of days between auction and delivery date (P=0.63) and the presence of horns (P=0.56) did not influence sale price of heifer calves sold through video auction from 2010 through 2016.

The fixed effects included in the final model for lots of heifer calves were 1) year of sale, 2) whether the lot was a mixed-gender or single-sex lot, 3) geographical location of lot origin, 4) breed description, 5) health protocol, 6) base weight variation within the lot, 7) frame score, 8) flesh score, 9) Certified Natural program nested within implant status, 10) Non-Hormone Treated Cattle program nested within implant status, 11) age and source verified, 12) whether the lot qualified for Superior Progressive Genetics program, 13) size of the lot (linear terms), 14) size of the lot (quadratic terms), 15) base weight (linear terms), 16) base weight(quadratic terms), 17) whether the lot qualified for Bovine Viral Diarrhea-Persistently Infected Free program, and 18) the implant status.

The lots of heifers used in this analysis averaged a base weight of 547 pounds. The average number of heifer calves in a lot was 90 head. An overall average sale price for a lot of heifers selling through Superior Livestock video auction from 2010 through 2016 was $163.86/cwt (Table 2.3).

Table 2.3 - Non-adjusted means, medians, and ranges for factors describing the lots of beef heifer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Mean ± SD	Median	Range
Number of calves in the lot	89.6 ± 62.0	83	4 to 1,040
Base weight of the lot (lb)	547.4 ± 77.6	545	220 to 850
Number of days from auction to forecasted delivery	64.2 ± 48.5	63	0 to 293
Price per 100 pounds ($)	163.86 ± 48.34	150.00	82.00 to 402.00

Red Angus-sired heifer calves had the greatest sale price ($P<0.05$) at $173.88/cwt compared to heifers in all other breed descriptions (Table 2.4). Lots of Charolais and Black Angus-sired heifer calves sold for less than Red Angus-sired heifer lots but did not differ from each other in sale price ($P<0.05$; $168.74 and $167.66/cwt, respectively). English and English-crossed and English and Continental-crossed heifer calves had similar sale prices but that were greater ($P<0.05$) than Brahman influenced heifer calves at $165.79/cwt and $165.58/cwt, respectively. Brahman influenced heifer calves had the lowest sale price ($P<0.05$, $162.78/cwt); (Table 2.4).

Table 2.4 – Effect of breed description of lot on the sale price of heifer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Breed description of the lot				<0.0001
English and English-crossed	1,581	165.79[a]	3.01	
English and Continental -crossed	4,732	165.58[a]	2.80	
Black Angus sired[e]	5,962	167.66[b]	4.88	
Red Angus sired[f]	716	173.88[c]	11.10	
Charolais sired[g]	457	168.74[b]	5.96	
Brahman influenced	5,507	162.78[d]	0.00	

The model was adjusted for the random effect of auction date nested within auction year.
[a,b,c,d]Values within a factor without a common superscript differ ($P < 0.05$).
[e]Lots of calves in this breed group were sired by Black Angus bulls and out of dams with no Brahman influence.
[f]Lots of calves in this breed group were sired by Red Angus bulls and out of dams with no Brahman influence.
[g]Lots of calves in this breed group were sired by Charolais bulls and out of dams with no Brahman influence.

King et al. (2006) reported a shift in the breed description of lots of calves for which buyers paid premiums. Lots of steer and heifer calves were not analyzed separately but they did report heifer calf lots sold for less ($P<0.05$) than lots of steer calves. Until 2000, English and Continental crossbred calves sold for the highest sale price. In 2000, English and English crossbred calves surpassed Continental influenced lots in sale price (King et al., 2006). While the results from this analysis are separated by sex of the lot, in steer calf lots, the highest sale price was from a Continental sire breed. Red Angus-sired lots of heifer calves were valued most by the buyers in this analysis. While the intent for the purchase of lots of heifer calves may not be as clear as steers because they could be purchased for breeding purposes or to enter the feedlot eventually, buyers may shift their buying preferences. A factor influencing sale price of lots of heifer calves that did not influence lots of steer calves was qualifying for the bovine-viral diarrhea persistently infected free program. While calves that are persistently infected are not desired at any stage of production, buyers purchasing lots of heifers to use as replacement females in the breeding herd may value tested free lots to ensure no females will be the source of infection for a herd.

The results in this analysis are representative and applicable of relatively large (300+ head of cows) cow-calf operations in the United States. The average lot size of steers and heifers was 106 and 90 head, respectively. The average beef cow-calf operation in the United States has 40 cows (USDA, ERS, 2017), which would not produce enough calves to sell a semi-load size lot from a single operation. Lots of calves sold through Superior Livestock's video auction are directly transported to the destination set by the buyer. If producers market the calves in a semi-load lot size group, the transportation cost per head decreases for the buyer.

There are numerous differences between a larger cow-calf operation and a small scale (less than 100 beef cows as defined by a USDA survey (USDA, APHIS, 2011)), specifically with management and marketing of beef calves. The USDA subset of the survey included biosecurity, health, management, and marketing practices for small scale beef producers (less than 100 head of beef cows) (USDA, APHIS, 2011). The marketing portion of the survey results for small scale beef producers showed those producers were less likely to target their production practices to meet requirements for specific breed influenced programs or enroll their calves in age and source verification programs (USDA, APHIS, 2011). This could be influenced by the increased costs associated with various programs divided across a smaller number of animals and buyers may be more likely to add premiums to uniform, single source, semi-truck load size lots. The results in this study are also representing a nationwide market price. There were lots of calves sold from all regions of the United States, though the Northeast region was not included in this analysis due to few number of lots. The sale prices should not be directly compared to local markets within a region due to the difference in the marketing venue and the ability to overcome local climate and market challenges.

References

Drovers Guest Editor. 2014. Survey Details Angus Influence. AgWeb. Farm Journal. Accessed 01 October 2017. https://www.agweb.com/mobile/article/survey_details_angus_influence _naa_beef_today_guest_editor/

Eastwood, L.C., C.A. Boykin, M.K. Harris, A.N. Arnold, D.S. Hale, C.R. Kerth, D.B. Griffin, J.W. Savell, K.E. Belk, D.R. Woerner, J.D. Hasty, R.J. Delmore, J.N. Martin, T.E. Lawrence, T.J. McEvers, D.L. VanOberbeke, G.G. Mafi, M.M. Pfeiffer, T.B. Schmidt, R.J. Maddock, D.D. Johnson, C.C. Carr, J.M. Scheffler, T.D. Pringle, and A.M. Stelzleni. 2017. National Beef Quality Audit-2016: Transportation, mobility, and harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and by-products. Translation Animal Science. 1:229-238.

Jim, G.K., C.S. Ribble, P.T. Guichon, and B.E. Thoralkson. 1991. The relative economics of feeding open, aborted, and pregnant feedlot heifers. Canadian Veterinary Journal. 32:613-617.

King, M.E., M.D. Salman, T.E. Wittum, K.G. Odde, J.T. Seeger, D.M. Grotelueschen, G.M. Rogers, and G.A. Quakenbush. 2006. Effect of certified health programs in the sale price of beef calves marketed through a livestock video auction service from 1995 through 2005. JAVMA 229:1389-1400.

Seeger, J.T., M.E. King, D.M. Grotelueschen, G.M. Rogers, and G.S. Stokka. 2011. Effect of management, marketing, and certified health programs on the sale price of beef calves sold through a livestock video auction service from 1995 through 2009. JAVMA 239:451-466.

Sewell, H.B. 1993. Heifers versus steers in feedlot. University of Missouri-Columbia, Department of Animal Sciences. Agricultural publication G02082. http://cattle.rfitz.com/heifersvssteers.txt

Vanek, J.K., M.J. Watts, and G.W. Brester. 2008. Carcass quality and genetic selection in the beef industry. Journal of Agricultural and Resource Economics. 33(3): 349-363.

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 2009. Beef 2007-08. Part II: Reference of beef cow-calf management practices in the United States, 2007-08. USDA-APHIS-VS, CEAH. Fort Collins, CO.

United States Department of Agriculture, Agriculture Marketing Service (USDA, AMS). 2017. Certified beef programs. Agricultural Marketing Service, United States Department of Agriculture, Washington, DC. Accessed 09 August 2017. https://www.ams.usda.gov/services/auditing/certified-beef-programs

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 2011. Small-scale U.S. cow-calf operations. USDA-APHIS-VS, CEAH. Fort Collins, CO. 564.0411.

United States Department of Agriculture, Economic Research Service (USDA, ERS). 2017. Cattle and Beef: Background. Accessed 01 July 2017. https://www.ers.usda.gov/topics/animal-products/cattle-beef/background/

Zimmerman, L.C., T.C. Schroeder, K.C. Dhuyvetter, K.C. Olson, G.L. Stokka, J.T. Segger, and D.M. Grotelueschen. 2012. The effect of value-added management on calf prices at Superior Livestock Auction video markets. J. Agricultural and Resource Economics. 37(1):128-143.

Chapter 3 - Breed trends in beef calf lots marketed through video auctions from 1995 through 2016

Abstract

The objective was to characterize the potential change in the percentage of lots of beef calves with Brahman influence among calves originating from various regions of the United States marketed through summer video auctions from 1995 through 2016. Data were available on 84,869 lots (10,199,814 total calves) of beef calves marketed through 177 summer video auctions. Breed composition of lots of beef calves were categorized as 1) English and English-crossed, 2) English and Continental-crossed, or 3) Brahman influenced. United States regions included: West Coast (CA, ID, NV, OR, UT, and WA), Rocky Mountain/North Central (CO, IA, IL, IN, MI, MN, MT, ND, NE, SD, WI, and WY), South Central (AZ, KS, MO, NM, and OK), Texas (TX), Coastal (AL, FL, GA, LA, MS, and SC), Subcoastal (AR, KY, NC, TN, VA, and WV), and Northeast (CT, DE, MA, MD, ME, NH, NJ, NY, OH, PA, RI, and VT). The Northeast region was excluded from this study due to few lots representing this region. The Cochran-Armitage trend test was used to determine the presence of an increasing or decreasing trend in the percentage of lots with Brahman influence over time with a P-value ≤ 0.05 considered significant. There was a decrease ($P<0.0001$) in percentage of lots of beef calves with Brahman influence in the United States during the 22 years analyzed with the percentage of Brahman influenced lots ranging from 12 to 29%. The percentage of lots of beef calves marketed in the United States characterized as English and Continental-crossed also decreased ($P<0.0001$) from 1995 through 2016. There was an increase ($P<0.0001$) in the percentage of lots of English and English-crossed beef calves with no Brahman influence. Percentage of lots with Brahman influence decreased ($P<0.0001$) in four regions: West

Coast, Rocky Mountain/North Central, South Central, and Texas. There was no change (P=0.72) in percentage of lots with Brahman influence originating from the Coastal region which had a range of 89 to 98% of lots with Brahman influence. In the Subcoastal region, the percentage of lots with Brahman influence increased (P=0.03). Of the 84,869 lots marketed via summer video auctions from 1995 through 2016, 73,445 lots sold. Of the sold lots, Brahman influenced lots had average price discounts of $4.30/cwt and $3.13/cwt when compared with English and English-crossed and English and Continental-crossed lots, respectively. Over the 22 years analyzed, the smallest discount of Brahman influenced lots compared with English and English-crossed lots was in 1996 at $1.93/cwt and $1.45/cwt in 1997 when compared with English and Continental-crossed lots. The greatest price discounts of Brahman influenced lots were in 2014 at $7.01/cwt and $5.11/cwt compared with English and English-crossed and English and Continental-crossed lots, respectively. The percentage of lots of beef calves with Brahman influence marketed via summer video auctions appears to be decreasing in the United States as a whole while either remaining unchanged or increasing specifically in the Coastal and Subcoastal regions where Brahman influenced calves are adapted to the warmer, more humid climates.

