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Estimating Desirable Cattle Traits Using Latent Class and Mixed Logit Models: A Choice Modeling Application to the U.S. Grass-Fed Beef Industry

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ESTIMATING DESIRABLE CATTLE TRAITS USING LATENT CLASS AND MIXED LOGIT MODELS: A CHOICE MODELING APPLICATION TO THE U.S. GRASS-FED BEEF INDUSTRY

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I dedicate this work to my mum, wife, kids, and sister’s family for their prayers and words of encouragement throughout my doctoral program. I know it has not been easy especially for my wife and kids, living without me the period I have been in the U.S. studying.

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ABSTRACT

This study examines the preferences for cattle traits using mixed logit and latent class models. Choice experiment data from a 2013 mail survey of 1,052 U.S. grass-fed beef producers were used. The findings indicate that grass-fed beef producers generally preferred lower-priced, heavy animals that were small-to-medium framed and easy to handle for grass-finishing. Black animals that were retained from their own calves were preferred. Relative to intact males, steers and heifers were preferred. Except for the estimated parameter for the weight attribute, the standard deviations for the temperament, body frame, source, color, gender, and price attribute levels were significant at the $P \leq 0.05$ levels, implying the presence of heterogeneity in the sample. It is important to understand the existing preference heterogeneity within the study population as it provides insights to cattle producers and cattle marketers on the value placed on cattle traits by different groups of grass-fed producers.

CHAPTER 1: INTRODUCTION

1.1 Trends in the U.S. Beef Industry

Relatively little research has been conducted on the economics of production of grass-fed beef segment of the U.S. beef industry over the past 50 years. Discussion of production and consumption trends in the entire U.S. beef industry is provided in this section. The U.S. is ranked as the world's largest producer of beef (USDA NASS, 2015). The meat and poultry industries were the two largest segments of U.S. agriculture in 2000 (Katz and Boland, 2000). Reports from The American Meat Institute (2011) indicate a total meat and poultry production of more than 92.1 billion pounds in 2010, up 1.2 billion pounds from 2009. Beef accounted for only about 359 million pounds of the increase with poultry accounting for the remaining increase.

Results in Table 1 indicate a persistent decrease in the total number of cattle in the U.S. from 113 million in 1984 to 96 million in 1991. The number gradually increased after 1991 to attain another high of 101 million in 1997 before declining to a low of 90 million in 2011. The latest reports from USDA National Agricultural Statistics Service (NASS) indicate a combined cattle and calves inventory of 89.8 million head on January 1, 2015 (Figure 1). Total beef exports from the U.S. were 5.6 billion pounds in 2014 (Matthews and Haley, 2015). Top U.S. beef export markets are Canada, Japan, Mexico, South Korea, and Hong Kong (USDA NASS, 2015). According to the USDA cattle inventory published Jan. 1, 2013, more than 50% of the total value of U.S. sales of cattle and calves comes from the following top five states: Texas, Nebraska, Kansas, California, and Oklahoma.

Corn prices were not stable for the period 1984-2011 (Table 1). Fluctuations in grain and cattle prices coupled with the increased public awareness of health and environmental concerns have fueled interest in grass-finishing cattle (Martin and Rogers, 2004). During the period 1984-

2011, (Table 1), corn price fluctuated between a low of $1.56/bu and a high of $6.01/bu. A notable response (decrease) in the level of beef production and demand for red meat was realized during the same period.

Like cattle inventory, domestic consumption of beef has been declining. Per capita consumption of meat and population statistics are reported in Table 2. An inverse relationship between population growth rate and per capita consumption of red meat is evident within the specified period. Population has been gradually increasing while a per capita consumption of red meat has been consistently declining. As indicated in Table 2, the highest per capita consumption of red meat during the specified period was 79.2 pounds. This value was recorded in 1985 with the lowest value of 61.1 pounds recorded in 2009. On average, the annual decline in the per capita consumption of red meat shown in Table 2 was 0.75 pounds.

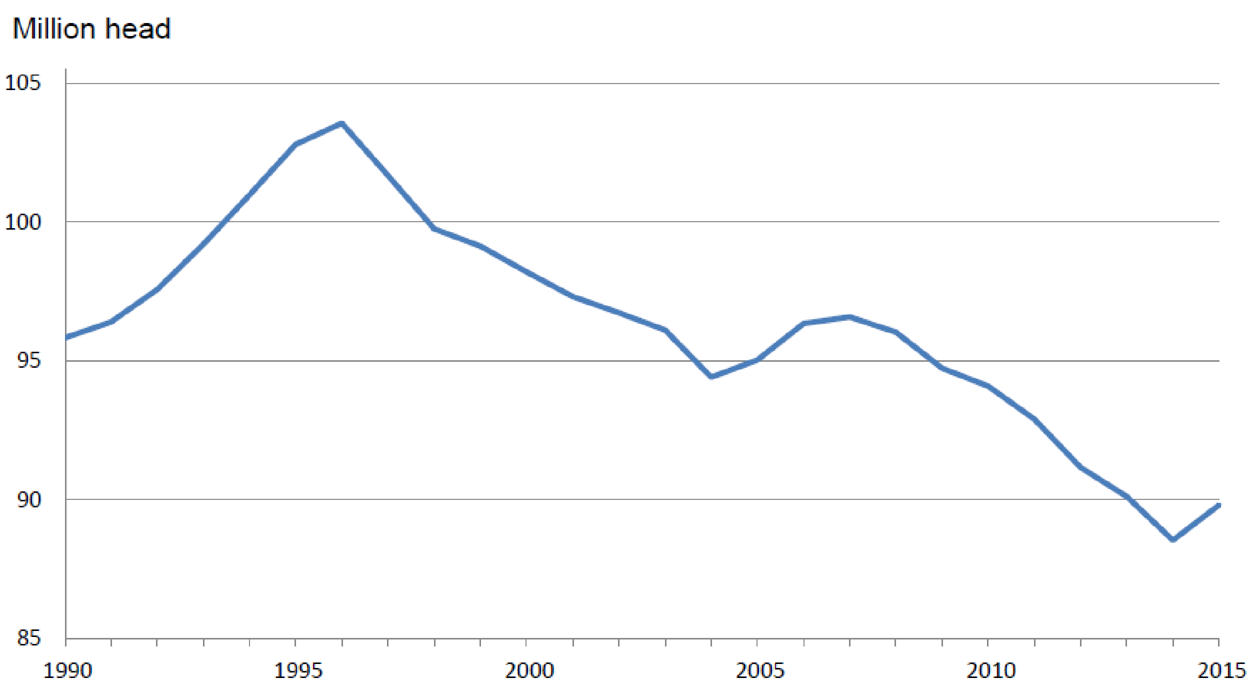

Figure 1. U.S. Cattle Inventory
Source: USDA NASS 2015

On the other hand, demand for chicken and turkey have continued to increase with slight recent downturns as shown in Table 2 and Figure 2. Katz and Boland (2000) found a 25% loss of beef market share to the pork and poultry industries. Health concerns have been cited in the literature as the main reason for decreased red meat demand (Katz and Boland, 2000; Goodson et al., 2002; Grunert et al., 2004; McCluskey et al., 2005). In addition, rapid technological progress in broiler production that has led to a decrease in cost of production have allowed chicken prices to decrease relative to other meats.

Table 1. Corn Price, Total Cattle, and Beef Productions in the U.S.

Year	Corn Price $/bu	Total Cattle (000)	Beef Production* (mil. lbs)
1984	3.05	113,360	23,418
1985	2.49	109,582	23,557
1986	1.96	105,378	24,213
1987	1.56	102,118	23,405
1988	2.27	99,622	23,424
1989	2.43	96,740	22,974
1990	2.40	95,816	22,634
1991	2.33	96,393	22,800
1992	2.28	97,556	22,968
1993	2.21	99,179	22,942
1994	2.40	100,974	24,278
1995	2.56	102,785	25,117
1996	3.57	103,548	25,421
1997	2.60	101,656	25,420
1998	2.19	99,744	25,634
1999	1.87	99,115	26,400
2000	1.84	98,198	26,777
2001	1.89	97,277	26,108
2002	2.13	96,704	27,090
2003	2.24	96,100	26,215
2004	2.44	94,882	24,547
2005	1.96	95,438	24,683
2006	2.28	97,102	26,152
2007	3.38	97,003	26,421
2008	4.76	96,035	26,570
2009	3.75	94,521	25,951
2010	3.83	92,700	26,310
2011	6.01	90,800	26,200

* Commercial carcass weight

Source: ERS (2012).

Figure 2 indicates a persistent decline in per capita consumption of total red meat and beef. On the other hand, demand for poultry meat has been on the rise since the 1970s (specific per capita consumption data for grass-fed beef was not available for the period covered in Figure 2). As indicated in Table 2 and Figure 2, per capita consumption of chicken dropped slightly in 2008 by 1.4 pounds and a relatively significant drop of 4.8 pounds in 2009.

Table 2. Average Annual Per Capita Consumption of Meat and Population Statistics

Year	Population (000)	Beef (lbs)	Total Red Meat (lbs)	Total Poultry (lbs)
1985	238,466	79.2	134.3	65.6
1986	240,651	78.8	131.0	68.1
1987	242,804	73.9	125.9	73.1
1988	245,021	72.7	128.0	74.6
1989	247,342	69.3	124.0	77.0
1990	250,132	67.8	120.2	80.5
1991	253,493	66.6	119.2	81.7
1992	256,894	66.2	121.4	85.3
1993	260,255	64.6	118.7	87.3
1994	263,436	66.3	120.9	88.0
1995	266,557	66.6	120.6	87.2
1996	269,667	67.2	117.9	88.5
1997	272,912	65.7	115.7	88.4
1998	276,115	66.7	120.0	89.1
1999	279,295	67.5	121.9	93.5
2000	282,403	67.6	120.5	93.3
2001	285,335	66.2	118.2	93.4
2002	288,216	67.9	121.2	100.7
2003	291,089	64.4	117.6	99.4
2004	293,908	66.1	119.0	101.5
2005	296,639	65.6	117.1	103.1
2006	299,801	66.2	117.2	104.7
2007	301,580	65.2	117.4	103.1
2008	304,375	62.8	113.5	101.7
2009	307,007	61.1	112.3	96.9

Source: ERS (2012).

The Food Market Institute report (2005) indicated an increase in the domestic supply of grass-fed beef. Among the reasons for the persistent growth have been the economic changes taking place in both the production and consumption of grass-fed beef. Increasing numbers of health conscious beef consumers have boosted the demand for hormone-free and antibiotic-free grass-fed beef, attracting more beef producers to grass-finishing. Media reports and results from scientific studies dealing with beef attributes have raised consumer awareness on the implications associated with choices they make in their beef consumption (Katz and Boland, 2000). Early growth of grass-fed beef industry was slowed by lower grain prices of the early 1960s. The oversupply of grain following World War II initiated a trend towards grain-feed dependence. Interest in alternative methods of finishing cattle for slaughter other than in the feedlots was practically nonexistent during the 1950s and 1960s (Martin and Rogers, 2004). However, the increasing corn prices shown in Table 1 accelerated the growth in grass-fed beef industry (Martin and Rogers, 2004).