Introduction

The cow herd in the United States develops as producers make decisions to produce a product of value to their customers. The decisions are also based on the available feed resources and the production environment (Hardin et al., 2013). Production environment includes not only the available forage and local climate but other factors such as disease exposure and intensity of management practices (Hammack, 2009). While some segments of cattle production, such as feedlots, are primarily localized to one region in the United States, beef cow-calf producers are spread throughout the entire country (Figure 1.3). The cow herd in the United States has evolved over time to produce a product that optimizes operational goals while maximizing profitability (Hawkes et al., 2008). Production environments across the United States vary drastically. Management decisions by beef producers in the Gulf Coast vary from those in the mountainous regions due to environmental factors (Hardin et al., 2013). One decision beef producers consider when selecting breeds to utilize to be efficient and profitable is genetic-environmental interaction (Hammack, 2009).

Cow herds located in sub-tropical climates, such as the Gulf Coast are likely to utilize breeds adaptable to the climate. An estimated 40% of all beef cows in the United States are in the southern region, which has a relatively hot climate (Cundiff et al., 2012; Spangler, 2012). Brahman cattle are widely known for their ability to tolerate hot and humid climates as well as for their insect and parasite resistance (Hawkes et al., 2008; Cundiff et al., 2012; Spangler, 2012).

The opportunity to evaluate potential changes in the influence of the Brahman breed on beef calves produced in the United States was available through lots of beef calves marketed through a video auction service. The primary objective was to characterize the potential change in the percentage of lots of beef calves with Brahman influence among calves originating from

various regions of the United States marketed through summer video auctions from 1995 through 2016. As a potential explanation for the changes in the influence of the Brahman breed in the United States as well as within the regions, the trends of English and English-crossed and English and Continental-crossed lots were also evaluated for the same time period. In addition, the price differences among the three breed descriptions were included as a possible explanation for changes in breed composition.

Material and Methods

Data Collection

1995 – 2016: General Breed Descriptions

Information describing factors about lots marketed through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) was obtained from the auction service in an electronic format. These data were collected for lots of beef calves offered for sale during summer sales from 1995 through 2016.

The database has evolved since 1995 with changes in the industry, which provides opportunity to analyze additional information. In all years of the database, the six to eight largest sales were recorded, which were in the summer months, typically from May to October. For consistent sale comparison from 1995 through 2016, summer video sales were used in the analysis. Because mixed-gender lots were not included in the database until 2010 and cannot be compared across all 22 years, no lots of mixed-gender were included in the analysis. Since the start of the Superior Livestock Auction database in 1995, breed descriptions of lots of beef calves have been characterized as: 1) Brahman influenced, 2) English and Continental-crossed, or 3) English and English-crossed. Percentage of lots marketed for each of the three breed description categories

were analyzed for the entire United States for a national trend. To assess potential regional trends, the United States was divided into seven regions.

Figure 3.1 illustrates the regions used in the analysis. The West Coast included the states of Alaska, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington. The Rocky Mountain/North Central region included Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming. The South Central region included the states of Arizona, Kansas, Missouri, New Mexico, and Oklahoma. Texas was a separate region due to the large number of lots originating from the state. Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina comprised the Coastal region. The Subcoastal region included the states of Arkansas, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia. Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont were in the Northeast region. The Northeast region was excluded from the study due to the few number of calf lots marketed originating from this region.

1999 – 2016: Detailed English Breed Type

As the beef industry evolved, additional information was included in the description of a lot of beef calves. With more information available, more variables were described in the database, which allowed for additional information to be analyzed. In 1999, breed descriptions of lots of beef calves were characterized in more defined categories. However, not all breed descriptions have a sufficient number of lots to analyze. Lots of beef calves were characterized as either 1) black/black white face (at least 90% black), 2) primarily Angus (at least 90% Angus) sired by Angus bulls, and 3) primarily Red Angus sired by Red Angus bulls are included in this analysis.

These lots included in this section of analysis were sold from 1999 through 2016 via summer video auction.

Black/black white face (at least 90% of calves are black hided) lots are comprised of lots described as black hided calves that we may or may not know the breed composition of but the beef calves in the lot are at least 90% black hided and have no Brahman influence. Beef calf lots in this category are lots that would be grouped in the English and English-crossed group in the 22-year analysis portion of the study. Lots in this class can be described as out of Angus and a few Angus cross cows by Black Angus bulls, 100% black hided to lots only described as black and black white face, 90% black. Lots of beef calves categorized in this group are not described as having heavy Continental influence, even if the 90% of the calves in the lot are black hided. For example, if a lot is described as out of English-Continental cross cows by black Limousin bulls, 90% black, the lot would be categorized as English and Continental-crossed calves.

Primarily Angus (at least 90% Angus) sired by Angus bulls lots are described as calves from Angus cows by Angus bulls with no Brahman influence. Lots in this description also could be described from Angus and very few Angus cross cows and sired by Angus bulls. Not all Angus sired calves are included in this category; the dam must also be described as Angus based. Thus, the calves described in this group are at least 90% Angus.

Primarily Red Angus described lots are calves described as from Red Angus cows and Red Angus cross cows and sired by Red Angus bulls. In this description, the dams and sires of a lot of beef calves must be primarily Red Angus with no Brahman influence.

2010 – 2016: Single Sire Breeds

Beginning in 2010, specific breeds used as sires of lots of beef calves were recorded in the database. There are numerous breeds recorded as sires in the database, however, not all the sire breed descriptions have a sufficient number of lots to analyze. The sire breed of a lot was determined based on lot description information provided by the seller and sales representative. For a lot of beef calves to be included in a sire breed category, all calves in a lot must have been sired by a single breed. Lots of calves sired by multiple breeds were categorized in a separate group from single breed sires and are not included in this analysis. A minimum of 50 lots of calves were required for a single sire breed to be included in this analysis. The single sire breed categories included in this analysis were Angus, Brangus, Charolais, Hereford, Red Angus, and SimAngus. Lots included in the sire breed portion of the analysis were offered for sale from 2010 through 2017.

Statistical Analysis

The Cochran-Armitage trend test was used to determine the presence of an increasing or decreasing trend in percentage of lot of beef calves categorized in a specific breed or sire breed description with $P \leq 0.05$ considered significant. The Cochran-Armitage is a test for trend in binomial proportions for levels of a single variable and the null hypothesis is no trend. Presence of potential trends were assessed nationally as well as within the six regions for Brahman influenced, English and Continental-crossed, and English and English-crossed lots of beef calves. Only a potential national trend from 1999 through 2016 was assessed for lots of beef calves characterized as black/black white face (at least 90% black), primarily Angus (at least 90% Angus) sired by Angus bulls, and primarily Red Angus sired by Red Angus bulls. Likewise, presence of a

potential national trend in from 2010 through 2017 for the specific single sire breed categories of Angus, Charolais, Red Angus, and SimAngus was determined.

Results and Discussion

National Trend in United States

1995 – 2016: General Breed Descriptions

Data analyzed for the trends of Brahman influenced, English and Continental-crossed and English and English-crossed lots were collected from 177 summer livestock video auctions from 1995 through 2016. There were 84,869 lots (10,199,814 total calves) used in the analyses. There was a decrease ($P<0.0001$) in percentage of Brahman influenced lots in the United States during the 22 years (Figure 3.2) The percentage of lots of beef calves marketed in the United States characterized as English and Continental-crossed with no Brahman influence also significantly decreased ($P<0.0001$) from 1995 through 2016. There was an increase ($P<0.0001$) in the percentage of lots of English and English-crossed beef calves with no Brahman influence.

The decrease in percentage of lots of beef calves with Brahman influence marketed via video auction in the United States could be a result of several factors. A potential explanation for the change in breeds utilized in the United States is price differences between lots characterized as Brahman influenced, English and English-crossed beef calves with no Brahman influence, and English and Continental-crossed with no Brahman influence. Of the 84,869 lots of beef calves marketed via video auction from 1995 through 2016, 73,445 lots sold. Price differences were evaluated with a multiple regression analysis adjusting for all factors significantly influencing price each year. Of the sold lots, Brahman influenced lots had average price discounts of $4.30/cwt and $3.13/cwt when compared with English and English-crossed and English and Continental-

crossed with no Brahman influence lots, respectively. Over the 22 years analyzed, the smallest discount for Brahman influenced lots compared with English and English-crossed lots was in 1996 at $1.93/cwt and when compared with English and Continental-crossed with no Brahman influence lots, in 1997 at $1.45/cwt. The greatest price discount for Brahman influenced lots was in 2014 at $7.01/cwt and $5.11/cwt compared with English and English-crossed and English and Continental-crossed with no Brahman influence lots, respectively (Table 3.1).

1999 – 2016: Detailed English Breed Type

The opportunity for another possible explanation of the increase in the percentage of lots nationally described as English and English-crossed was available through other breed descriptions categorized in the database.

In 1999, breed descriptions of lots of beef calves were characterized in more defined categories. The breed descriptions included in this section of the analysis are lots that previously were a part of the English and English-crossed class. While there are numerous breed descriptions characterized in the database, not all the breed descriptions have sufficient number of lots for appropriate analysis. Lots of beef calves characterized as either 1) black/black white face (at least 90% black), 2) primarily Angus (at least 90% Angus) sired by Angus bulls, and 3) primarily Red Angus sired by Red Angus bulls are included in this section of the analysis.

There was a 33% increase ($P<0.0001$) in the percentage of lots characterized as black/black white face from 1999 through 2016. In 1999, 0.5% of the lots of beef calves marketed we categorized black/black white face. The percentage increased to 34% by 2016 (Figure 3.3). There were 18,876 lots characterized as black/black white face, which accounted for 25% of the total lots marketed via the video auction service during that time.

Lots of beef calves described as primarily Angus decreased (P<0.0001) from 1999 through 2016. The peak of lots of primarily Angus beef calves was in 1999 at 14%, while the lowest percentage was in 2005 (4%). The breed description provided by the seller and sales representative for a lot of beef calves determines how the lot is categorized. For lots to be included in this class, they must be described as at least 90% Angus genetics. It is likely the breed descriptions did not always provide enough detail to be included in this group (i.e. dam was not listed as specifically Angus cows). Lots of calves that were at least 90% black hided and of known English-type origin but not specifically stated Angus were categorized as black/black white face. Primarily Angus lots accounted for 7% of the total lots marketed from 1999 through 2016.

Lots of beef calves characterized as primarily Red Angus increased (P<0.0001) 3% from 1999 to 2016 (Figure 3.3). Red Angus lots account for 2% of the total lots of beef calves marketed through the video auction service from 1999 through 2016.

The breed descriptions with sufficient number of lots are primarily English origin breeds. The lots characterized as black/black white face could be a result of other breeds than English type cattle. There was a 30% increase in the lots described as English and English-crossed with no Brahman influence from 1999 through 2016 while the percentage of English and Continental-crossed with no Brahman influence lots was decreasing (Figure 3.3).

While the exact breed composition of the lots described as black/black white face is unknown, the breeds that influenced this lot description most likely were English influenced. Wessler (2011) noted an increase in USDA Angus defined type cattle or black hided cattle over a 15-year time span. The shift in the breeds producers chose to utilize may have partially resulted from the increase of branded beef programs, with nearly 70% of the branded beef programs having preliminary requirements of either Angus influence or a predominantly black hide (Eastwood et

al., 2017; USDA-AMS, 2017). The increase in percentage of English and English-crossed lots and black/black white face described lots of beef calves marketed via video auction is likely influenced by the increase in branded beef programs.

2010 – 2016: Single Sire Breeds

As the database and the beef industry continued to evolve, the specific sire breed of a lot of beef calves was recorded in the database starting in 2010. In order for a lot of beef calves to have a single sire breed categorized, the breed description of the lot must have stated the specific breed of bull siring the lot. Lots of beef calves sired by multiple breeds were categorized separately from single sire breed lots. This allowed the opportunity to assess other potential breed trends, specifically breeds of bulls being utilized by those who marketed their calves through the video auction service. From the breed descriptions provided about each lot of beef calves, for approximately 9.5% of the lots, a sire breed class cannot be determined. There were 32,043 lots of beef calves marketed via 187 video auctions through Superior Livestock Auction from 2010 through 2017 included in the analysis (Table 3.2).

The percentage of lots of beef calves sired by Angus bulls decreased ($P<0.0001$) from 2010 through 2017. Angus-sired lots, however, comprised the greatest percentage of single-sired lots marketed, ranging from 70 to 82%. Percentage of lots of beef calves sired by Red Angus and SimAngus-sired lots of beef calves increased ($P<0.0001$) during this time. The percentage of lots of beef calves sired by Brangus and Charolais bulls also increased ($P=0.004$ and $P=0.0003$, respectively). There was no change ($P=0.43$) in percentage of lots of beef calves sired by Hereford bulls (Table 3.3).

Cow-calf producers consider numerous factors when making sire selections for their operations. Based on the production goal of the calves being produced, owners may have different considerations for sires they select. Producers raising calves with the intention of retaining heifers for breeding purposes may place more selection pressure on maternal characteristics versus a producer selling their calves at weaning who may look at growth performance traits in a sire. Of the individual breeds that sired lots of beef calves marketed through Superior Livestock video auction, Angus-sired lots are the largest single sire group. While the percent of Angus-sired lots decreased, during the same period of time, Red Angus, SimAngus, Brangus, and Charolais-sired lots increased. Producers are likely changing the genetics of their sires to use on a primarily black cow herd.

Regional Trends

The United States was divided into seven regions to evaluate potential regional breed trends in lots of beef calves marketed via summer video auction from 1995 through 2016. The breed descriptions lots included in the regional analysis are described as Brahman influenced, English and Continental-crossed, or English and English-crossed because those are the consistent breed lot descriptions recorded from 1995 through 2016. Lots from the Northeast region were excluded from the analysis due to few lots originating from the region.

The percentage of calf lots categorized as Brahman influenced and English and Continental-crossed that were marketed and originating from the West Coast, Rocky Mountain/North Central, and South Central United States regions as well as Texas all decreased ($P<0.001$) from 1995 through 2016. In these same regions, during the same time period, the percentage of lots of beef calves categorized as English and English-crossed increased ($P<0.0001$)

(Figure 3.4, Figure 3.5, Figure 3.6, Figure 3.7). These four regions comprised 94% of all the lots marketed via video auction from 1995 through 2016 (Figure 3.8). Table 3.4 lists the number of total lots from each region and the total number of head in each region.

The Coastal region comprised 5% of the lots in the analysis. The percentage of lots of beef calves characterized as Brahman influenced in the Coastal region remained unchanged (P=0.72) from 1995 through 2016. The percentage of Brahman influenced lots ranged from 89% in 2012 to 98% in 1996. On average, 95% of lots of beef calves marketed from the Coastal region were characterized as Brahman influenced. English and Continental-crossed lots decreased (P=0.08) in the Coastal region, while the percentage of English and English-crossed lots of beef calves increased (P=0.008); (Figure 3.9).

In the Subcoastal region, the percentage of lots of beef calves characterized as Brahman influenced and English and English-crossed increased (P=0.03; P<0.0001, respectively). The percentage of English and Continental-crossed lots of beef calves decreased (P=0.0001) from 1999 through 2016 (Figure 3.10). Only 1% of the total lots of beef calves marketed through the video auction service originated from the Subcoastal region from 1995 through 2016 (Figure 3.2). In this regional analysis, one lot of beef calves can have a larger impact on the trend in this region because of the few number of total lots.

The Coastal and Subcoastal regions have different environments than other regions of the United States. Producers in these regions need to utilize breeds that are efficient in the hot and humid environment. Many producers maintain a cowherd with Brahman influence because of the breed's heat tolerance and parasite resistance. While Brahman influenced lots of beef calves were discounted compared to English and Continental-crossed and English and English-crossed lots, calves from the Coastal and Subcoastal regions need the Brahman influenced to efficiently

perform. The Coastal and Subcoastal regions decreased in the percentage of lots of beef calves characterized as English and Continental-crossed while the percentage of English and English-crossed lots increased. This might be a result of producers who were not in the extreme hot and humid environments attempt to capture premiums based on breed composition for their calves compared to selling Brahman influenced lots of beef calves. Producers located in regions other than the Coastal and Subcoastal regions are likely utilizing breeds other than Brahman-influenced cattle to target specific breed-influenced programs in attempt to gain premiums associated with those programs. The first branded beef program was introduced in 1978 and since then there have been more than 130 branded beef programs developed (Speer, 2013). Black-hided, Angus-type cattle are commonly sold for a greater sale price than other hide colors, likely because of their potential performance in the feed lot as well as marketability as Angus-type cattle.

Beef production in the United States is widespread throughout the country. Producers must consider numerous factors when determining management decisions for an operation. Factors such as available resources, customer demand, and the production environment are only a few of the factors impacting profitability for a producer. The production practices for one operation may not be the optimal choice for a different producer.

Figures and Tables

Figure 3.1 - Map of regions within the United States for analysis

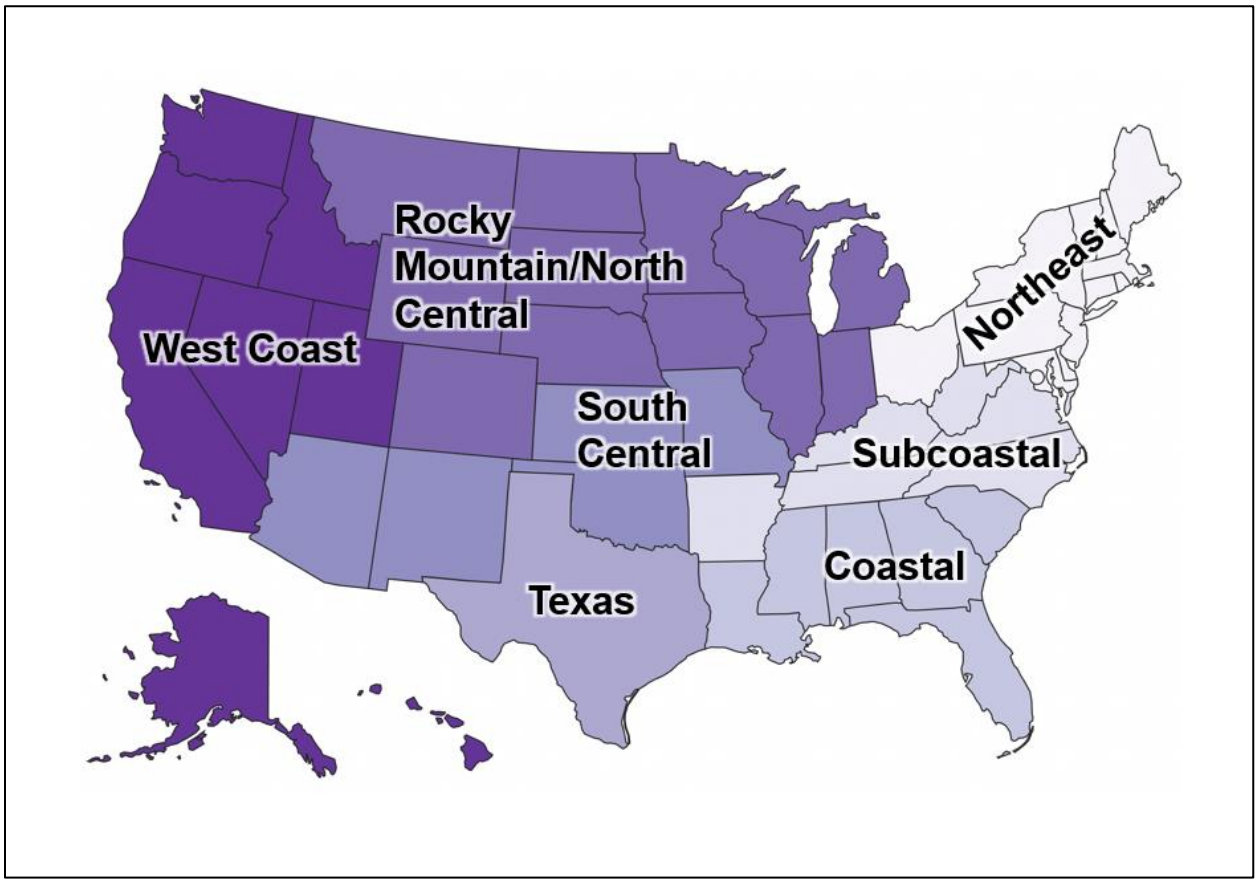
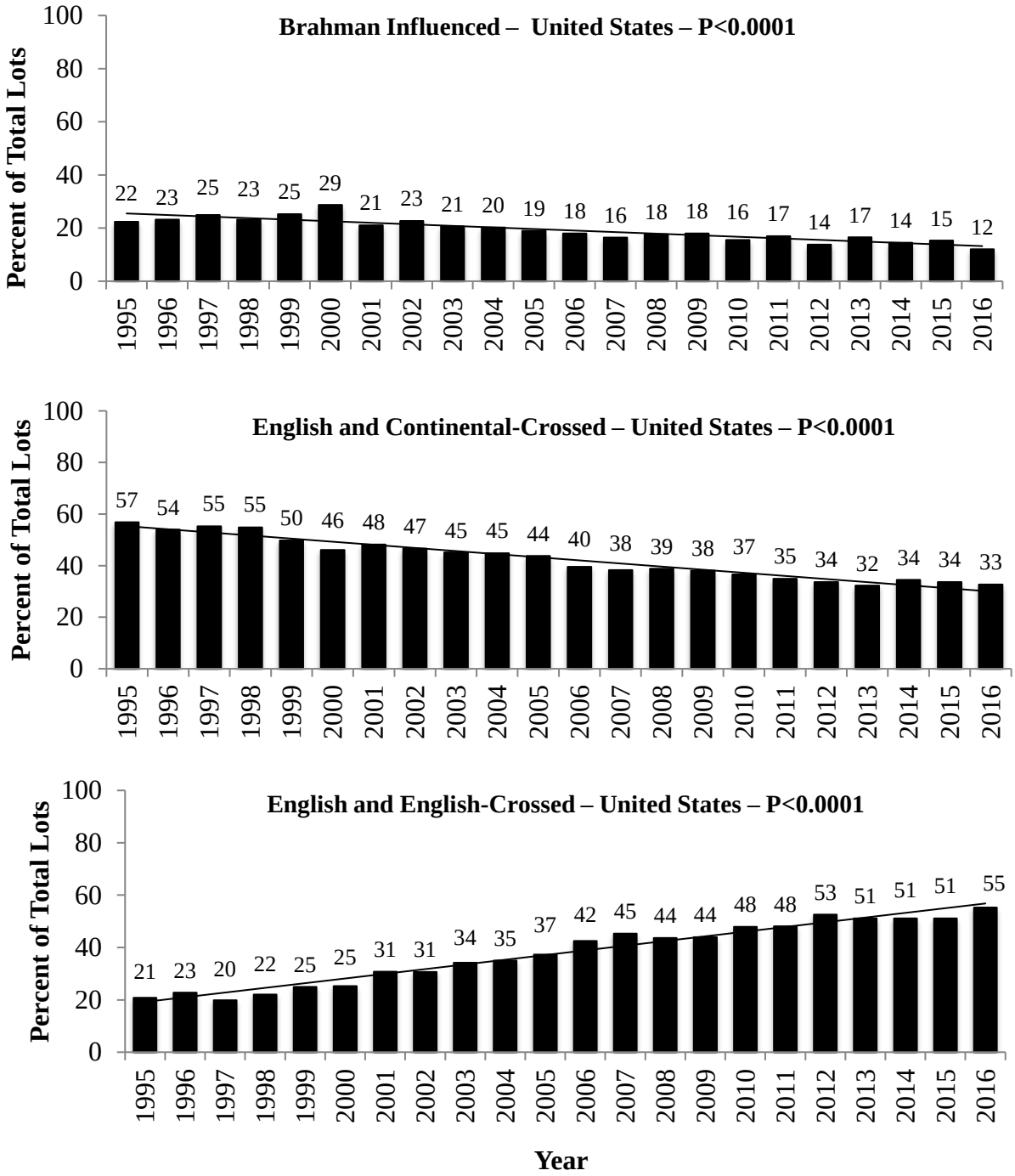


Figure 3.2 - Breed trends described in percentage of beef calf lots in the United States from 1995 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The Northeast region was excluded from the study due to the few number of calf lots marketed originating from this region. The Northeast region included the states of: Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont.