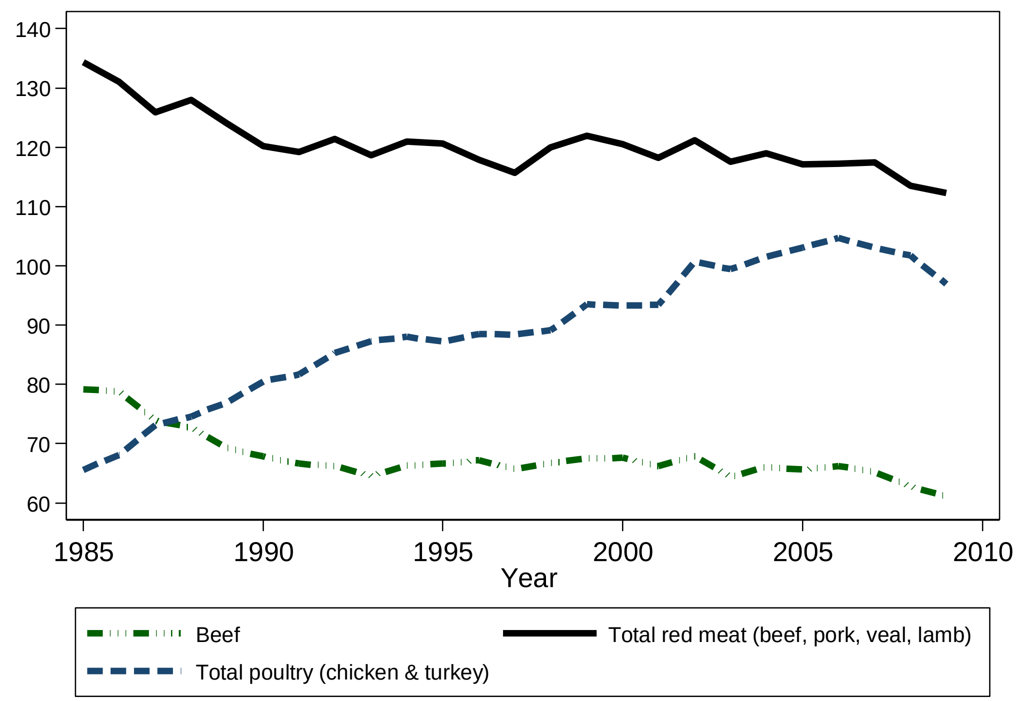

Figure 2. Annual Per Capita Consumption of Meat Products
Source: ERS (2012).

1.2 Grass-Fed Beef

On October 5, 2007, the USDA proposed the definition of grass-fed animals as livestock whose lifetime diet must consist only of grass and forage, with the exception of milk consumed prior to weaning. In 2009, the American Grass-Fed Beef Association (AGA) introduced a certification program and standards outlining the procedure followed in producing certified grass-fed beef. AGA later launched a label for grass-fed beef. The AGA standards incorporate the following grass-fed beef attributes: the beef came from cattle that ate only grass from pastures, not feedlots; the cattle received no hormones or antibiotics in their feed; the cattle were humanely raised and handled; and the cattle must have been born and raised in the U.S. In developing these standards, AGA thus brings together farms sharing common attributes stated above (AGA Standards, 2011). Despite its small share of the beef industry, grass-fed beef is a differentiated product that is preferred by an increasing number of consumers (Mathews and Johnson, 2013).

Discovery of Bovine Spongiform Encephalopathy (BSE) in 2003 in a cow imported from Canada dramatically altered the U.S. beef market in 2004 (USDA ERS, 2012). Local demand for beef in the U.S. plummeted during this period. Subsequent BSE discoveries in Texas tested in November, 2004, and confirmed in June, 2005, and a confirmation in Alabama in March, 2006, further escalated the scare within the U.S. domestic beef market (USDA ERS, 2012). BSE is transmitted by feeding products derived from infected animals such as meat and bone meal. Grass-fed beef therefore qualifies to be BSE-free. A significant shift to consumption of grass-fed beef was expected following the discovery of BSE. McCluskey et al. (2005) confirmed the relevance of the BSE events on marketing of grass-fed beef which is believed to be BSE-free.

The Food Market Institute (2005) highlighted the trends of grass-fed beef demand. U.S. revenue from the sale of grass-fed beef were projected to increase from just under $5 million in 1998 to over $1 billion in 2010 (Food Market Institute, 2005). Reports by Bauman (2013) in Drovers Cattleman Network newsletter indicate a 25% annual growth rate in U.S. grass-fed beef market. The report further stated that grass-fed beef accounted for 3-6% of beef sales in the U.S. in 2012. Increased consumer interest in healthy food, animal welfare, and environmental sustainability make grass-finishing a desirable option for beef producers.

The increase in demand for grass-fed beef is partially due to consumer concern for the fat content in meat products. Kerth et al. (2007) found that finishing Angus-cross steers on forage resulted in a carcass with less fat compared to those finished on feeds that included grain. Preference for healthy beef that comes from local producers and from animals that are considered by some to be humanely treated is rising (French et al., 2000). A study conducted by Sitz et al. (2005) indicated that consumers rated beef raised and produced domestically (in the U.S.) highly. Consumers were willing to pay an average of $3.68/0.45 kg of domestically produced steak, $2.48/0.45 kg of Australian grass-fed steak, and a numerically lower value per 0.45 kg of Canadian steak (Sitz et al., 2005). Increased awareness on matters associated with healthy food has influenced beef consumption patterns (Variyam and Golan, 2002). Harris (2002) found a 178% increase in the supply of new "all natural products" and a 57% increase in new organic products supply over the period, 1995-2000. As consumer preferences evolve, it is important for U.S. beef producers to understand such trends when considering producing specialty products such as grass-fed beef (McCluskey et al., 2005).

1.3 Need for the Study

Beef characteristics have been the main focus of many stated preference studies conducted in the past (Cox et al., 2006; Kerth et al., 2007; Umberger et al., 2002). Willingness to pay for specific meat quality traits such as tenderness, juiciness, or marbling has been widely investigated. Little has been done to evaluate beef producer preferences for production-related attributes such as daily weight gain, gender, temperament, and/or coat color of the animal. New grass-fed beef producers face the common question, “which animal should I choose?” The answer to this question, in fact, remains at large for most categories of beef producers grain-fed or grass-fed. Selection of animals with high feed efficiency implies reduced cost of feeding and, hence, improved profitability. Breeds having high feed efficiency, however, can be difficult to handle (an example of a trade-off between feed efficiency and temperament issues). A beef producer always faces attribute trade-offs in selecting animals for beef production. Sy et al. (1997) found an attribute trade-off between easy calving and birth weight for calves among purebred breeders. They found that purebred breeders preferred heavy calves (indicated by a large part-worth for weaning weight) to easy calving. Conjoint analysis approach will be used to provide an understanding of how producers traded off between various cattle attributes represented by a set of hypothetical animal profiles.

Grass-fed beef producers need to consider animal attributes that improve farm productivity and profitability in their selection programs. Superior cattle traits such as marbling, faster growth rates, and weather tolerance can contribute positively to productivity, efficiency, and profitability of beef production. Of particular interest to the grass-fed beef segment is the selection of cattle with traits such as faster growth rates and higher feed efficiency.

Animals raised entirely on grass grow relatively slowly, lengthening the production time and thus most likely to increase the total cost of production (Mathews and Johnson, 2013). Beef producer knowledge of breeds with desired traits (improved feed efficiency and faster growth rates) is thus crucial for success in this industry. Animal attributes and management practices that affect the value of individual feeder cattle have large economic impact (Lambert et al., 1989). Determination of grass-fed beef producer preferences for cattle traits is the overall objective of this study. At conclusion of the study, I will shed light on the "new producer" question raised before, "which animal should I choose?"

1.4 Objectives of the Study

The objectives of this study are:

1. To determine U.S. grass-fed beef producer preferences for selected cattle traits.
2. To investigate preference heterogeneity for cattle traits across segments of grass-fed beef producers.
3. To estimate the economic values of selected cattle traits for the U.S. grass-fed beef producer.

1.5 Significance of the Study

Limited research has been conducted evaluating beef producer preferences for cattle traits. As a matter of fact, we are unaware of any that have focused specifically on the preferences for cattle traits in the grass-fed beef segment. The need to get the animal to market weight faster with minimum possible feed intake is a goal of any beef producer. It is critically important especially for a grass-fed beef producer who is required to comply with strict forage and no-grain dietary requirements, and may be required to comply with no growth promotants and no antibiotics requirements. Furthermore, grass-fed beef production generally involves significant daily interaction between the farmer and animals that are raised to over 1,000 lb and are usually rotated among pastures on a regular basis. This, as well as the fact that animal temperament has been found to be linked to meat quality (Kadel et al., 2006), suggests that identifying animals with milder temperament would be of importance. An option would be to employ improved breed selection programs to produce cattle with the desired attributes. Superior cattle traits such as high marbling scores, ability to gain weight faster, and climatic tolerance can contribute positively to this industry.

Knowledge of the type of animal most desired for grass-fed production will provide cow-calf producers (in areas with significant cow-calf production) with knowledge of the most preferred calves for purchase by the grass-fed beef segment and the values that grass-fed beef producers place on these animals. Furthermore, the information will be of use to new grass-fed producers who need information on the types of animals that the existing (respondents to this study) believe are best for grass-finishing.

1.6 Organization of the Study

The remainder of this dissertation will be organized as follows. The literature review is sub-divided into two major sections: (1) discussion of studies conducted on the U.S. grass-fed beef industry, which provides information on production and marketing segments in the industry; and (2) a conjoint analysis section, which provides general information on the experimental design used and the selection of cattle traits. Following the literature review is a chapter discussing the data and methods. Three crucial steps in conjoint analysis are discussed in this chapter: selection of cattle traits, experimental design and data collection, and econometric methods used in the estimation of part-worth utilities. A brief discussion of the ordered probit model used to estimate producer perceptions of important cattle traits is also included. The fourth chapter provides results and discussion. Chapter five provides a summary of the major findings and conclusions from the study.

CHAPTER 2: REVIEW OF LITERATURE

2.1 The U.S. Grass-Fed Beef industry

Most studies of grass-fed beef have been conducted within the food and animal science fields. Several have compared consumer preferences for forage-finished versus grain-finished meats (Cox et al., 2006; Kerth et al., 2007; Umberger et al., 2002). Generally, little recent research has been conducted on farmers' production activities, specific farm level strategies on how to finish beef cattle on pasture, beef breeding programs, and post-farm gate methods of marketing grass-fed beef. Lozier et al. (2005), however, indicated an emerging interest in predominantly forage-finished beef at both producer and consumer ends. Estimates from FeedInfo News Service (2010) indicate that alternative beef production systems supplied approximately 3% of the U.S. beef market in 2010, producing natural, grass-fed, and organic beef. Spiselman (2006) reported retail sale of grass-fed beef products of over $120 million in 2005 with more than 1,200 new producers across the U.S. grass-finishing at least some of their beef cattle. The report further projected a 30% annual growth rate of the grass-fed beef market in the following ten years (Spiselman, 2006).