Table 3.1 - Price discounts of lots of Brahman influenced beef calves sold through 178 Superior Livestock video auctions in the summers of 1995 through 2016 compared with lots of English and English-crossed or English and Continental-crossed calves

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price discount ($/cwt)	Percentage of price discount
		1995		
Breed description of the lot				
English and English-crossed	336	66.27	-1.93	-2.91
English and Continental-crossed	918	66.00	-1.66	-2.52
Brahman influenced	322	64.34	0.00	
		1996		
Breed description of the lot				
English and English-crossed	426	60.67	-2.32	-3.82
English and Continental-crossed	1,006	60.05	-1.70	-2.83
Brahman influenced	361	58.35	0.00	
		1997		
Breed description of the lot				
English and English-crossed	360	88.70	-2.57	-2.90
English and Continental-crossed	962	87.58	-1.45	-1.66
Brahman influenced	401	86.13	0.00	
		1998		
Breed description of the lot				
English and English-crossed	435	72.44	-2.62	-3.62
English and Continental-crossed	923	71.87	-2.05	-2.85
Brahman influenced	348	69.82	0.00	
		1999		
Breed description of the lot				
English and English-crossed	601	85.30	-3.07	-3.60
English and Continental-crossed	1,200	84.22	-1.99	-2.36
Brahman influenced	479	82.23	0.00	
		2000		
Breed description of the lot				
English and English-crossed	640	97.30	-3.51	-3.61
English and Continental-crossed	1,186	95.89	-2.10	-2.19
Brahman influenced	580	93.79	0.00	
		2001		
Breed description of the lot				
English and English-crossed	819	98.48	-3.18	-3.23
English and Continental-crossed	1,210	97.68	-2.38	-2.44
Brahman influenced	385	95.30	0.00	

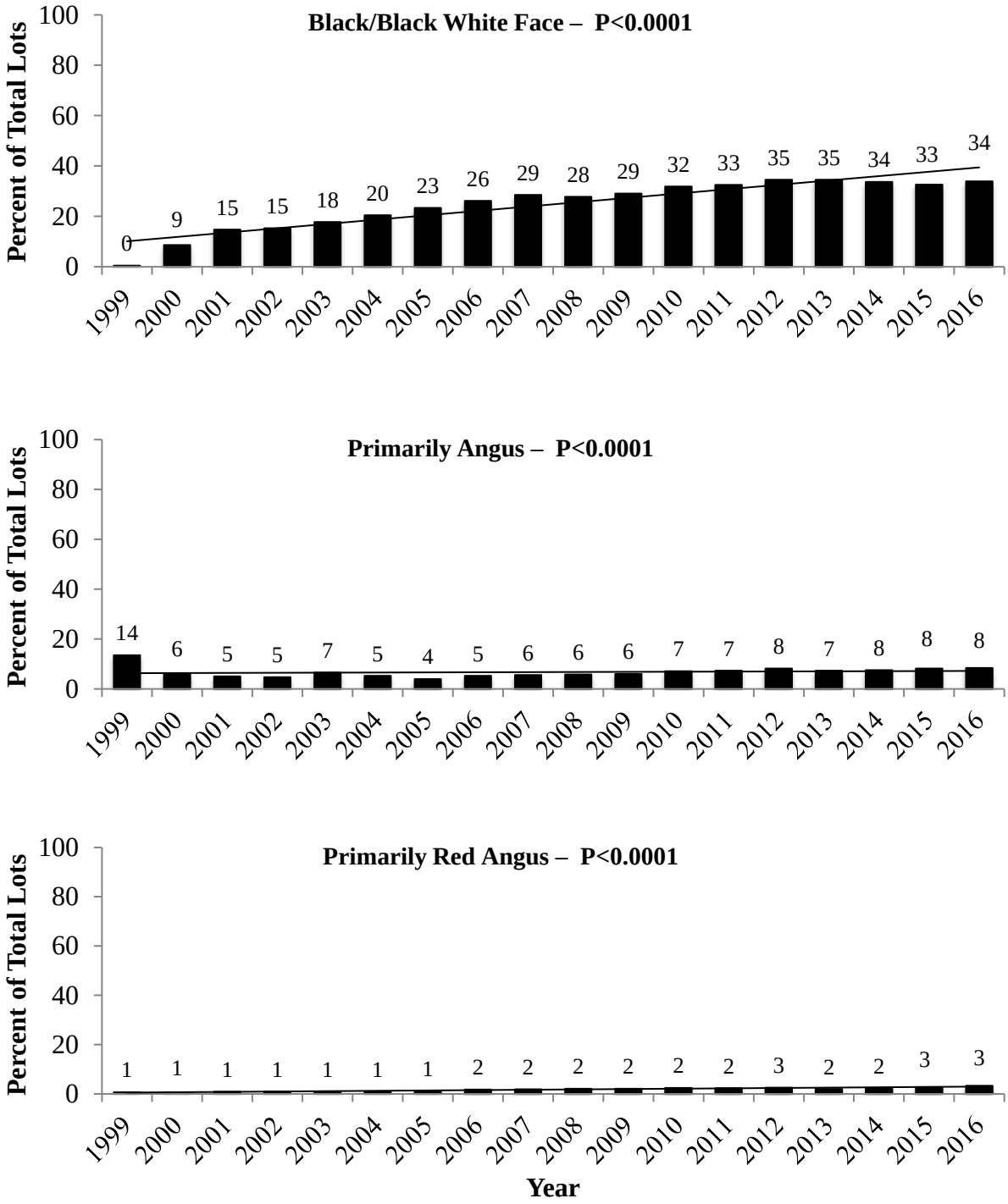
Table 3.1 Continued

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price discount ($/cwt)	Percentage of price discount
		2002		
Breed description of the lot				
English and English-crossed	868	83.51	-3.46	-4.14
English and Continental-crossed	1,121	82.23	-2.18	-2.65
Brahman influenced	450	80.05	0.00	
		2003		
Breed description of the lot				
English and English-crossed	1,197	98.36	-3.98	-4.05
English and Continental-crossed	1,467	96.93	-2.55	-2.63
Brahman influenced	486	94.38	0.00	
		2004		
Breed description of the lot				
English and English-crossed	1,348	121.21	-4.97	-4.10
English and Continental-crossed	1,552	119.76	-3.52	-2.94
Brahman influenced	531	116.24	0.00	
		2005		
Breed description of the lot				
English and English-crossed	1,498	117.98	-3.62	-3.07
English and Continental-crossed	1,566	116.91	-2.55	-2.18
Brahman influenced	520	114.36	0.00	
		2006		
Breed description of the lot				
English and English-crossed	1,521	123.02	-6.22	-5.06
English and Continental-crossed	1,368	121.45	-4.65	-3.83
Brahman influenced	628	116.80	0.00	
		2007		
Breed description of the lot				
English and English-crossed	1,874	118.30	-4.50	-3.80
English and Continental-crossed	1,558	117.07	-3.27	-2.79
Brahman influenced	659	113.80	0.00	
		2008		
Breed description of the lot				
English and English-crossed	1,763	111.36	-5.78	-5.19
English and Continental-crossed	1,365	110.00	-4.42	-4.02
Brahman influenced	613	105.58	0.00	
		2009		
Breed description of the lot				
English and English-crossed	1,844	100.38	-4.39	-4.37
English and Continental-crossed	1,381	99.24	-3.25	-3.27
Brahman influenced	581	95.99	0.00	

Table 3.1 Continued

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price discount ($/cwt)	Percentage of price discount
		2010		
Breed description of the lot				
English and English-crossed	2,533	117.39	-4.06	-3.46
English and Continental-crossed	1,937	116.37	-3.04	-2.61
Brahman influenced	835	113.33	0.00	
		2011		
Breed description of the lot				
English and English-crossed	2,296	141.69	-5.99	-4.23
English and Continental-crossed	1,519	140.69	-4.99	-3.55
Brahman influenced	820	135.70	0.00	
		2012		
Breed description of the lot				
English and English-crossed	1,978	160.26	-4.57	-2.85
English and Continental-crossed	1,285	158.72	-3.03	-1.91
Brahman influenced	560	155.69	0.00	
		2013		
Breed description of the lot				
English and English-crossed	2,247	162.80	-5.34	-3.28
English and Continental-crossed	1,441	161.50	-4.04	-2.50
Brahman influenced	1,040	157.46	0.00	
		2014		
Breed description of the lot				
English and English-crossed	2,068	246.71	-7.01	-2.84
English and Continental-crossed	1,448	244.81	-5.11	-2.09
Brahman influenced	728	239.70	0.00	
		2015		
Breed description of the lot				
English and English-crossed	2,271	239.42	-6.86	-2.87
English and Continental-crossed	1,523	237.43	-4.87	-2.05
Brahman influenced	684	232.56	0.00	
		2016		
Breed description of the lot				
English and English-crossed	2,386	142.39	-4.60	-3.23
English and Continental-crossed	1,547	141.84	-4.05	-2.86
Brahman influenced	642	137.79	0.00	

Figure 3.3 - Lots of beef calves characterized as black/black white face, primarily Angus, and primarily Red Angus from 1999 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
Lots of beef calves characterized as either 1) black/black white face (at least 90% black), 2) primarily Angus (at least 90% Angus) sired by Angus bulls, and 3) primarily Red Angus sired by Red Angus bulls.

Table 3.2 - The number of lots of beef calves described as from a single-sire breed offered for sale via 178 Superior Livestock video auctions from 2010 through 2017

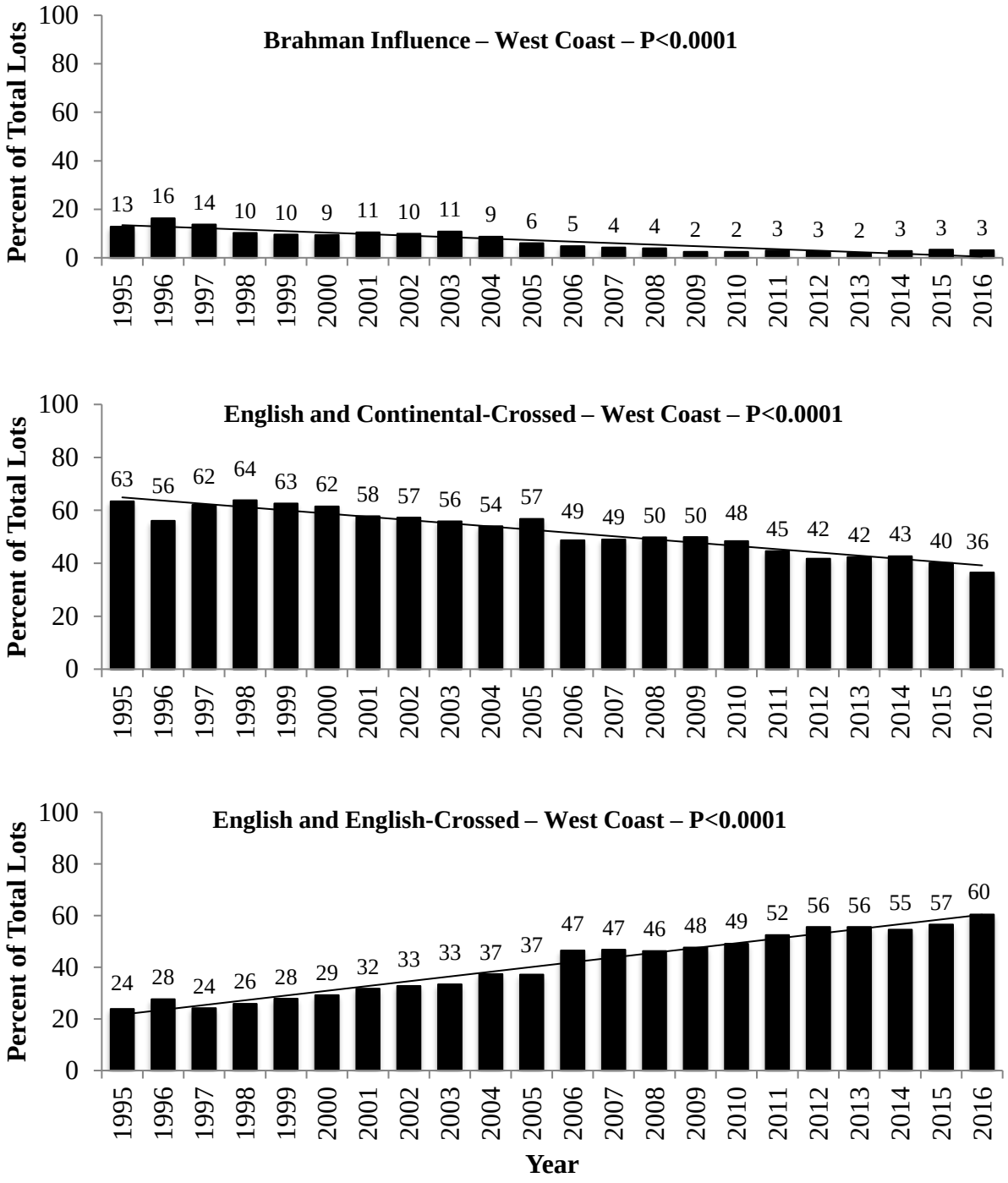
	Year							
Sire Breed	2010	2011	2012	2013	2014	2015	2016	2017
Angus	3,480	3,187	2,983	3,121	2,656	2,762	3,167	3,333
Red Angus	320	327	323	362	315	364	474	494
Charolais	294	277	273	276	252	317	375	355
Brangus	55	73	75	75	67	94	97	85
Hereford	54	58	54	58	60	55	61	61
SimAngus	30	68	63	79	75	128	201	230
Total Lots	4,233	3,990	3,771	3,971	3,425	3,720	4,375	4,558

Table 3.3 - The percentage of lots of beef calves described as from a single-sire breed offered for sale via 178 Superior Livestock video auctions from 2010 through 2017

	Year								
Sire Breed	2010	2011	2012	2013	2014	2015	2016	2017	P-value
Angus	82.2	79.9	79.1	78.6	77.6	74.2	72.4	73.1	<0.0001
Red Angus	7.6	8.2	8.6	9.1	9.2	9.8	10.8	10.8	<0.0001
Charolais	7.0	6.9	7.2	7.0	7.4	8.5	8.6	7.8	<0.0003
Brangus	1.3	1.8	2.0	1.9	2.0	2.5	2.2	1.9	=0.004
Hereford	1.3	1.4	1.4	1.5	1.8	1.5	1.4	1.3	=0.43
SimAngus	0.7	1.7	1.7	2.0	2.2	3.4	4.6	5.1	<0.0001

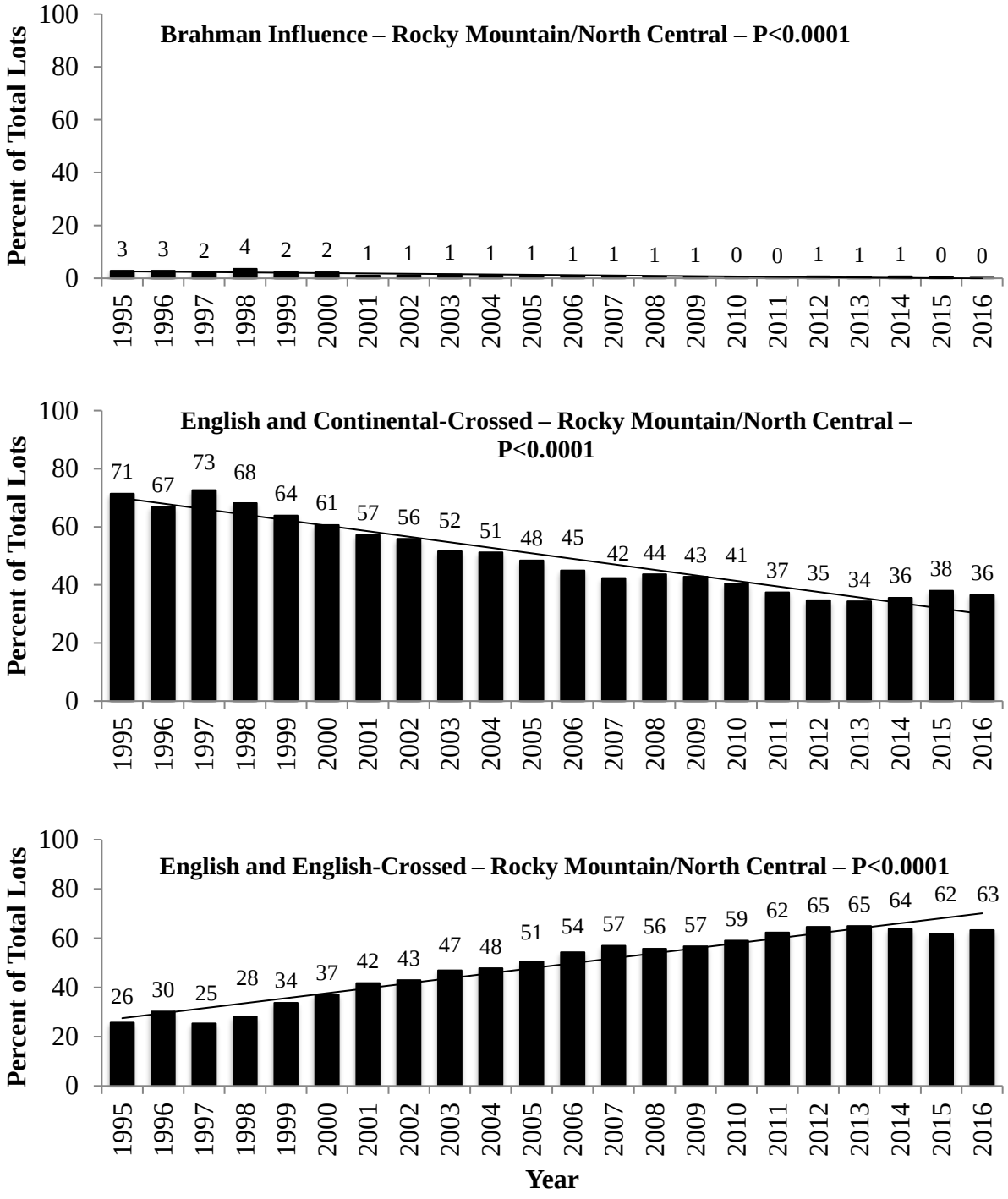
The *P* value represents an increasing or decreasing trend within each single sire breed.

Figure 3.4 - Breed trends of lots of beef calves from West Coast region from 1995 through 2016



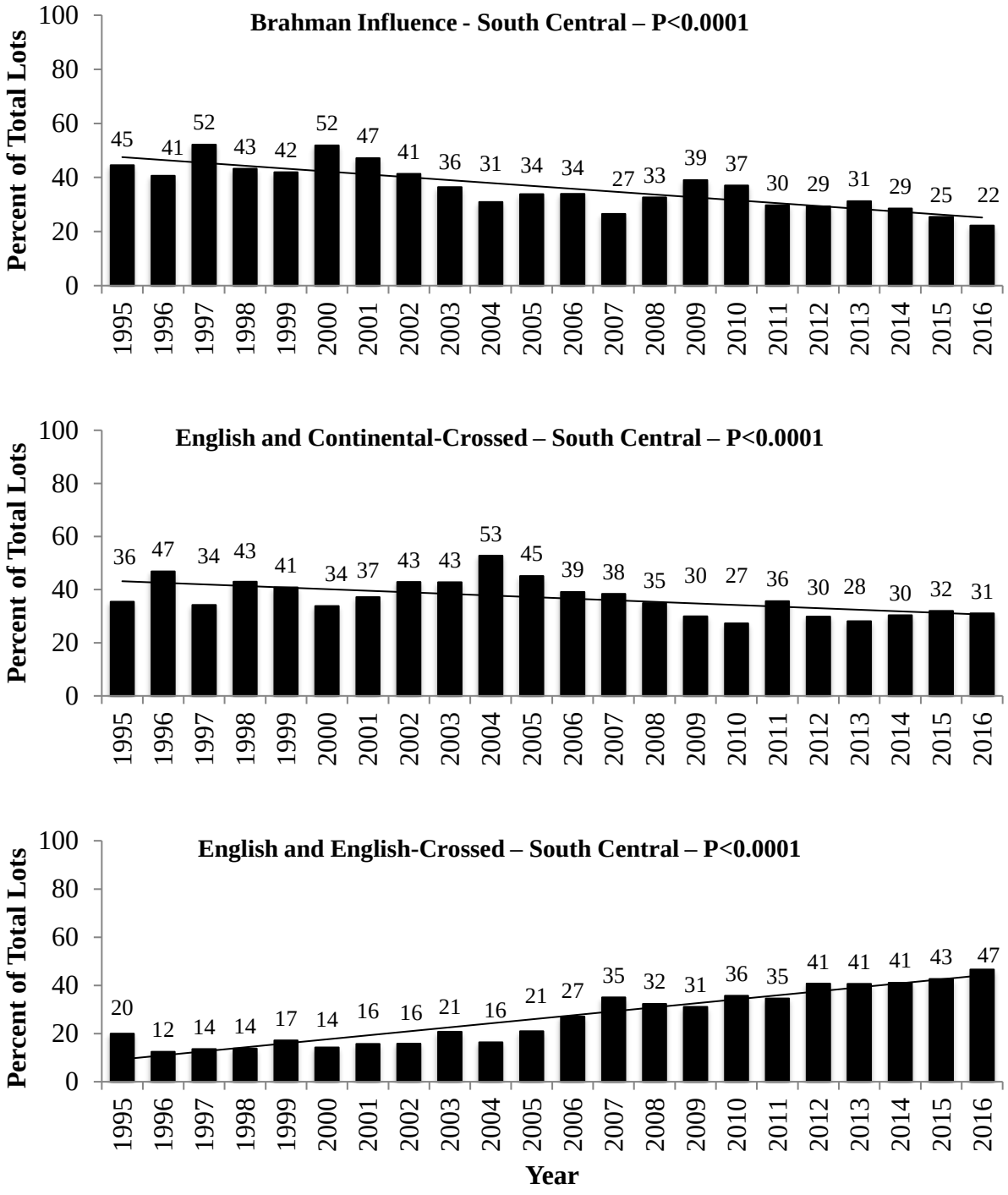
Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The West Coast region included the states of: Alaska, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington.