On the demand side, Umberger et al. (2002) found that approximately 23% of consumers were willing to pay a premium of $1.36 per pound for grass-fed beef. Approximately 22% of consumers surveyed by Kerth et al. (2007) preferred grass-fed beef to grain-fed beef. Concerns over antibiotic use, animal rights, and the use of growth promotants have boosted the demand for grass-fed beef (Lusk et al., 2003; Spiselman, 2006). Media and social networks have promoted consumer awareness and discussed the importance of healthy meat. Such awareness has made beef consumers more concerned about how their food is raised than ever before. Beef producers using production systems that promote best management practices that are consistent with environmental conservation and healthy food policies are becoming successful at tapping into an increasing market share of the beef market (McCluskey et al., 2005).

2.1.1 Production Segments

Sy et al. (1997) shows that the U.S. beef production system is comprised of three main segments: purebred breeders (seed stock), feeders, and commercial cow-calf producers. Knowledge of these segments is crucial in understanding the sources of variation in preference for cattle traits in a beef production system. The flow chart diagram below provides a snapshot of the U.S. beef industry structure (Katz and Boland, 2000). The product flow is top to bottom, whereas the information flow is from bottom to top (Katz and Boland, 2000). Weaned calves intended for sale as commercial feeder cattle, but not yet placed in the feedlot, are commonly referred to as stocker cattle (Johnson et al., 2010).

The U.S. grass-fed beef industry is characterized by most of the segments represented in the flow chart diagram above, except that grass-fed beef animals are not finished in feedlots, but instead are finished on pasture. Outlaw et al. (1997) pointed out some relationships between market price signals, production systems (segments), and cattle selection mechanisms. Market prices for cattle are affected indirectly by a number of factors: hay prices, grain prices, weather, price of competing meats, and general economic situation (Lambert et al., 1989). Other direct factors that affect the market price are related with the type (characteristics) of feeder cattle traded: sex, weight, body frame, and breed (Lambert et al., 1989).

Using consumers' preference for leaner beef as an example, Outlaw et al. (1997) explained how consumers' preference/market price signal is transmitted through the marketing system, from packers to cattle feeders, and eventually to cow-calf producers. They suggested that, cattle feeders use this signal in determining the amount of premium they are willing to pay cow-calf producers to obtain the type (size and/or breed) of weaned calf that can produce leaner meat. On the other hand, cow-calf producers may react to this premium (market price signal) by purchasing breeding stock from seedstock producers with the desired traits (Outlaw et al., 1997). This example provides a simple illustration of how demand for some cattle traits may be relayed through a production and/or marketing system. Market price signals travel upstream from the beef consumer to the producer in the form of implicit premiums and discounts paid for calf characteristics (Zimmerman et al., 2012).

2.1.2 Marketing Grass-fed Beef

Few studies have addressed how farmers market grass-fed beef. Lozier et al. (2005) presented findings from a survey of 149 beef producers from 46 different states in the U.S. and Canada who identified their product as "pasture-finished". Evaluation of data collected on marketing of grass-fed beef indicated that 95% sold directly to individual consumers, 28% sold to independent stores or butcher shops, and lower numbers, 16%, 7%, and 5% sold to restaurants, wholesalers, and chain supermarkets, respectively. Steinberg (2008) obtained results that were consistent with Lozier et al. (2005)—approximately 80% of marketed beef was directly sold to consumers. Identified direct producer-consumer niche markets for grass-fed beef could be a viable alternative to most production and marketing systems (Kerth et al., 2007). Lozier et al. (2005) indicated direct marketing as a viable strategy for improving farm profitability. Eighty-three percent of respondents obtained a price premium for their beef, with approximately 25% reporting a premium of over 75 cents per pound (Lozier et al., 2005). At the international level, Umberger et al. (2002) found Japan, Mexico, Korea and Canada as major beef export markets for the U.S. On the other hand, the U.S. imports grass-fed beef from Australia, New Zealand, Brazil and Argentina, most of which is processed (USDA ERS, 2012).

2.2 Conjoint Analysis

Understanding the value that consumers place on goods they choose to consume has been the pursuit of many academic studies. Little has been done to determine the values placed on the traits of cattle that producers choose to raise on their farms. The main focus of this study is the determination of U.S. grass-fed beef producer preferences for cattle traits. Every consumer has a unique utility function for a given good; likewise, every beef producer has unique utility for traits embodied in cattle. This uniqueness in utility derived from cattle traits is reflected by the heterogeneity in producer preferences for cattle traits. Most demand valuation studies (Loureiro and Umberger, 2003; Lusk et al., 2003; Lusk and Parker, 2009; Steiner et al., 2009; Umberger et al., 2002) have attempted to determine the value of individual attributes of goods by estimating consumer’s willingness to pay using conjoint analysis.

Conjoint analysis has been widely used in various disciplines such as marketing, health, transportation, and environmental sciences in measuring and evaluating the relative importance of characteristics of goods (Green et al., 2001). The three most commonly used designs in conjoint analysis are: traditional, adaptive, and choice-based designs (Orme, 2003). Traditional conjoint analysis involves ranking or rating of hypothetical profiles (Harrison et al., 2002; Lusk et al., 2008). To obtain individual utilities, respondents are asked to rank or rate selected goods or product profiles. Adaptive conjoint analysis is a self-explicated preference model that uses computer software (Orme, 2003). The software adapts the pairing process to respondent answers to ensure that the experiment proceeds with only those attributes that are responded to (Orme, 2003). Adaptive conjoint analysis does a better job especially when dealing with large designs—having lots of attributes and levels.

Choice-based design is a stated preference method that describes goods and/or services in terms of their attributes and levels. It presents respondents with a hypothetical shopping setting for them to choose what they prefer. One way to obtain part-worth or willingness to pay values in a choice experiment is by including a price attribute in product profiles (Chung et al., 2009; Mayen et al., 2007; Ouma et al., 2007). Respondents have an option to choose the "neither" alternative in the hypothetical profile; thus it is considered a more flexible model. The widely accepted and most desired advantage of choice experiments is that they mimic shopping experience in a real-market setting. Examples of studies that have used choice-based conjoint analysis to estimate producer preferences for cattle traits include, Ouma et al. (2007), Ruto et al. (2008), and Scarpa et al. (2003). It has been used extensively in demand analysis to estimate consumer willingness to pay (Lusk et al., 2003; Lusk and Parker, 2009; and Steiner et al., 2009).

Ouma et al. (2007) estimated heterogeneity in preference of 506 cattle-keeping households in Kenya using a choice-based conjoint analysis. A greater majority of respondents in the study (Ouma et al., 2007) were uneducated and thus researchers deemed it necessary to include pictorial profiles in their choice set. Pictorial profiles were used to describe the differences in traits and levels. Each respondent was presented with twelve choice sets in the case of cows and/or eleven in the case of bulls in the survey instrument. The survey question asked respondents to choose the animal profile that described the animal they preferred most. A "don't buy" option was included for respondents who preferred neither option (Ouma et al., 2007). A desirable feature with choice-based experiments is the inclusion of "don't buy". It makes it a more flexible model given that it allows respondents to choose neither option.

Before estimating their mixed and latent class logit models, Ouma et al. (2007) employed effect coding for the choice experiment variables. A priori expectations of utility associated with each choice experiment variable guided the coding process. For instance, the researchers expected the trait levels associated with trypanotolerance, high fertility in bulls, and high milk yields in cows to increase producers' utility. Estimation of the mixed and latent class logit models indicated the existence of preference heterogeneity based on cattle production systems (Ouma et al., 2007).

Using choice experiment surveys and a latent class model, Ruto et al. (2008) estimated preferences of cattle buyers for indigenous cattle breeds. They were able to determine heterogeneity in cattle trait valuations across respondents buying cattle for different purposes/reasons (breeding, slaughter, and resale). Ruto et al. (2008) pointed the limitation of using traditional multinomial logit models (which assume homogeneity of preference) in their model selection. Preferences for cattle traits were relatively homogenous within segments of cattle buyers but highly heterogeneous across the segments (Ruto et al., 2008). For instance, those who bought animals for slaughter attached high premiums to animals in good body condition, breeders on the other hand preferred the gender of the animal to good body condition. While most respondents are expected to prefer weight and good body condition, some may possibly prefer thinner animals in comparatively poor body condition to be fattened and then resold (Scarpa et al., 2003).

Analysis of feeder cattle based on a representative steer or heifer that is defined by an explicit set of characteristics does not fully account for the source of price variability observed in the market. A deeper understanding of the value that producers place on different cattle traits (both genotypic and phenotypic) is important for this type of market (Sy et al., 1997). It is therefore appropriate to decompose the market price/value of cattle to obtain part-worth estimates—the relative importance of specific cattle traits (Ouma et al., 2007; Tano et al., 2003). For instance, the value that a producer is willing to pay for a specific trait provides a reason for his or her selection of the types of animals raised on his or her farm. Computation of willingness to pay is useful in understanding the existing heterogeneity in producer preference for cattle traits. The next section provides information from the literature on cattle traits that will be addressed in the current study, including: weight, price, color, temperament, source, body frame, and gender (discussion will be in the order in which they are listed).

2.2.1 Cattle Traits

A number of studies in the field of animal science have discussed the importance of body weight attribute in making production and marketing decisions (Igo et al., 2013; Scaglia et al., 2014; Steinberg, 2008). Body weight is an important attribute to be considered during animal selection, especially for beef producers. Huff and Parrish (1993) found age, live weight, and gender of the animal to be the most important intrinsic factors that influence meat quality. Weight can be used to determine the appropriate time to sell or harvest beef. Spiselman (2006) indicated that, grass-fed cattle generally do not reach a slaughter weight of 1,150 lbs until they are 22 to 30 months old, as opposed to grain-finished cattle that are generally slaughtered at between 14 to 18 months of age weighing approximately between 1,100 and 1,250 lbs. However, Steinberg (2008) reported 17 months as the minimum age that pasture finished cattle can produce acceptable carcasses and meat products. Grass-fed cattle have been shown to gain between 2.1 and 3.0 lbs/day (depending largely on the specific type of forage fed and animal genetics/breed), while grain-fed cattle have posted daily gains of between 2.2 and 4.1 lbs/day (Ferrell et al., 2006; Myers et al., 1999; and Simmone et al., 1996). Gerrish (2007) reported a gain of at least 0.9 kg/d for pasture-finished cattle if forage quality and availability are maintained—which is close to Comerford et al.'s (2005) gain of 1.0 kg/d. A summarized comparison of grass-fed and grain-fed beef systems is provided in Table 3 below.

Table 3. A Comparison of Production Performance by System for Spring Born Calves.

Growth indicator	Grass-fed	Grain-fed
Starting weight, lbs	425	475
Days on feed	366	303
Post weaning ADG	1.65	3.06
Feed: Gain, dry matter	10.99	6.22
Marketing date	2 - Nov	31 - Jul
Final weight, lbs	1,029	1,401
Carcass weight, lbs	623	876

Source: Acevedo et al. (2006)

Important to note is that days on feed (days on forage in the case of grass-fed beef) is significantly different between grass-finishing and grain-finishing, with grass-fed beef production taking 63 days longer than grain-fed beef (Table 3). Grass-fed beef animals are raised exclusively on pasture and forage (post-weaning). No grain supplement, no growth promotants (hormones), and no antibiotics may be used in grass-fed beef system. On the other hand, increased grain in animal diet (in the case of grain-fed) raises the level of starch (energy), which in turn leads to increased rate of daily weight gain by the animals. Confinement of cattle in grain-fed systems with a high-concentrate diet eliminates the need for extensive grazing lands and shortens the period of time needed to bring cattle to slaughter weight (Mathews and Johnson, 2013). Final weights and marketing dates are also different for the two systems, both of which have implications on the levels of farm profits and cost structure. Outlaw et al. (1997) suggested that the two most common determinants of length of feeding period are the weather which determines pasture availability and the breed type.