Figure 3.5 - Breed trends of lots of beef calves from Rocky Mountain/North Central region from 1995 through 2016



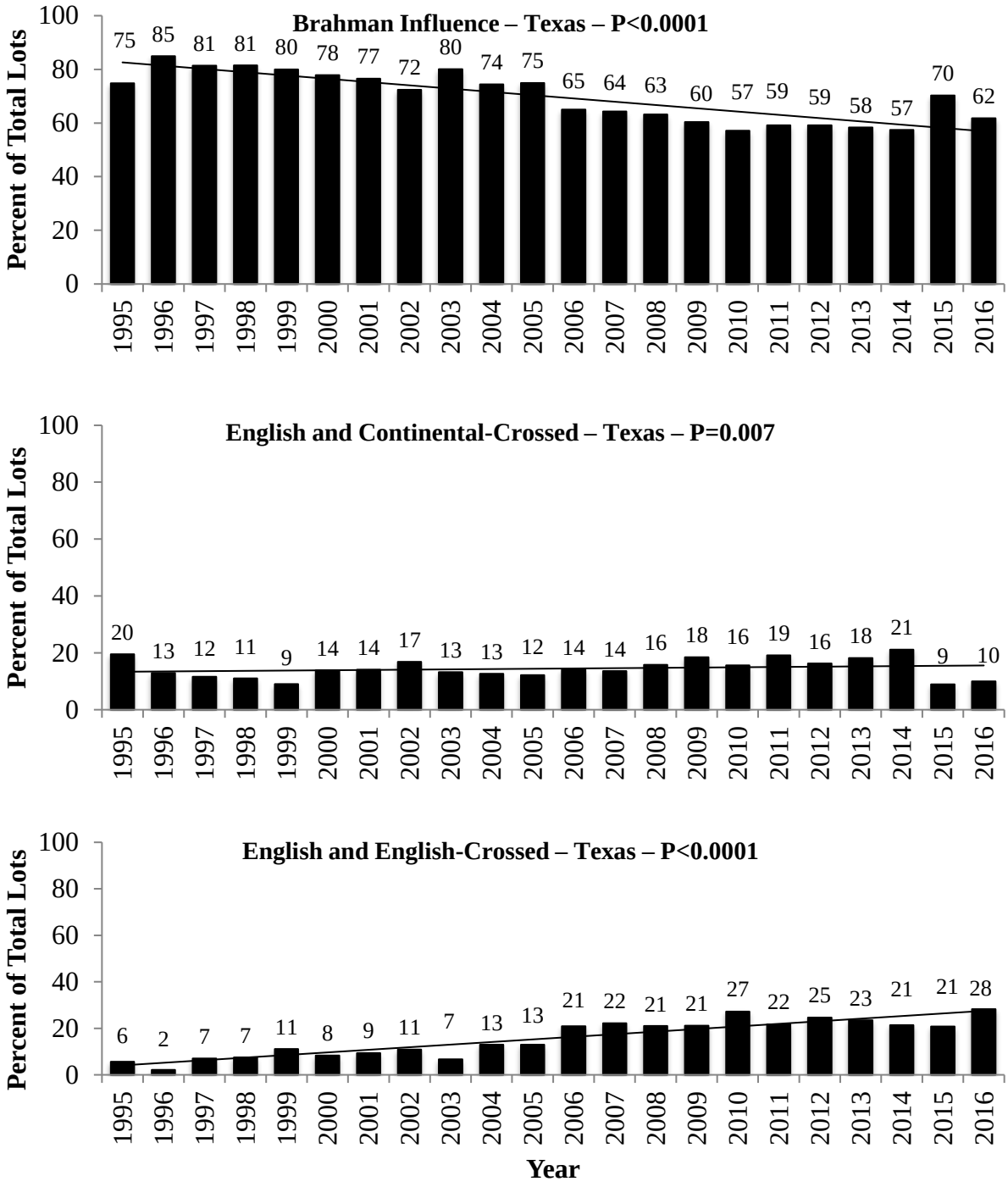
Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The Rocky Mountain/North Central region included the states of: Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming;

Figure 3.6 - Breed trends of lots of beef calves from South Central region from 1995 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The South Central region included the states of: Arizona, Kansas, Missouri, New Mexico, and Oklahoma.

Figure 3.7 - Breed trends of lots of beef calves from Texas region from 1995 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
Texas was a separate region due to the large number of lots originating from the state.

Figure 3.8 - Percent of lots of beef calves marketed from each region of the United States via summer video auction from 1995 through 2016

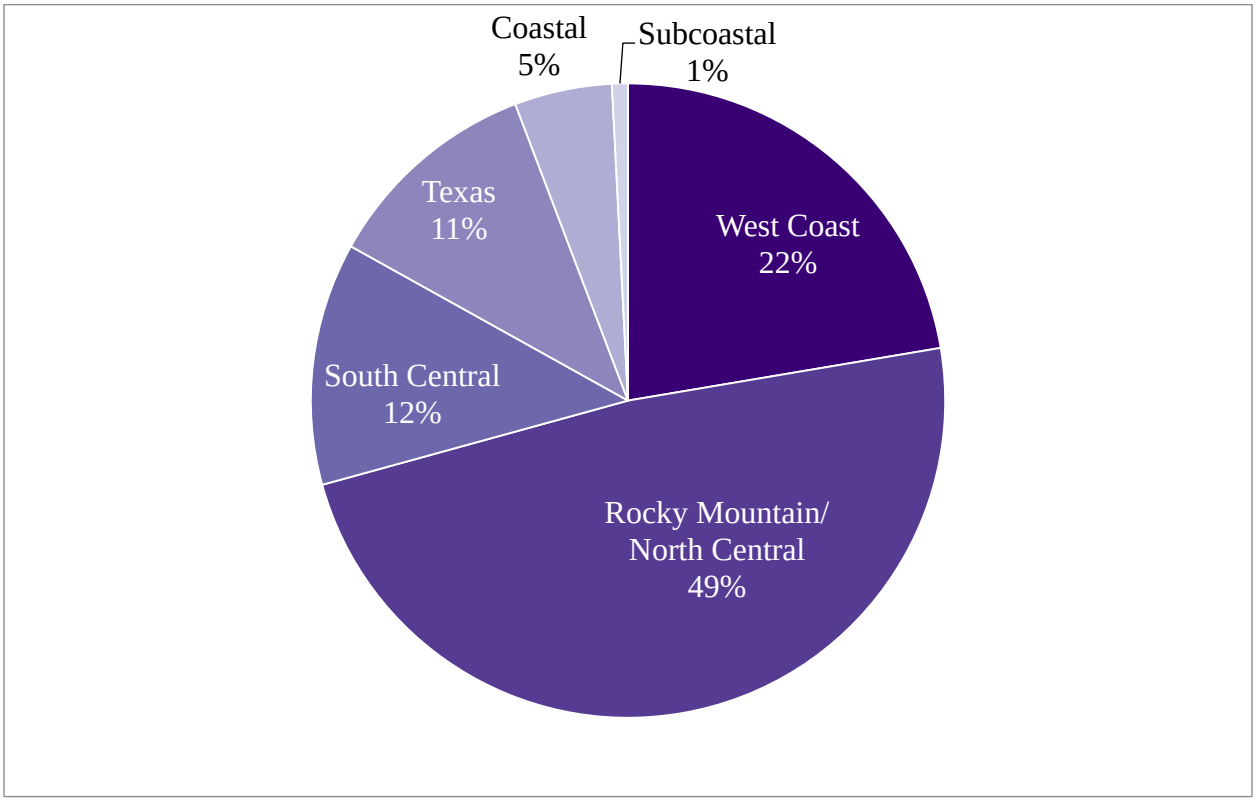
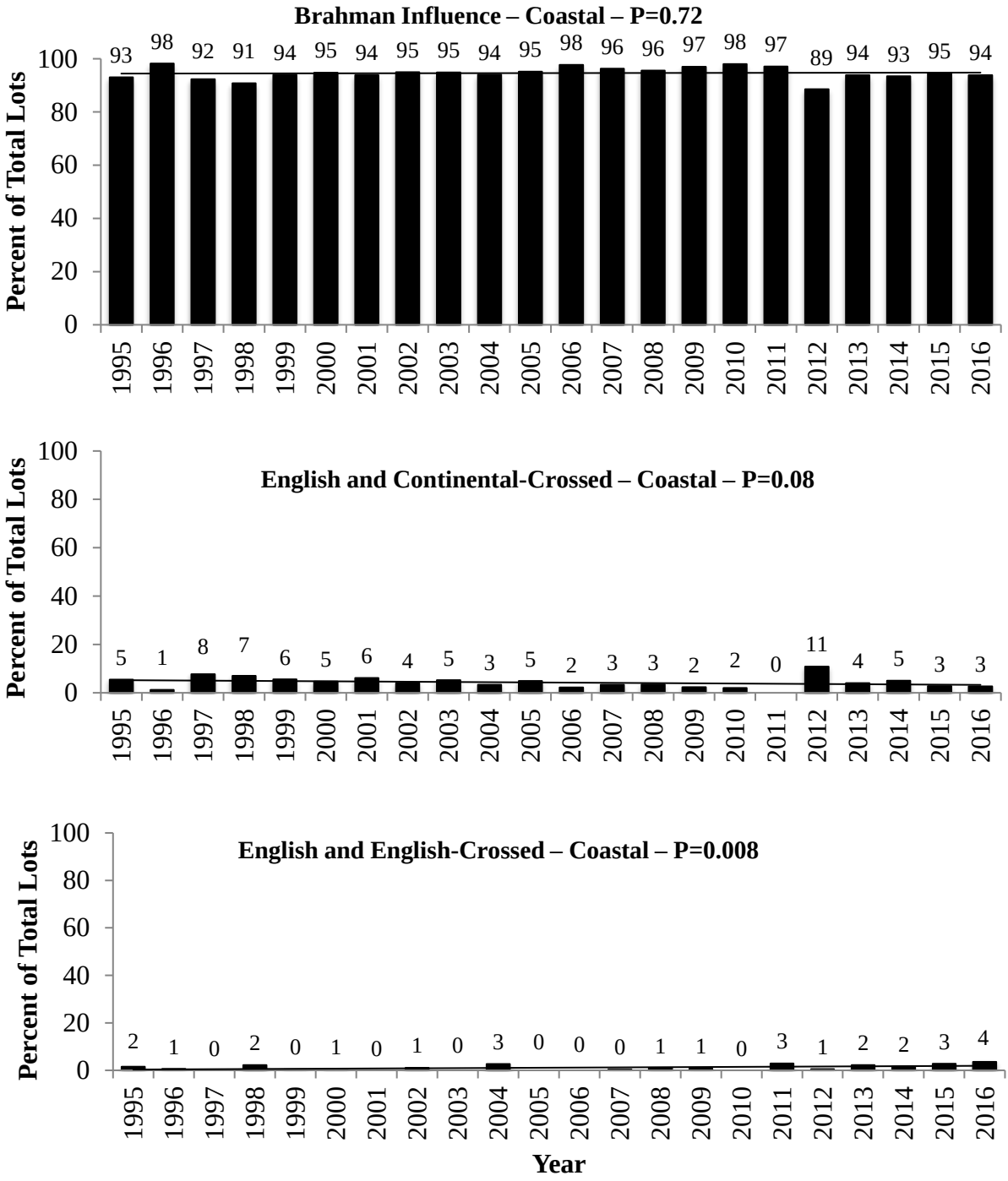


Table 3.4 - Number of lots and total head marketed from each region via summer video auction from 1995 through 2016

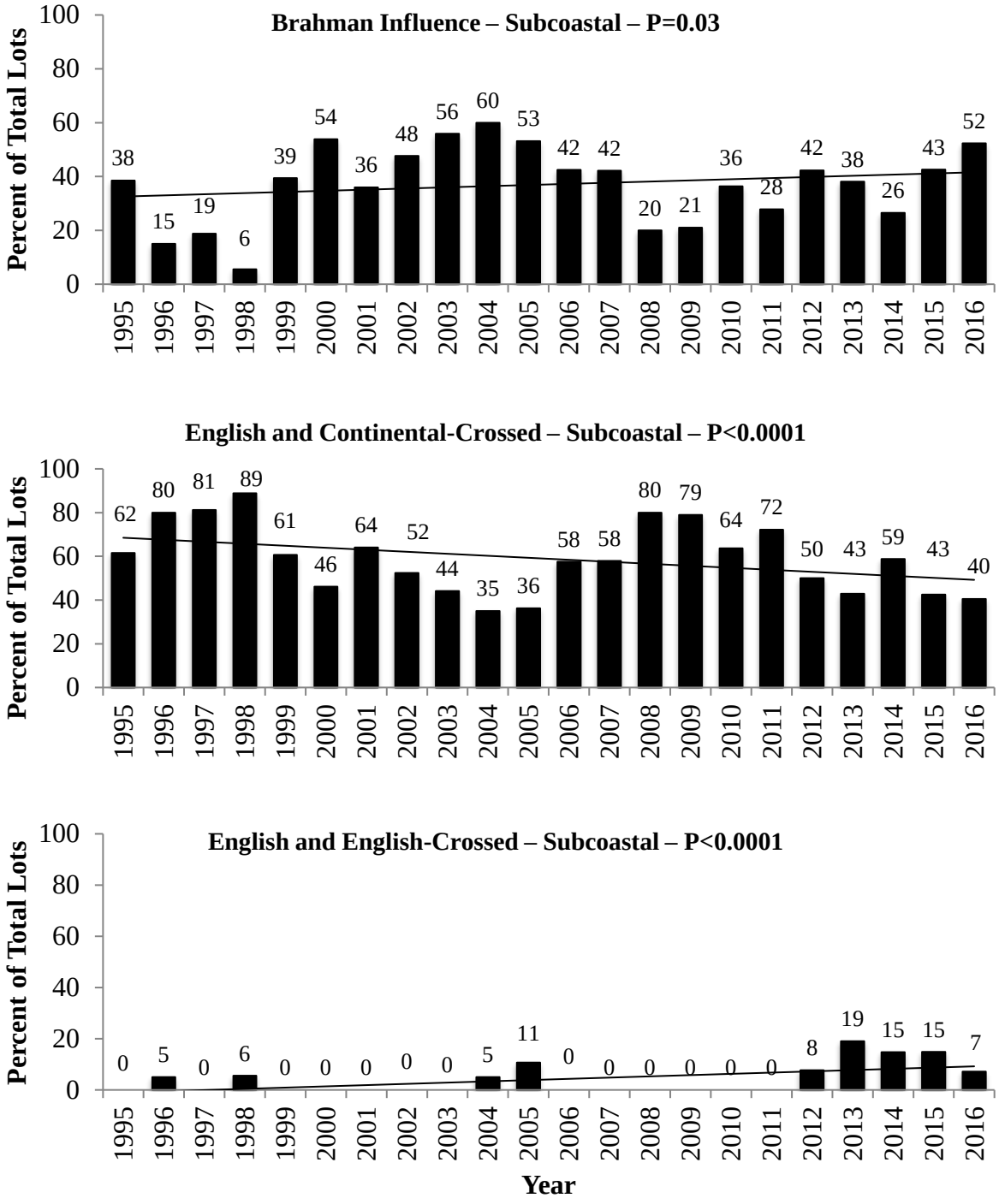
Region	Total Number of Lots	Total Head
West Coast	18,962	2,213,826
Rocky Mountain/ North Central	41,059	5,080,328
South Central	10,492	1,248,858
Texas	9,448	1,105,248
Coastal	4,221	486,877
Subcoastal	687	64,677

Figure 3.9 - Breed trends of lots of beef calves from Coastal region from 1995 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The Coastal region included the states of: Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina.

Figure 3.10 - Breed trends of lots of beef calves from Subcoastal region from 1995 through 2016



Percent of total lots represents the percent of lots categorized as the breed description from lots marketed via summer video auctions from 1995 through 2016.
The *P* value represents an increasing or decreasing trend within each breed description.
The Subcoastal region included the states of: Arkansas, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia.

References

Cundiff, L.V., R.M. Thallman, and L.A. Kuehn. 2012. Impact of Bos *indicus* genetics on the global beef industry. Beef Improvement Federation Research Symposium, Houston, TX. http://www.brahman.org/PDFs/CundiffBIF.pdf

Eastwood, L.C., C.A. Boykin, M.K. Harris, A.N. Arnold, D.S. Hale, C.R. Kerth, D.B. Griffin, J.W. Savell, K.E. Belk, D.R. Woerner, J.D. Hasty, R.J. Delmore, J.N. Martin, T.E. Lawrence, T.J. McEvers, D.L. VanOberbeke, G.G. Mafi, M.M. Pfeiffer, T.B. Schmidt, R.J. Maddock, D.D. Johnson, C.C. Carr, J.M. Scheffler, T.D. Pringle, and A.M. Stelzleni. 2017. National Beef Quality Audit-2016: Transportation, mobility, and harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and by-products. Translation Animal Science. 1:229-238.

Hammack, S.P. 2009. Texas adapted genetic strategies for beef cattle II: Genetic-Environmental Interaction. AgriLife Extension. Texas A&M System. E:187.

Hardin, R., D.T. Brown, C.H. Knight, and T.G. Dyer. 2013. Selecting a beef breed. University of Georgia Extension Circular. 859.

Hawkes, J.M., J.M. Lillywhite, and J. Simonsen. 2008. Breed influence on feeder calves. New Mexico State University, College of Agriculture and Home Economics, Cooperative Extension Service. Circular 634.

Spangler, M.L. 2012. Utilizing Brahman germplasm in crossbreeding systems. Beef Improvement Federation Research Symposium, Houston, TX. http://www.brahman.org/PDFs/Utilizing-Brahman-Germplasm-in-Crossbreeding-Systems.pdf

Speer, N. 2013. Industry at a glance: Growth of USDA-Certified beef programs. BEEF Magazine. Accessed 10 July 2017. http://www.beefmagazine.com/retail/industry-glance-growth-usda-certified-beef-programs

United States Department of Agriculture, Agriculture Marketing Service (USDA, AMS). 2017a. Certified beef programs. UDSA, AMS, Washington, DC. Accessed 09 August 2017. https://www.ams.usda.gov/services/auditing/certified-beef-programs

Wessler, B. 2011. Trends in hide color. Drovers. Accessed 10 July 2017. http://www.cattlenetwork.com/drovers/markets/Trends-in-hide-color-125028789.html

Appendix A - Supplemental results from breed composition affecting the sale price of lots of steer and heifer calves sold via video auction from 2010 through 2016

Table A.1 - Factors that did not have a significant effect on the sale price of steer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	*P* value
Verified Natural Beef program status	almost totally confounded with NHTC
Days between auction date and forecasted delivery date	0.7780
Implant status	0.3974
Presence of horns	0.3398
BVD-PI free status	0.3715
VAC 34 compared with VAC 34+	0.9996
VAC 45 compared with VAC 45+	1.0000

The model was adjusted for the random effect of auction date nested within auction year. P>0.05 was considered nonsignificant.

Table A.2 - Factors affecting the sale price of steer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Auction year				<.0001
2010	4,575	119.63[a]	-37.01	
2011	4,306	144.75[b]	-11.89	
2012	3,893	167.15[c]	10.51	
2013	4,231	166.94[c]	10.30	
2014	4,065	238.27[d]	81.63	
2015	3,911	238.67[d]	82.03	
2016	4,122	156.64[bc]	0.00	
Base weight of the lot	29,103		-0.1750	<.0001
Base weight of the lot (quadratic)[e]	29,103		0.0003	<.0001
Number of calves in the lot	29,103		0.0188	<.0001
Number of calves in the lot (quadratic)[f]	29,103		-0.00002	<.0001
Sold in mixed-gender lot				<.0001
Yes	6,880	173.83[a]	-4.36	
No	22,223	178.19[b]	0.00	
Region of the United States where the lot originated[g]				<.0001
West Coast	6,515	175.02[a]	3.75	
Rocky Mountain/North Central	10,511	180.28[b]	9.01	
South Central	8,214	177.46[c]	6.19	
South East	3,863	171.27[d]	0.00	
Value-added health protocol that was administered to the lot				<.0001
VAC 34 or VAC 34+	11,605	174.68[a]	2.72	
VAC 45 or VAC 45+	8,048	179.53[b]	7.57	
VAC PreCon	1,385	178.76[b]	6.80	
Weaned and received a viral vaccination at some time[h]	4,091	179.15[b]	7.19	
Non-weaned and received a viral vaccination at some time[h]	963	171.96[c]	0.00	
VAC 24	3,011	171.96[c]	0.00	
Breed description of the lot				<.0001
English and English-crossed	2,668	175.54[a]	4.57	
English and Continental-crossed	7,180	175.36[a]	4.39	
Black Angus sired[i]	10,019	177.23[b]	6.26	
Red Angus sired[j]	1,296	177.86[bc]	6.89	
Charolais sired[k]	490	179.09[c]	8.12	
Brahman influenced	7,450	170.97[d]	0.00	

Table A.2 continued

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Variation in weight within the lot				.0021
Fairly even	1,573	176.59[a]	1.15	
Uneven	24,799	176.00[a]	0.56	
Very uneven	2,731	175.44[b]	0.00	
Frame score of the lot				<.0001
Small medium-medium	12,792	175.48[a]	-0.80	
Medium-medium large	12,674	176.27[b]	-0.01	
Medium large	3,637	176.28[b]	0.00	
Flesh score of the lot				<.0001
Light medium	1,686	176.73[ab]	2.64	
Light medium-medium	2,359	176.90[a]	2.81	
Medium	24,086	176.32[b]	2.23	
Medium heavy-heavy	972	174.09[c]	0.00	
Qualified for the Certified Natural or Certified Natural Plus program[l]				<.0001
Yes	7,329	175.72[a]	-0.57	
No	21,774	176.29[b]	0.00	
Qualified for the Non-Hormone Treated Cattle program[m]				<.0001
Yes	2,509	177.01[a]	2.01	
No	26,594	175.00[b]	0.00	
Enrolled in an Age and Source Verification program[n]				<.0001
Yes	9,604	177.13[a]	2.24	
No	19,499	174.89[b]	0.00	
Qualified for the Superior Progressive Genetics program[o]				<.0001
Yes	8,109	176.41[a]	0.80	
No	20,994	175.61[b]	0.00	

The model was adjusted for the random effect of auction date nested within auction year.