Although market prices may provide information on the overall value of the animal, they do not tell us much about the value of some specific characteristics embodied in an animal that are important to farmers in different production and marketing segments. For instance, cattle traits such as temperament and disease resistance cannot be explicitly traded in the market and therefore lack price or market value. Market value, however, can be attached to some traits like coat color and weight. Lambert et al. (1989) identified feeder cattle auction price as one factor that reflect the value of animal characteristics. With grass-fed beef, markets are thin and the volume of animals available to estimate the value of specific traits is greatly reduced. Derivation of the economic value of cattle traits to use in breed improvement and/or selection requires the use of valuation methods.

Conjoint analysis has been successfully used to identify cattle traits that are preferred by beef producers in conventional (grain-fed) beef production. Using conjoint analysis, Sy et al. (1997) found a positive marginal value for a steer with a weaning weight of 650 pounds and negative marginal value for a steer with a weaning weight of 550 pounds (for an average producer), meaning that heavier steers were more preferred and more highly valued by producers. Ouma et al. (2007), Scarpa et al. (2003), and Tano et al. (2003) are additional examples of studies that have used conjoint analysis to assess the relative importance of cattle traits. Inclusion of price as an attribute is useful in estimating the implicit values of traits used in conjoint analysis (Mayen et al., 2007). Livestock characteristics such as breed, gender, body frame, masculinity, gut fill, body condition, and body weight can have significant impacts on the level of returns from a beef enterprise. Beef producers have some control over most of these characteristics, implying that they can improve their farm returns by adopting better animal selection techniques. There are many traits that the producer can control: body weight, gender, breed, body condition, gut fill, and age at harvest (Lambert et al., 1989).

Seed stock producers select animals based on the demand of their customers (cow-calf operators). For instance, a purebred-cow operator generally prefers a more uniform coat color than a crossbred-cow operator (Knight and Dyer, 2013). On the other hand, cross-breeders value some breeds as major contributors to their desired coat color. As an example, most cross-breeding programs value Black Angus for its color and superior carcass quality (Greiner, 2009). Greiner (2009) indicated a high demand for black Angus-influenced feeder cattle in the Eastern Corn Belt. Coat color is a trait that has been overlooked by many studies. It has been left out of most preference studies involving common performance traits such as weaning weight, growth rates, and carcass yield. Spiselman (2006) indicated that coat color affects how people perceive cattle. As an addition to the aforementioned contribution to cross-breeding programs, coat color is an important attribute when considering the adaptability of cattle to different agro-ecological zones/regions (Ouma et al., 2007).

Producers who obtain feeder cattle to finish in feedlots or pasture select animals based on the attributes of the animal and its expected end-product (live animal and/or meat product).

Knight and Dyer (2013) identified calf crop percentage, weaning weight, market price, and annual cow costs as some of the factors influencing returns to a commercial cow-calf operation. Most of these attributes are under the control of the farm operator. The grass-fed beef producer can utilize breeding and cattle selection to select for attributes that are profitable to his or her farming enterprise.

Major factors known to affect temperament of an animal are genetics and the environment. Cattle with poor temperament (aggressive) can cause serious management problems. Burrow and Corbet (2000) found indigenous crosses (*Bos Indicus*) to be more aggressive than exotic breeds (*Bos Taurus*). Kadel et al. (2006) recommended the inclusion of a temperament trait in beef breeding programs. Longer flight time, an indicator of better temperament, is genetically correlated with improved meat tenderness (Kadel et al., 2006).

Other traits related to cattle adaptability to the environment include: heat tolerance, resistance to disease, hair coat density, and pulmonary arterial pressure (Prayaga et al. 2009). Source of feeder cattle is another important trait. Gillespie et al. (2004) suggested that producers who buy their cattle using private treaty are typically interested in specific animal characteristics; they will thus be willing to pay a price premium for animals with these traits. Premiums paid for feeder calves are also based on market specifications such as frame size, breed composition, muscling, coat color, conformation and structure (Sölkner et al. 2008).

Animals having smaller body frames generally tend to reach maturity earlier. When compared to Continental breeds, British breeds are generally smaller in mature size and reach maturity earlier (Greiner, 2009). Gwin (2009) found that tall, lanky cattle may take an extra year or more to finish without grain, increasing production costs. Camfield et al. (1999) showed that large framed steers took a relatively longer time to mature than medium framed steers.

Several criteria must be taken into consideration while making breed selection decisions. Given the limited amount (quantity and quality) of pasture and feedstuffs available, breeds that attain maturity faster should be selected. Breed selection is conducted according to the production system operated (Outlaw et al., 1997). For instance, seedstock operators may prefer crossbreeding programs that utilizes two or more breeds to generate some desired trait. On the other hand, they may exclusively utilize one breed type possessing a desired dominant trait (Knight and Dyer, 2013).

Gender of the animal has an important influence on growth rates and behavior patterns. Bretschneider (2005) found gender as an important factor in determining the pattern of growth, behavior, and eventual carcass composition of beef cattle. Among the reasons for castrating calves are the aggressive behavior, the lower tenderness, and the dark color of meat from intact males (Bretschneider, 2005). Productivity differences between intact males and steers in terms of growth rate, feed conversion, and meat color are important in making breed selection decisions. Other factors responsible for productivity differences between intact males and steers are breed, age at castration, and nutritional conditions (Keane, 1999).

Tano et al. (2003) studied farmer preferences for the following cattle traits: feeding ease, weight gain, disease resistance, reproductive performance, temperament, size, fitness to traction, and fertility in Southern Burkina Faso, West Africa. They found fitness to traction, disease resistance, and fertility to be the most desired bull characteristics. For cows, Tano et al. (2003) found reproductive performance, disease resistance, and feeding ease to be the most preferred traits. A prior understanding of the West African people and their environment helps in understanding this preference behavior. In general, characteristics of the West African people (Southern Burkina Faso) may include (but are not limited to) the following: low literacy levels, they use cattle to perform multiple functions (besides dairy and beef production, cattle are used to pay a dowry), there is low investment in farm inputs, and cattle are exposed to a number of tropical diseases and harsh environmental conditions. Results obtained in Tano et al. (2003) reflect producer preference and production practices of the region—such preference could be unique to the Southern Burkina Faso context.

Animal selection usually focuses on more than one trait. It is important not to overlook any trait for a narrowed selection based solely on a genotype for a marker associated only one trait (Van Eenennaam, 2004). Diversified criteria that employ both traditional and marker-assisted criteria should be employed to ensure retention of economically relevant traits. Different production segments value cattle traits differently. This study estimates preferences for cattle traits by producers operating different productions systems and who are located in different regions across the U.S.

CHAPTER 3: DATA AND METHODS

3.1 Conjoint Analysis

Conjoint analysis describes a broad range of techniques used in evaluating the relative importance that consumers place on product/service attributes. It arose from the consumer theory developed by Lancaster (1966) which assumes that utility is derived from the characteristics of a good rather than the good itself. It is therefore possible to decompose the total utility of a good into separate utilities of its constituent characteristics called the part-worth utilities (Louviere et al., 2000). For the case of cattle selection, conjoint analysis allows for the analysis of farmer preferences for different cattle characteristics in terms of the benefits that they perceive to result from various genetic traits (Tano et al., 2003).

In terms of utility, the choice of a particular hypothetical profile (of an animal with a specific bundle of traits) is a function of the characteristics of that animal, the farmer's socio-economic background, and the interactions between the farmer's background and the characteristics of that animal (Tano et al., 2003). The attributes of a product (rather than the product itself) offer utility. It is therefore possible to design a hypothetical product comprising attributes and levels. Total utility thus becomes the sum of the part-worths for each attribute's levels. In a choice experiment, a number of hypothetical product profiles are presented to respondents to choose the alternatives they prefer. The hypothetical product profiles that respondents choose from are referred to as choice sets. For instance, each choice situation shown in Figure 3 represents a hypothetical animal profile described in terms of levels and traits. Respondents are asked to select one of the three options: "Animal A", "Animal B", or "Neither" (Figure 3). It is therefore very important to provide respondents with enough choices to be able to sufficiently investigate their preferences. However, caution should be taken to avoid overloading respondents with too many choices. Information or attribute overload could force respondents to simplify their choice task by ignoring less important traits or levels. Respondent fatigue and response bias increase as the number of alternatives increases (Louviere et al., 2000).

Choice 1

Attributes	Animal A	Animal B
Weight	550 lbs	650 lbs
Body frame	Small	Small
Temperament	Easy	Difficult
Gender	Heifer	Heifer
Source	Retained	Auction
Color	Non-black	Non-black
Price	$120/cwt	$160/cwt

❖ **Which animal would you retain/purchase for forage finishing if these were the only feeders available?**

- ☐ Animal A
- ☐ Animal B
- ☐ Neither

Figure 3. Sample of a Choice Experiment Question

Conjoint analysis involves three crucial steps. The first step entails the selection of attributes and their respective levels. Both the attributes and levels should be common descriptors of product (in our case cattle) characteristics/traits known by the targeted group of respondents. An important question to guide this step is, "what specific characteristics are valued most by the consumers (or producers) in this segment?" In this study, a list of important cattle characteristics and producer attributes were developed following the information gathered from the available literature and advice obtained from industry experts. Construction of an appropriate experimental design and survey instrument to use in collecting data is the second step. Selection of the model to use in estimating the part-worth utilities is the third step in conjoint analysis. Model selection relies heavily on the way the survey instrument was designed.

3.1.1 Selection of Breed Traits and Levels

Available literature was reviewed to identify the most important/relevant cattle characteristics and levels for grass-fed beef producers. Selection of attributes and their corresponding levels is the first step in any conjoint analysis as it draws directly from the research objectives (Hair et al., 2006). Beef producers have a defined preference structure for specific cattle traits depending on their production systems. Some characteristics are associated with specific breeds of cattle while others overlap across different breeds. For instance, differences exist across breeds on the number of days that an animal stays on feed to attain a given weight, some desired fat thickness, yield grade, etc. Different approaches can be employed in the process of determining attributes and levels to use in a conjoint study. Ouma et al. (2007), Ruto et al. (2008), and Sy et al. (1997) used focus group discussions in their selection of attributes and levels. Tano et al. (2003) employed a participatory consultative procedure in developing their hypothetical products.

Initially for this study, a list of 15 cattle traits was developed based upon literature review, knowledge of the industry, and discussion with producers. This was too many for any useful choice-based conjoint analysis to handle. To retain a desirable set of traits as well as reduce the number of attributes and their levels, experts in the fields of animal science (a ruminant nutritionist) and agricultural marketing were consulted. Follow-up discussion with four Louisiana grass-fed beef producers about the attributes confirmed the appropriateness of these attributes and their levels for the study. Using participatory consultative procedures, Tano et al. (2003) was able to ultimately reduce a list of 14 bull and 15 cow traits to hypothetical profiles of seven traits each, for cows and bulls. As will be discussed in the next section, the number (for our study) was eventually reduced to seven cattle attributes.

3.1.2 Experimental Design

Conjoint analysis may employ one of several designs in collecting data for analysis. Full profile, adaptive, and choice-based designs are the three commonly used designs. As will be discussed later, a full profile design may overload respondents with choices thus compromising the validity of the findings. Adaptive designs utilize a computer software that continually adjusts the questions asked based on responses to preceding questions (Orme, 2003). Traditional conjoint analysis employs ranking or rating of product profiles where respondents are asked to rate each profile based on an interval rating scale selected by the researcher. A rating scale of 0 to 10 has been widely used (Gillespie et al., 1998) with 0 representing the least preferred product and 10 the most preferred product. Although rankings and/or ratings-based conjoint studies provide more information about a product profile, there is increased likelihood of response bias and respondent fatigue as the number of alternatives increases (Louviere et al., 2000).

The choice experiment is a technique of conjoint analysis used for determining the relative importance of a product's attributes in a consumer's choice process. The stated choice method was preferred for the present study because it mimics a real market situation better than rankings or ratings. It allows for the possibility to study tradeoffs between important characteristics including variations in relevant variables observable in the actual field. Researchers can thus guide new animal improvement programs by providing implicit values of cattle traits for producers for the hypothetical profiles described in terms of traits and their respective levels (Tano et al., 2003). Application of the choice experiment in this study required individuals to choose among animals with seven cattle attributes for forage finishing. A smaller number of traits per hypothetical profile eases the respondent's choice task (not having to select from a larger choice frame).

Of the seven attributes considered, five consisted of three levels each and the remaining had two levels each. These attributes were: (1) weight in pounds (lbs) at which the animal is introduced to the forage finishing phase (550, 650, and 750 lbs); (2) body frame, referring to the animal's skeletal size based on its hip height (small, medium, and large); (3) temperament, referring to how easy or difficult it is to handle the animal; (4) gender or sex of the animal (heifer, steer, or intact male); (5) the source of the feeder animal for grass-finishing (retained from own cows, purchased at auction, or purchased via private treaty); (6) the animal's color, referring to the coat color of the animal which was generalized for ease of analysis to two levels, black or non-black; and (7) the price representing the value of the animal per hundredweight (cwt), indicating the price to purchase the animal or the market value of the retained animal for producers who background their animals. Based on the prevailing market prices in 2013 and the previous couple of years, three price levels were chosen ($120, $140, and $160), and are shown in Table 4. Figure 4 illustrates feeder prices in dollars per hundredweight ($/cwt) for 750 pound feeder steers. There has been a significant increase in feeder steer prices (Figure 4) since the time the study was conducted (August 10, 2013). For instance, the price for a 750 pound feeder steer in August, 2013, was about $145/cwt, which was slightly lower than the 5 year average price of $150/cwt. Recent prices shown in Figure 4 indicate a high of about $230/cwt in January, 2015.

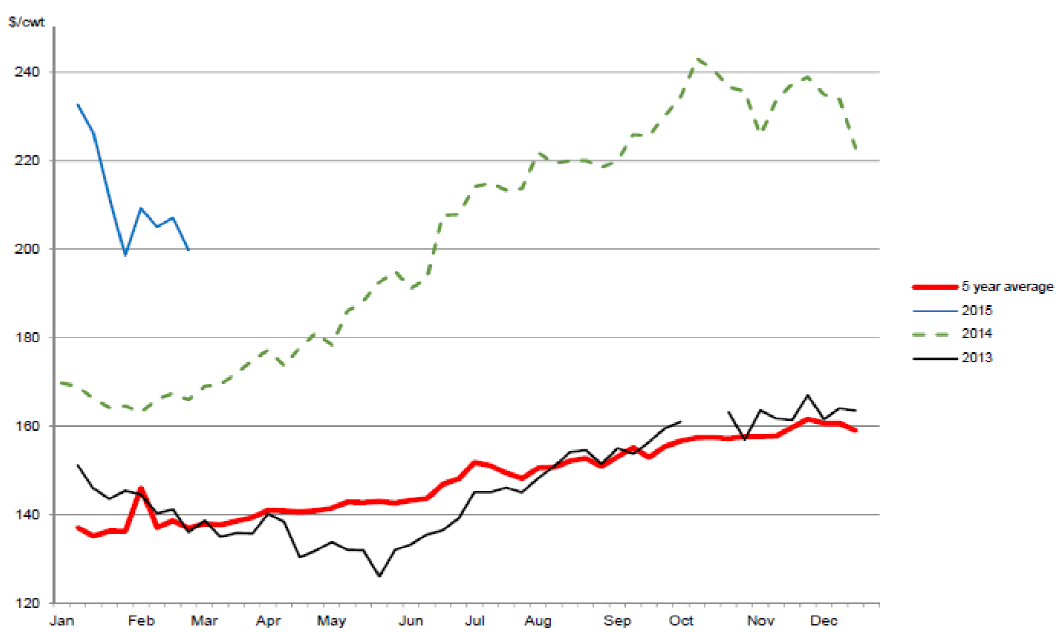

Figure 4. 750 lb Feeder Steer Prices
Source: USDA NASS (2015).

Table 4. Variables Used in the Choice Experiment

Attribute	Level codes
Weight	550 lbs (base level)[a] 650 lbs 750 lbs
Body frame	Small Medium Large (base level)
Temperament	Easy Difficult (base level)
Gender	Heifer Steer Intact male (base level)
Source	Retained Auction Private treaty (base level)
Color	Non-Black Black (base level)
Price	$ 120/cwt $ 140/cwt $ 160/cwt (base level)

[a] indicates the base/reference level.

Respondents were presented with the choice scenario illustrated in Figure 3 consisting of three alternatives. Given the five 3-level and two 2-level traits, a full factorial design would yield (3^5 x 2^2) = 972 profiles. It is practically infeasible to work with such a large number of choice sets. To reduce the number of profiles/choice sets to a manageable size, an orthogonal fractional factorial design having 18 profiles was used. A randomized selection of nine choice sets (pair-wise comparisons of the 18 cattle profiles) was obtained. Each choice scenario in Figure 3 represents a hypothetical animal described in terms of levels and traits shown in the experimental design in Table 4. See the Appendix questionnaire for all nine choice sets.

The primary objective of reducing the number of hypothetical products (animals) while retaining enough information to estimate all part-worth utilities is achieved via the fractional factorial design (Hair et al., 2006; Harrison et al., 2002). The fractional factorial design also ensures that orthogonality (independence among the hypothetical product levels) is maintained

(Hair et al., 2006). A computer generated design maximizing a D-efficiency criterion can also be used to accommodate such an unbalanced 2-level and 3-level attribute mix. Both methods (orthogonal fractional design and D-efficiency criterion) have the same capacity to reduce the number of profiles as well as generate uncorrelated hypothetical profiles (Lusk et al., 2003).

Respondents were asked to select the animal they would retain/purchase for forage finishing. The survey question was framed in the following way, "Suppose you are selecting animals to bring into your herd to raise to slaughter/harvest weight. These could be either *purchased* or could have been *produced from your own cows (retained)*. "Animal A" and "Animal B" will represent hypothetical profiles of animals that could be brought into your herd for forage finishing. You will be asked to choose between these two animals based on the characteristics provided. Other than the characteristics provided, imagine that the animals are identical. If neither is acceptable, then the "neither" option can be chosen".

A brief definition of the attributes was provided as follows, "*Weight* refers to the weight in pounds (lbs) at which the animal is introduced to the forage-finishing phase; *Body Frame* refers to the animal's skeletal size based on its hip height (how big the animal is); *Temperament* refers to how easy or difficult the animal is to handle; *Gender* refers to whether the animal is a heifer, steer, or intact (non-castrated) male; *Source* refers to how you obtain the feeder animals for grass-finishing (retained from own cows, auctions, and/or private treaties); *Color* refers to the coat color of the animal, generalized as either black or non-black for this survey; *Price* represents the value of the animal per hundredweight (cwt). This could be the price paid to purchase the animal or the *market value of the retained animal* (produced from your cows)."

Three options were available to choose from: Animal A, Animal B, or Neither. The inclusion of a "neither" option served as an "opt-out" base and was available for all choices.

Choice experiments have an added advantage of allowing respondents to indicate that they would choose to buy/retain neither option. A survey pretest with four grass-fed beef producers from Louisiana indicated that they were familiar with the selected attributes in the hypothetical profiles and would be comfortable with the nine choice sets developed.

Preference directionality may lead to the existence of dominant options. For instance, there is a danger of the “neither” option dominating the other options. A clear method of handling such dominant options has not been found. Rose and Bliemer (2009) suggested exclusion of such irrelevant options. On the contrary, other studies found no significant impact of such options on the performance of parameter estimates (Mehta, Moore, and Pavia, 1992; Moore and Holbrook, 1990). Louviere, Henser, and Swait (2000) cautioned against the exclusion of such options by arguing that such action could lead to the degradation of the design’s statistical properties.

3.1.3 Data Collection

A survey package was mailed to a total of 1,052 U.S. grass-fed beef producers on August 10, 2013, following the Tailored Design Method recommended by Dillman et al. (2007). The names of grass-fed beef producers were collected via an extensive Internet search. Sources included www.eatwild.com, the American Grass-fed Association, Market Maker, and individually advertised grass-fed beef farms. The package contained a personally addressed and signed cover letter explaining the purpose of the survey, ten-page questionnaire, and a postage-paid return envelope. Two weeks later (August 23, 2013), a postcard reminder was sent to producers who had not responded. A brief explanation highlighting the importance of the survey was provided in the reminder note. A new personally addressed and signed cover letter, a questionnaire, and a return envelope were sent on September 13, 2013, (three weeks following the postcard reminder) to nonrespondents. Finally, a postcard reminder was sent on October 4, 2013, encouraging nonrespondents to complete the survey and thanking those who had already responded. All were sent using first-class mail to improve the possibility that the envelope would be opened, and so that “bad addresses” would be returned. The questionnaire is found in the appendix.

A total of 384 usable surveys were received. Returns from individuals no longer in the grass-fed beef business and bad addresses totaled 117. After adjusting for returns from bad addresses and those from farmers who were no longer in the grass-fed beef business, a 41.1% return rate was obtained. This rate is compared with past studies that used similar approaches, for instance for Louisiana crawfish producers, 15% (Gillespie and Nyaupane, 2010); dairy, 15% (Paudel et al., 2008); and for meat-goat producers, 43% (Gillespie et al., 2013). A similar return rate (41%) was obtained by Gillespie et al. (2007) in their conventional beef producer study of the Louisiana beef industry.

A definition for grass-fed beef was provided at the beginning of the questionnaire to ensure that responses from only grass-fed beef producers were obtained. The definition was, “Grass-fed/finished beef refers to beef from cattle whose lifetime diet consists only of grass and other forage (no grains fed), with the exception of milk consumed prior to weaning. Some would call this forage-fed/finished beef”. The survey was sub-divided into nine sections: Farm operations, breeding and other management practices, selecting animals for grass-finishing, pasture and grazing management, reasons for selecting the grass-fed beef enterprise, goal structure, marketing, important challenges facing the industry, and demographic information. The first question asked respondents if they raised any grass-fed beef cattle at any time during

2012. Those who answered yes were asked to continue with the next question; otherwise, they were to stop and mail back the questionnaire in the envelope provided.