[a,b,c,d]Values within a factor without a common superscript differ ($P < 0.05$).

[e]In order to prevent multicollinearity between the linear and quadratic base weight terms, the base weight of each lot was centered at zero by subtracting the mean base weight of all the lots (581.3 lb) from the base weight of each lot.

[f]In order to prevent multicollinearity between the linear and quadratic lot size terms, the number of calves in each lot was centered at zero by subtracting the mean lot size of all the lots (105.4 head) from the lot size of each lot.

[g]States in the region of origin were: West Coast—California, Idaho, Nevada, Oregon, Utah, and Washington; Rocky Mountain/North Central—Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming; South Central—Arizona, Kansas, Missouri, New Mexico, Oklahoma, and Texas; South East—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, and Virginia.

[h]Calves in this category were vaccinated against one or more of the following respiratory tract viruses at some time between birth and the date of delivery: IBR, BVD Type 1, BVD Type 2, PI_3, and BRSV.

[i]Lots of calves in this breed group were sired by Black Angus bulls and out of dams with no Brahman influence.
[j]Lots of calves in this breed group were sired by Red Angus bulls and out of dams with no Brahman influence.
[k]Lots of calves in this breed group were sired by Charolais bulls and out of dams with no Brahman influence.
[l]For a lot of calves to qualify for the Certified Natural program, the seller of the calves must complete and sign a Certified Natural consignment affidavit verifying that the calves have never received and will not receive the following: A. Ionophores-Rumensin, Bovatec, Cattlyst, or Gain-Pro, B. Antibiotics and/or Sulfas fed or injected-Aureomycin, Nuflor, Draxxin, CTC, or Albon, C. Growth promoting hormones/steroids fed, oral, or injected-Revalor, MGA, Lutalyse, Ralgro, or Dexamethasone, D. Beta Adrenoceptor-agonist fed or injected-Optaflexx, and E. Any type of animal by-product in feedstuffs, mineral supplements, or feed tubs-fish oil, milk replacers, animal fat, feather meal, poultry litter, yellow grease, or any type of by-product from fish, birds, or mammals. This list of prohibited products was not limited to only the examples given. The seller must review all feedstuffs, minerals, and supplements for actua ingredient content before signing the affidavit. The seller must also certify that he/she/it was the original owner of the consigned calves or supply a signed "all natural" certification from the original owner. Any calves that received therapeutic treatment must be individually identified and not shipped without the buyer's permission. The Certified Natural Plus program had the same basic requirements as the Certified Natural program with the additional requirement that these calves also qualified for another natural program (Meyer Natural, JBS & 5 Rivers Natural, etc.). The consignor must sign the necessary paperwork for these programs.
[m]The NHTC program is a USDA approved, non-biased, third-party audit that verifies the source, age, and non-hormone treated status of beef calves. A description of the NHTC program is available at the following Internet address: www.usa-beef.org/for-distributors-sellers/non-hormone-programme/. Carcasses from calves qualifying for this program were eligible to be marketed to the European Union.
[n]The seller of calves consigned to sell through a Superior Livestock Auction video sale must complete and sign an affidavit verifying that the calves were enrolled in a USDA approved Age and Source Verification program and had program compliant ear tags.
[o]For a lot of calves to qualify for the Superior Progressive Genetics program, the consignor must have purchased enough bulls from a qualified Superior Progressive Genetics seedstock producer to sire an entire lot of calves. Specific requirements for the Superior Progressive Genetics program can be obtained at the following Internet address: www.superiorlivestock.com/value-added-programs/superior-progressive-genetics.

Table A.3 - Factors that did not have a significant effect on the sale price of beef heifer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	*P* value
Verified Natural Beef program status	almost totally confounded with NHTC
Presence of horns	0.5649
Days between auction date and forecasted delivery date	0.6334
VAC 34 compared with VAC 34+	0.7257
VAC 45 compared with VAC 45+	0.2264

The model was adjusted for the random effect of auction date nested within auction year. P>0.05 was considered nonsignificant.

Table A.4 - Factors affecting the sale price of heifer calves sold through 164 Superior Livestock video auctions from 2010 through 2016

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Auction year				<.0001
2010	3,071	114.45[a]	-32.05	
2011	2,883	138.15[b]	-8.35	
2012	2,606	158.63[c]	12.13	
2013	2,840	157.98[c]	11.48	
2014	2,570	228.38[d]	81.88	
2015	2,361	227.73[d]	81.23	
2016	2,624	146.50[bc]	0.00	
Base weight of the lot	18,955		-0.1467	<.0001
Base weight of the lot (quadratic)[e]	18,955		0.0003	<.0001
Number of calves in the lot	18,955		0.0221	<.0001
Number of calves in the lot (quadratic)[f]	18,955		-0.00002	.0001
Sold in mixed-gender lot				<.0001
Yes	6,595	166.13[a]	-2.54	
No	12,360	168.67[b]	0.00	
Region of the United States where the lot originated[g]				<.0001
West Coast	4,153	166.28[a]	2.51	
Rocky Mountain/North Central	6,375	171.49[b]	7.72	
South Central	5,230	168.08[c]	4.31	
South East	3,197	163.77[d]	0.00	
Value-added health protocol that was administered to the lot				<.0001
VAC 34 or VAC 34+	7,316	166.30[a]	1.96	
VAC 45 or VAC 45+	5,248	170.47[b]	6.13	
VAC PreCon	722	169.94[bc]	5.60	
Weaned and received a viral vaccination at some time[h]	2,849	169.47[c]	5.13	
Non-weaned and received a viral vaccination at some time[h]	676	163.90[d]	-0.44	
VAC 24	2,144	164.34[d]	0.00	
Breed description of the lot				<.0001
English and English-crossed	1,581	165.79[a]	3.01	
English and Continental-crossed	4,732	165.58[a]	2.80	
Black Angus sired[i]	5,962	167.66[b]	4.88	
Red Angus sired[j]	716	173.88[c]	11.10	
Charolais sired[k]	457	168.74[b]	5.96	
Brahman influenced	5,507	162.78[d]	0.00	

Table A.4 continued

Factor	Number of lots	Least squares mean of sale price ($/cwt)	Price difference	*P* value of factor
Variation in weight within the lot				.0004
Fairly even	848	168.38[a]	1.50	
Uneven	15,865	166.95[b]	0.07	
Very uneven	2,242	166.88[b]	0.00	
Frame score of the lot				.0263
Small medium-medium	8,673	167.09	-0.56	
Medium-medium large	8,063	167.47	-0.18	
Medium large	2,219	167.65	0.00	
Flesh score of the lot				.0002
Light medium	1,266	168.34[a]	2.35	
Light medium-medium	1,633	167.69[a]	1.70	
Medium	15,495	167.60[a]	1.61	
Medium heavy-heavy	561	165.99[b]	0.00	
Were calves in the lot implanted?				.0023
Yes	4,845	167.10[a]	-0.61	
No	14,110	167.71[b]	0.00	
Qualified for the Certified Natural or Certified Natural Plus program[l]				.0028
Yes	5,097	167.13[a]	-0.55	
No	13,858	167.68[b]	0.00	
Qualified for the Non-Hormone Treated Cattle program[m]				<.0001
Yes	1,687	168.58[a]	2.35	
No	17,268	166.23[b]	0.00	
Enrolled in an Age and Source Verification program[n]				<.0001
Yes	5,971	168.71[a]	2.61	
No	12,984	166.10[b]	0.00	
Qualified for the Superior Progressive Genetics program[o]				<.0001
Yes	4,918	168.30[a]	1.79	
No	14,037	166.51[b]	0.00	
Qualified for the BVD-PI Free program[p]				.0259
Yes	367	168.01[a]	1.21	
No	18,588	166.80[b]	0.00	

The model was adjusted for the random effect of auction date nested within auction year.
[a,b,c,d]Values within a factor without a common superscript differ (P < 0.05).
[e]In order to prevent multicollinearity between the linear and quadratic base weight terms, the base weight of each lot was centered at zero by subtracting the mean base weight of all the lots (547.4 lb) from the base weight of each lot.

[f]In order to prevent multicollinearity between the linear and quadratic lot size terms, the number of calves in each lot was centered at zero by subtracting the mean lot size of all the lots (89.6 head) from the lot size of each lot.
[g]States in the region of origin were: West Coast—California, Idaho, Nevada, Oregon, Utah, and Washington; Rocky Mountain/North Central—Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming; South Central—Arizona, Kansas, Missouri, New Mexico, Oklahoma, and Texas; South East—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.
[h]Calves in this category were vaccinated against one or more of the following respiratory tract viruses at some time between birth and the date of delivery: IBR, BVD Type 1, BVD Type 2, PI_3, and BRSV.
[i]Lots of calves in this breed group were sired by Black Angus bulls and out of dams with no Brahman influence.
[j]Lots of calves in this breed group were sired by Red Angus bulls and out of dams with no Brahman influence.
[k]Lots of calves in this breed group were sired by Charolais bulls and out of dams with no Brahman influence.
[l]For a lot of calves to qualify for the Certified Natural program, the seller of the calves must complete and sign a Certified Natural consignment affidavit verifying that the calves have never received and will not receive the following: A. Ionophores-Rumensin, Bovatec, Cattlyst, or Gain-Pro, B. Antibiotics and/or Sulfas fed or injected-Aureomycin, Nuflor, Draxxin, CTC, or Albon, C. Growth promoting hormones/steroids fed, oral, or injected-Revalor, MGA, Lutalyse Ralgro, or Dexamethasone, D. Beta Adrenoceptor-agonist fed or injected-Optaflexx, and E. Any type of animal by-product in feedstuffs, mineral supplements, or feed tubs-fish oil, milk replacers, animal fat, feather meal, poultry litter, yellow grease, or any type of by-product from fish, birds, or mammals. This list of prohibited products was not limited t only the examples given. The seller must review all feedstuffs, minerals, and supplements for actual ingredient content before signing the affidavit. The seller must also certify that he/she/it was the original owner of the consigned calves or supply a signed "all natural" certification from the original owner. Any calves that received therapeutic treatment must be individually identified and not shipped without the buyer's permission. The Certified Natural Plus program had the same basic requirements as the Certified Natural program with the additional requirement that these calves also qualified for another natural program (Meyer Natural, JBS & 5 Rivers Natural, etc.). The consignor must sign the necessary paperwork for these programs.
[m]The NHTC program is a USDA approved, non-biased, third-party audit that verifies the source, age, and non-hormone treated status of beef calves. A description of the NHTC program is available at the following Internet address: www.usa-beef.org/for-distributors-sellers/non-hormone-programme/. Carcasses from calves qualifying for this program were eligible to be marketed to the European Union.
[n]The seller of calves consigned to sell through a Superior Livestock Auction video sale must complete and sign an affidavit verifying that the calves were enrolled in a USDA approved Age and Source Verification program and had program compliant ear tags.
[o]For a lot of calves to qualify for the Superior Progressive Genetics program, the consignor must have purchased enough bulls from a qualified Superior Progressive Genetics seedstock producer to sire an entire lot of calves. Specific requirements for the Superior Progressive Genetics program can be obtained at the following Internet address: www.superiorlivestock.com/value-added-programs/superior-progressive-genetics.
[p]Lots of calves had to be documented to be Bovine Viral Diarrhea-Persistently Infected free through laboratory testing.