Respondents who indicated that they had raised grass-fed beef at any time during 2012 were requested to proceed with the survey. First, they were to indicate the total number of years they had operated the grass-fed beef enterprise. Number of years in operation is an indicator of grass-fed beef producer experience in the industry. Four production segments were listed for farmers to indicate their participation in: cow-calf, seedstock, stocker, and finishing segments. Respondents were also asked about demographics, farm descriptors, and opinions about the industry.

For the choice experiment, respondents were asked to evaluate nine choice sets and choose the most preferred alternative from each choice set. Respondents were requested to suppose they were selecting animals to bring into their herd to raise to harvest weight. It was clearly stated that these animals could be either purchased or could have been backgrounded (produced from their own cows). Two hypothetical animals, A and B, were provided as indicated in Figure 3. Respondents were asked to imagine/assume that the animals were otherwise identical for any other aspects/traits not represented in the hypothetical profile.

3.1.4 Econometric Methods Used in Part-worth Estimation

As stated earlier, choice experiments arose from consumer theory developed by Lancaster (1966) that postulates that utility is derived from the characteristics of goods. Overall utility can therefore be decomposed into separate utilities for its constituent characteristics. Accordingly, for purposes of our study, grass-fed beef producers derive their utility from cattle attributes rather than cattle per se. McFadden's (1986) random utility theory is defined by a deterministic (V_{ij}) and a stochastic (ϵ_{ij}) component:

$$U_{ij} = V_{ij} + \epsilon_{ij}, \tag{1}$$

where U_{ij} is the *i*th producer's utility of choosing attribute *j*, V_{ij} is the non-stochastic portion determined by the cattle attributes and their value levels, and ϵ_{ij} is the stochastic element. The probability that producer *i* chooses alternative *j* is given by:

$$Prob\{V_{ij} + \epsilon_{ij} \geq V_{ik} + \epsilon_{ik}; for\ all\ k \in C_i\}, \tag{2}$$

where C_i is the choice-set of respondent *i* comprising alternatives A, B, and Neither (*Animal A*, *Animal B*, and *Neither* options in our choice set). Assuming V_{ij} is linear in unknown parameters, the functional form of the utility function may be represented as:

$$V_{ij} = \beta_1 x_{ij1} + \beta_2 x_{ij2} + \cdots + \beta_n x_{ijn}\ , \tag{3}$$

where x_{ijn} is the *n*th attribute for alternative *j* for producer *i*, and β_n represents the coefficients to be estimated. If the stochastic errors (ϵ_{ij}) are independently and identically distributed with the Weibull distribution (extreme value distribution) and the scale parameter is one, then the probability that individual *i* will choose alternative *j* is represented by the following conditional logit model:

$$P_{ij} = \frac{\exp(\beta x_{ij})}{\sum_{l=1}^{M} \exp(\beta x_{il})}. \tag{4}$$

The multinomial logit (MNL) and conditional logit models are the most commonly used logit models for discrete choice conjoint analyses. However, they have a major limitation of imposing unrealistic restrictions on an individual's decision making (Cameron and Trivedi, 2009). The models assume that the introduction of a third alternative should not affect the probability of choosing the first or the second alternative. The choice between any two pairs is simply a binary logit model and does not depend on the availability or attributes of the other alternatives (Cameron and Trivedi, 2009). This is called the independence of irrelevant alternatives (IIA) assumption.

Another important limitation with the conventional MNL model is the assumption outlined in equation (4) that all respondents share the same β coefficient for cattle traits or that all respondents have the same preference for cattle traits. Such an assumption may be unrealistic if respondents' tastes are heterogeneous. Other models have been introduced to account for such heterogeneity and to relax the IIA assumption. They include the random parameters/mixed logit model, the nested logit model, the heteroscedastic extreme value models, and the multinomial probit.

3.1.4.1 Mixed Logit Model (MLM) with Discrete Mixing Distributions

The development of simulation methods such as the simulated maximum likelihood resulted in a breakthrough in estimating more advanced models (e.g. mixed logit and multinomial probit) with relative ease. Advanced discrete choice models have the advantage of producing unbiased estimates of choice probabilities. However, an incorrect model specification may fail to deliver unbiased multivariate truncated normal variates (Henser and Greene, 2002). Multinomial logit models provide the starting points for most empirical estimations. The MNL models help ensure that the data are clean and that sensible results can be obtained from advanced models that depict more complex relationships (Louviere et al., 2000).

The mixed logit model is based on the assumption that there are *N* agents facing *J* alternatives on *T* choice occasions. Individual *i* is assumed to consider the full set of offered alternatives in choice situation *t* and to choose the alternative with the highest utility. The mixed logit is a well-known model where the kernel is the logit formula for a given choice or repeated choices made by an agent (Revelt and Train, 1998; Train, 2008). McFadden and Train (2000) showed the advantage of using the mixed logit to approximate any random utility model to any degree of accuracy with clear specification of variables and a mixing distribution. It is a flexible logit model that allows parameters associated with the observed variable to vary across individuals having a known population distribution. Among the MNL models, mixed logit models are the most flexible (Revelt and Train, 1998; McFadden and Train, 2000; Person, 2002; Bhat, 2003; Greene and Hensher, 2003). The rationality assumption requires agents to choose the alternative that maximizes their utility in each choice occasion.

The utility that individual *i* derives from choosing alternative *j* on choice occasion *t* is defined by the following function:

$$U_{ijt} = \beta_i x_{ijt} + \epsilon_{ijt}. \tag{5}$$

where x_{ijt} is a vector of (non-stochastic) alternative-specific attributes and ϵ_{ijt} is a random term not observed by the analyst and which is assumed to be distributed IID extreme value. Each β_i in vector β' is assumed to be random with unconditional density $f(\beta_i|\emptyset)$ where $\emptyset$ is the distribution of parameters β in the population—such as its mean and covariance (Train, 2008). The traditional McFadden's choice model provides the probability of a sequence of choices made by agent *i*:

$$Pr_i(\beta) = \prod_{t=1}^{T} \prod_{j=1}^{J} \left(\frac{\exp(\beta_i x_{ijt})}{\sum_{l=1}^{M} \exp(\beta_i x_{ilt})} \right)^{d_{ijt}}, \tag{6}$$

where d_{ijt} is a binary variable that equals 1 if respondent *i* chooses alternative *j* in time *t* and 0 otherwise. Conditional on knowing β_i, the probability of respondent *i* choosing alternative *j* on occasion *t* is given by the following conditional logit formula (McFadden, 1974):

$$L_{ijt}(\beta_i) = \frac{\exp(\beta_i x_{ijt})}{\sum_{l=1}^{M} \exp(\beta_i x_{ilt})}. \tag{7}$$

Hole (2007) demonstrated the probability of the observed sequences of choices based on equation (7) conditional on knowing β_i using the following model:

$$S_i(\beta_i) = \prod_{t=1}^{T} L_{ij(i,t)t}(\beta_i), \tag{8}$$

where $j(i,t)$ denotes the alternative chosen by individual i on choice occasion t. Since β_i is unknown, the unconditional probability of the sequence of the observed choices has to be evaluated for any possible values of β_i. This can be accomplished by integrating the conditional probability over the distribution of β:

$$Pr_i(\emptyset) = \int S_i(\beta)\, f(\beta_i|\emptyset) d\beta_i. \tag{9}$$

Equation (9) represents the unconditional probability of the sequence which is the weighted average of the product of logit formulas evaluated at different values of β. It is a general specification because it allows fitting of models with both individual-specific and alternative-specific explanatory variables.

The random parameters logit models can be used to estimate heterogenous preferences by allowing model parameters to vary over respondents. The problem is that it cannot account for the sources of heterogeneity. Boxall and Adamowicz (2002) suggested two possible approaches, which were successfully used by Salomon and Ben-Akiva (1983) and Cameron and Englin (1997) to deal with this problem. Salomon and Ben-Akiva (1983) conducted a multivariate cluster analysis of socio-demographic characteristics, then estimated individual choice models for each homogenous segment. Cameron and Englin (1997) adopted the method of parameterizing scales in binary logit models. Both of these approaches required a priori knowledge of the sources of heterogeneity. Socio-demographics may not be the only source of preference heterogeneity. A model that can incorporate all possible sources of heterogeneity should therefore be used. Latent class models can be used to estimate both the observable and unobservable heterogeneity caused by factors that cannot be observed by the analyst (Greene and Hensher, 2003).

3.1.4.2 Latent Class Model (LCM)

Understanding the form and source of heterogeneity in cattle preferences among grass-fed beef producers is of importance. In this study, we are going to use the latent class models (LCM) to estimate cattle trait preference heterogeneity in the U.S. grass-fed beef industry. The mixed logit model will be used to specify the random parameters which follow a continuous joint distribution across individuals and the latent class logit model will be used to estimate segment-specific parameters. It is possible to endogenously determine the number of segments/classes via the latent class approach. Production systems are part of the finite groups (segments) in the study population. Each segment is characterized by relatively homogenous preferences. However, these segments differ intrinsically in their preference structures. Demographic characteristics of a segment is an example of one cause of such inter-segment preference heterogeneity. Boxall and Adamowicz (2002) argued that attitudinal measures and quantifiable demographic characteristics are the determinants of membership in different classes/segments.

To capture preference heterogeneity, some empirical economists have included demographic characteristics in their demand functions (Boxall and Adamowicz, 2002). A major limitation to this approach is that it requires *a priori* selection of key individual characteristics and attributes. Researchers have limited access to such individual specific variables (e.g. income, debt-to-asset ratios) which are sensitive and considered private. The focus in these cases is on sociodemographic variables. Some researchers have taken advantage of their *a priori* knowledge of variables (Morey et al., 1993) by explicitly incorporating them into their indirect utility functions. However, in the case of random utility models, estimation of heterogeneity is difficult because individual characteristics are invariant among a set of choices (Boxall and Adamowicz, 2002). Some important individual specific variables may also be unobservable to the researcher. Latent class logit models have been developed to address this issue.

The LCM theory suggests that an individual's choice behavior depends on observable and unobservable heterogeneity that vary with factors that cannot be observed by the analyst (Greene and Hensher, 2003). Mixed logit models specify random parameters to follow a continuous joint distribution. Latent class models assume that preference heterogeneity across classes can be sufficiently explained by a discrete number of classes (Shen, 2009). While MLM can account for heterogeneity, they cannot adequately explain the sources of heterogeneity (Boxall and Adamowicz, 2002). Latent class models thus do a better job of incorporating and explaining the sources of heterogeneity. The probability that individual *i* belonging to class *s* chooses alternative *j* in the *t*th choice situation is:

$$P_{ijt|s} = \prod_{t=1}^{T} \frac{\exp(\beta_s x_{ijt})}{\sum_{l=1}^{M} \exp(\beta_s x_{ilt})} \quad s = 1, \ldots, S, \tag{10}$$

where β_s is the class-specific parameter used to capture heterogeneity in preference across classes, x_{ijt} is a vector of alternative-specific traits for individual *i*, and *t* is the number of choice occasions for individual i. A linear probability relation for the specific choice made by individual *i* can be formulated in the following way: let z_{it} denote the specific choice made in the *t*th occasion:

$$P_{ijt} = Prob(z_{it} = j|class = s). \tag{11}$$

This is a panel data sort of application since we assume that the same individual is observed in several choice occasions (Greene and Hensher, 2003). With class assignments, it is possible to estimate the contribution of individual *i* to the likelihood function which is the joint probability of the sequence $z_i = [z_{i1}, z_{i2}, \dots, z_{iT}]$:

$$P_{i|s} = \prod_{t=1}^{T_i} P_{it|s}, \quad (12)$$

where $P_{i|s}$ is the probability of individual *i* being in group *s*, which is the product of individual *i* belonging to group *s* in *t* occasions.

One important issue is the choice of the optimal number of classes to use. Roeder et al. (1999) suggest using Bayesian Information Criteria (BIC) to determine the optimal number of classes. Louviere et al. (2000) suggested other information theoretic criteria that have been widely used such as the Akaike Information Criteria (AIC) and its variant Consistent Akaike Information Criteria (CAIC). The optimum number of classes is at the point where the value of BIC, AIC, and/or CAIC is minimized.

3.1.4.3 Willingness to Pay (WTP)

A measure of economic value can be estimated as the negative ratio of the attribute coefficient and price coefficient using Hanemann's (1984) formula. Producer *i*'s WTP for cattle trait *k* is estimated using the following equation:

$$WTP_{ki} = MRS_{ki} = -\frac{\beta_{ik}}{\beta_{ip}}, \quad (13)$$

where β_{ik} is the coefficient of the *k*th cattle trait for farmer *i* and β_{ip} is the marginal utility of income for farmer *i* (coefficient of the price attribute). It is often interpreted as the marginal rate of substitution (MRS) between animal attributes and money (marginal implicit prices).

Alternative methods of eliciting WTP have been developed. Many economic studies have used contingent valuation methods to elicit people's WTP to determine the monetary value attached to non-market goods (Olsen and Smith, 2001). This method, however, is prone to many biases arising from the experimental designs used (in data collection) and data analysis methods (Damschroder et al., 2007). Smith and Richardson (2005) elicited WTP using open-ended survey questions to obtain personal use values of some treatment options in their clinical study (e.g. "how much would you be willing to pay to be cured?"). Researchers have, however, questioned the validity of open-ended questions because of the high number of non-responses and tendencies of skewed responses towards high values (Damschroder et al., 2007).

The advantage of using conjoint analysis techniques in measuring WTP is that it is possible to elicit WTP values for multiple attributes simultaneously. Holmes and Adamowicz (2003) pointed out that statistical designs used in conjoint analysis can allow for the reduction in collinearity among variables. DeShazo and Fermo (2002) argued that conjoint techniques can be used to estimate the marginal benefits that consumers derive from individual attributes of non-market goods.

Choice-based conjoint studies have been used to estimate consumer preferences for specific attributes of beef. Lusk et al. (2003) estimated the WTP for beef attributes for consumers from four countries: France, Germany, UK, and the United States. They compared consumer preferences for beef ribeye steaks from cattle raised without growth hormones or genetically modified corn. Results from Lusk et al. (2003) indicate that European consumers were willing to pay a higher price (premium) for steaks from animals that were not fed genetically modified corn than U.S. consumers.

Loureiro and Umberger (2003) estimated consumer willingness to pay for country-of-origin labeling. Results indicated that consumers were willing to pay an average of $184 per household annually for a mandatory country-of-origin labeling. Female respondents were also more likely to pay a premium for the mandatory country-of-origin labelling program than male respondents (Loureiro and Umberger, 2003). Lusk and Parker (2009), Steiner et al. (2009), Umberger et al. (2002), and McCluskey et al. (2005) are additional studies that have used willingness to pay valuations.

3.2 Independent Variables Used

A discussion of the independent variables used in the current study is provided in this section. Age, education level, total number of cattle raised on the farm, percentage of annual net farm income from the grass-fed beef enterprise, production system (whether or not it was a cow-calf operation), and the region of the U.S. where the farm was located were the independent variables included. Age was used as an indicator of experience in the industry. Preference for cattle traits may vary by age of grass-fed beef producers. Ouma et al. (2007) showed that producer age impacted the choices they made in selecting animals to raise on their farms. For instance, estimated coefficients indicated that "Class 2" members were most likely to be young crop-livestock (operating both crop and livestock enterprises) farmers who preferred trypanotolerant, cheap bulls having good traction potential and high live-weight (Ouma et al., 2007).

Education level was used to evaluate the impact of holding a college degree on the selection of cattle for finishing. A dummy variable indicating whether or not the grass-fed beef producer held a 4-year college degree was used. Abdulai et al. (2005) found a significant negative relationship between the duration of time required for a farmer to adopt a new crossbred cow technology and the number of years of schooling. They found that more educated farmers (in this case, having many years of schooling) were more likely to adopt/buy improved cattle breeds than the less educated. Education level was a significant determinant of class membership in Ouma et al. (2007), where “Class 2” membership was characterized by low levels of education and a preference for bulls that were tolerant to trypanosomosis and were lower priced.

To capture the impact of the scale of operation on animal selection, the total number of cattle raised was included as an independent variable. Economic theory suggests that economies of scale are associated with increasing the number of inputs (in our case, cattle raised) to a certain point beyond which any further increase results in diseconomies of scale (Caves et al., 1982). As the total number of cattle raised on the farm increases, the producer decision/choice on what animals to purchase/raise may change. The percentage of annual net farm income from the grass-fed beef operation was used as an indicator of diversification on the farm. Enterprise diversification implies operating multiple enterprises. In our case, a farmer operating a dairy, goat, sheep, or crop enterprise in addition to the grass-fed beef enterprise would be operating a more diversified farm. A lower percentage of annual net farm income from the grass-fed beef operation suggests greater diversification. Producers opt to diversify their operations if it is less costly to do so resulting in economies of scope (McNamara and Weiss, 2005). Hall et al. (2003) found diversification to be a viable management tool against the following risk factors: cattle price variability, hay price variability, and severe drought.

Cow-calf operators may have distinct preferences for cattle traits from those operators who simply finish animals (Outlaw et al., 1997). Thus, we are including the dummy variable for involvement in the cow-calf segment of the beef industry. Sy et al. (1997) found that breeders valued animal reproductive traits more than product (beef or milk) traits. For example, they found breeders to emphasize weaning weight and fertility over carcass yield and slaughter weight; cow-calf operators emphasized calving ease and temperament over carcass yield and muscling. Regional variables were included to capture regional differences in preferences for cattle traits. Regional differences are expected to be found since some regions such as the Southeastern U.S. are more likely raise animals that are more heat tolerant than the Northern states.

In the next section, additional analysis of important animal traits using an ordered probit model will be discussed. The model will be used to determine producer perception of the importance of the selected cattle traits based on the independent variables discussed above. Comparison of output from conjoint analysis and the ordered probit model based on these independent variables will clearly indicate the sources of preference heterogeneity. These are the covariates that will be used as perception drivers in the ordered probit and membership variables in the latent class models.

3.3 Additional Analysis of Animal Traits for Grass-Finishing

Additional comparison of the relative importance of ten cattle attributes was deemed necessary. Ten cattle attributes were evaluated to determine producer perceptions of their importance in breed selection decisions. Results were compared with those obtained from conjoint analysis to check if any inconsistencies existed in producer preferences. Conjoint analysis was used to estimate grass-fed beef producer preference for seven specific cattle traits/attributes with their respective levels, while additional analysis on general traits (using an ordered probit model, to be discussed in the next section) was used to provide a general producer perception of the level of importance of the 10 cattle traits.

In the mail survey questionnaire, respondents were asked the following question: “How important are each of the following attributes in your selection of grass-fed beef animals to produce on your farm?” The cattle attributes considered were: breed, expected average daily weight gain, frame score/body frame, expected carcass yield, disease resistance, expected reproductive performance, temperament, heat tolerance, hide/coat color of the animal, and parents of the animal were never fed grain. Importance of cattle attributes/traits were ranked on a response scale of 1 to 4 with 1 indicating “Not important at all and 4 indicating “Highly important”. The means, medians, and modes of responses for each attribute were estimated in order to determine the most and the least important of each of the 10 selected animal attributes.

3.3.1 The Ordered Probit Model

Ordered probit models allowed us determine the types of producers most likely to consider each of the ten cattle attributes to be of importance in selecting cattle to raise on their farms. This ordered probit model is useful in multivariate analysis where there is an ordinal dependent variable (Greene, 2000, p. 875). Each cattle trait/attribute contains four possible responses, $k = 4$, with 1 associated with “Not Important at All” and 4 associated with “Highly Important”. The undesirable consequence of using a linear regression model for such a problem is its implicit assumption of equality of scales in describing closely related attributes. For instance, linear regression assumes the difference between a *Not Important at All* response and a *Somewhat Important* response to be the same as that between a *Somewhat Important* and a *Very Important* response. Since responses in this case reflect ordinality, we lack sufficient evidence to prove that the differences are the same (Daykin and Moffatt, 2002).

The model divides the domain of an *N (0, 1)* distribution into k categories defined by k – 1 cutpoints, c_1, c_2, c_{k-1}. It assumes that individual respondents have a score,

$$s_i = X\beta + \varepsilon, \quad (14)$$

where the error term, $\varepsilon \sim N(0,1)$, β is a vector of parameters estimated, and *x* is a vector of respondent characteristics relevant in explaining his or her attitudes. The score, s_i, represents individual i's response to the survey question with values 1, 2. . . k. The score and the cutpoints are then used to generate probabilities for each respondent's weight placed on the *m* cattle traits.

Interest of the current study is not the interpretation of the cutpoints values but the directional effect of the independent variables used. Independent variables that were used in the ordered probit models were the same as those used as membership variables in the conjoint analysis. Signs on the parameter estimates of the ordered probit model were compared with those on the coefficients obtained from CLM, MLM, and LCM. For instance, the ordered probit considered breed as a general attribute while conjoint analysis provided results of producer preferences for its constituent characteristics such as weight, body frame, temperament etc. According to Scarpa et al. (2003), the term "breed" represents a collection of genes responsible for a recognizable set of phenotypic traits, which may be significantly different from those of other breeds. Results from the analysis of these traits is thus essential for livestock farmers, breeders, and marketers.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 A Summary Statistics of U.S. Grass-fed Producers

A description of U.S. grass-fed beef producers based on their production, socioeconomic, demographic, and geographic characteristics is provided in this section. By examining the overall distribution of survey responses from across the United States as represented in Figure 5, we see that responses were received from 46 of the 50 states. The darkest shaded states, Wisconsin and New York, recorded the highest response rates with 20-30 respondents each. North Dakota, Delaware, Alaska, and Hawaii were the only states that recorded zero-responses. Most states were represented by at least some individuals ranging between 1-12 respondents.

Summary statistics in Table 5 indicate that the vast majority (81%) of the 384 respondents produced their own calves for forage-finishing; 22% obtained feeders for grass-finishing via private treaty, and the smallest proportion (3%) of respondents purchased their feeder animals via auctions. Ten percent were certified organic grass-fed beef producers. Eighty percent were involved in the cow-calf segment. The average number of cattle on the farm was 127 animals. Existence of a large variance in the number of cattle raised was evidenced by its large standard deviation, 371.69. Seventy percent of respondents held 4-year college degrees. About 49% of the average farm’s annual net farm income came from grass-fed beef (on the survey, the range was between 40-59%). Not reported in Table 5 is the level of response by gender, where the majority of the respondents were male, accounting for 75% of the sample. On average, the total number of animals raised to slaughter weight was 40 head with a standard deviation of 127.13. This suggests a relatively high degree of variation in the scale of operation by responding producers. About 85% of respondents accessed the Internet for grass-fed beef information. The average number of years operating the grass-fed beef enterprise was 11 years.

Table 5. Summary Statistics of Variables Used.

Independent Variables	Unit Description	Mean	SD
Own Calves	= 1 if feeders from own calves, 0 otherwise	0.81	0.40
Private Treaty	= 1 if feeders form private treaty, 0 otherwise	0.22	0.42
Auction	= 1 if feeders from auction, 0 otherwise	0.03	0.18
Certified Organic	= 1 if certified organic, 0 otherwise	0.10	0.30
Cow-calf	= 1 if cow-calf producer, 0 otherwise	0.80	0.40
Total Number of Cattle	Total number of grass-fed beef animals	126.78	371.69
# Raised Slaughter	Total number of animals raised to slaughter	40.01	127.13
Sold Beef as Meat	= 1 if sold beef as meat, 0 otherwise	0.95	0.22
% Income from GFB	% of annual farm income from grass-fed beef	49.20	-
Access Internet	= 1 if accessed internet, 0 otherwise	0.85	0.36
Age	Age of the producer	54.66	13.73
Years of Operation	# of Years operating grass-fed beef enterprise	11.32	8.05
College Education	= 1 if held a 4-year college degree, 0 otherwise	0.70	0.46
Northeast	= 1 if farm was in the Northeast, 0 otherwise	0.22	0.41
Southeast	= 1 if farm was in the Southeast, 0 otherwise	0.15	0.34
Northwest	= 1 if farm was in the Northwest, 0 otherwise	0.18	0.38
Southwest	= 1 if farm was in the Southwest, 0 otherwise	0.11	0.28
Midwest	= 1 if farm was in the Midwest, 0 otherwise	0.33	0.47

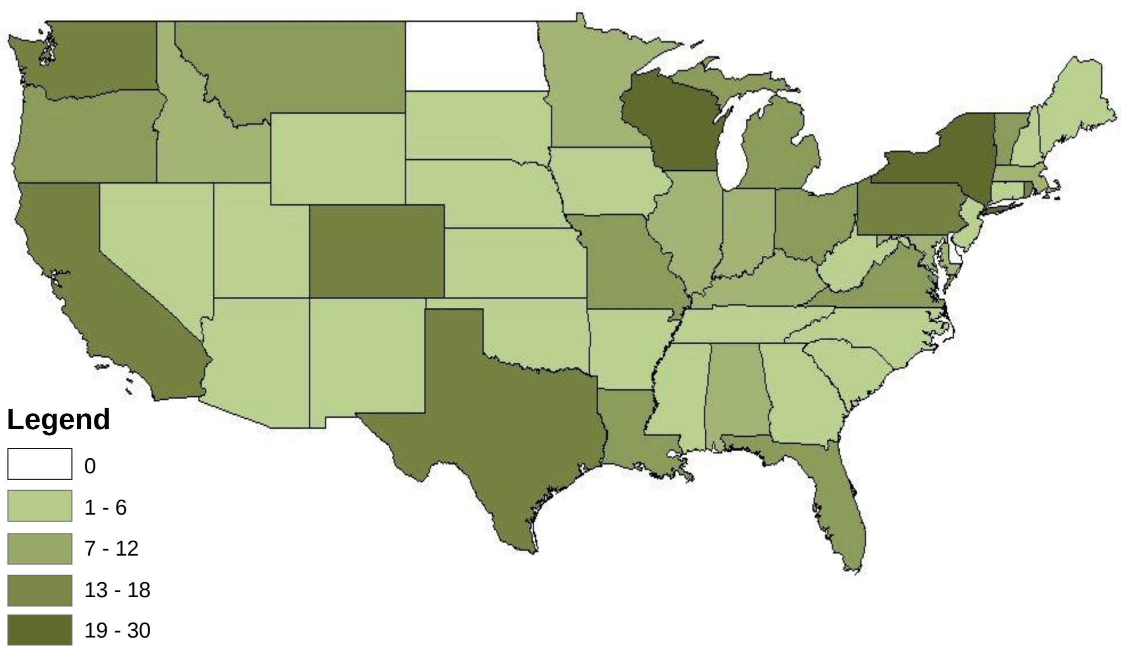

Figure 5. Distribution of Grass-Fed Beef Respondents in the United States

Of the five U.S. regions specified, a relatively large majority (33%) of respondents were located in the Midwest, 22% in the Northeast, and 18, 15, and 11% in the Northwest, Southeast, and Southwest, respectively. USDA Agriculture Research Service (2013) indicates that livestock productivity is affected by its geographical location in at least one of the following ways: pasture and forage crop availability, animal growth and reproduction, and disease and pest distributions. Adaptation to different geographical locations is partially determined by the type of cattle or breed raised.

As shown in Table 6, British breeds were raised by more than half of the respondents, 66%, with an additional 18% of respondents raising British crosses with Continental and/or Brahman. Other findings from the survey (not reported in Table 6) indicate that Angus and Angus crosses were the most popular breeds. The most likely reasons could be associated with the smaller body frames of British (Angus) breeds and the perception that black animals produce higher quality of beef, such as certified Angus beef. Furthermore, animals having small body frames reach maturity weight earlier, reducing the amount of feed and labor required per animal (Greiner, 2009). Of the 47 breed types indicated by respondents of the survey to be used, approximately 57% of respondents indicated that they raised Angus and/or Angus crosses. This supports previous studies (Lozier et al., 2005) that found Angus and Angus crosses as the most favored breeds raised by more than 50% of their grass-fed beef producer respondents.

Table 6. Animal Breed Types Produced and the Percentage of Producers.

Animal Breed Types	Percentage Keeping
British	66
Cross British and Continental	9
Cross British and Brahman	5
Continental	4
Cross British, Continental, and Brahman	4
Brahman	2
Cross Brahman and Continental	0

4.2 Importance of Cattle Attributes Using a Likert Scale

A summary of the ten cattle traits evaluated using Likert scale responses is provided in Table 7. Means, standard deviations, modes, and percentages for each category are provided. The most important attribute considered by grass-fed beef producers in selecting animals to produce on their farms is temperament. As indicated in Table 7, the mean response for temperament was 3.59 with 67% of respondents indicating that it is a highly important attribute considered in their animal selection. Disease resistance followed next with a mean of 3.19 and "Very Important" as the modal response. Expected reproductive performance followed with a mean of 3.03 and "Highly Important" as the modal response. Forty-four percent of respondents indicated that expected reproductive performance is a highly important attribute in animal selection. Body frame and expected carcass yield tied with means of 3.02 each and the same modal response, "Very Important"; with 55 and 50% of respondents indicating that body frame and expected carcass yield, respectively, were very important attributes in animal selection.

Table 7. Important Attributes Considered in Selection of Grass-fed Beef Animals to Produce.

Attributes	Mean	Mode	Not Important at All %	Somewhat Important %	Very Important %	Highly Important %
Temperament	3.59	Highly Important	1	8	25	67
Disease resistance	3.19	Very Important	3	16	41	40
Expected reproductive performance	3.03	Highly Important	14	12	30	44
Frame score/body frame	3.02	Very Important	2	18	55	25
Expected carcass yield	3.02	Very Important	2	21	50	27
Breed	2.94	Very Important	4	29	35	32
Expected average daily weight gain	2.82	Very Important	4	30	45	21
Heat tolerance	2.61	Very Important	14	32	34	20
Parent animals were never fed grain	2.24	Not Important at all	33	30	17	20
Hide/coat color of the animal	2.12	Not Important at all	35	30	22	13

Mean: 4=highly important, 3=very important, 2=somewhat important, 1=not important at all

Breed is a specific attribute indicating whether the animal is Angus, Hereford, Charolais, Brahman, etc. Different breeds generally display particular cattle attributes such as temperament, body frame, etc. The mean response for breed was 2.94 with 35% of respondents indicating that it is a very important attribute in animal selection (Table 7). Lozier et al. (2005) found breed as the most important criteria farmers used when selecting animals to purchase. Keane and Drennan (2009) found that carcass weight was significantly greater for Aberdeen Angus (British) than for Friesian (Continental) steers. Expected average daily weight gain and heat tolerance were rated as very important attributes in animal selection with means of 2.82 and 2.61, respectively—45 and 34% of respondents, respectively. The attribute, "Parents of animals were never fed grain", followed with a mean of 2.24 and "Not Important at All" as the modal response. Hide/coat color was the least important attribute with a mean of 2.12 and "Not Important at All" as the modal response, with 35% of respondents indicating that it was not important at all in animal selection. It is important to understand the determinants or drivers of producer responses shown in Table 7. Analysis of the effect of farm and farmer characteristics on the responses received is provided in the next section.

4.3 Ordered Probit Results

Using ordered probit models, we were able to determine the factors impacting farmers' perceptions of the importance of each of the ten attributes. The ordered probit model is useful in multivariate analysis where there is an ordinal dependent variable and the researcher desires to determine the impact of potential drivers on the dependent variable. Differences in producer tastes or preferences for cattle traits depend on the farm and farmer characteristics. For instance, new grass-fed beef producers with less than one year of experience in the industry may opt to first optimize on the reproductive or production-related cattle traits before the market-related traits. Nicole (2015) pointed out the need to first be reproductively efficient before concentrating on the “icing on the cake” of the carcass. Concentration on carcass genetics, “icing”, may begin once a base of animals having the necessary phenotype and maternal features has been built (Nicole, 2015).

The estimated coefficient for cow-calf producers is positive and highly significant at the 1% level for temperament (Table 8). This indicates that cow-calf producers were more likely to consider temperament as an important attribute in animal selection. Maternal traits play a crucial role in ensuring calf viability (Lorenz et al., 2011). Good maternal traits (mild temperament, calving ease etc.) can significantly impact calf health and thus reduce calf morbidity and mortality on cow-calf farms (Lorenz et al., 2011).

Older, larger-scale (in terms of number of cattle raised) grass-fed beef producers were more likely to consider temperament as an important attribute in animal selection. The farm size result was expected given the increased management demands with more animals on the farm. Livestock management practices such as vaccination, dehorning, feeding, and castration can be carried out more easily if the animals are less aggressive and easy to handle. Likewise, those producers who received higher percentages of net farm income from grass-fed beef production and those specializing in the enterprise (grass-fed beef production) were more likely to consider temperament as an important attribute (Table 8).

On the other hand, grass-fed beef producers who sold grass-fed beef as meat (relative to those who sold live animals) and those from the Northeast and Northwest (relative to those from the Midwest) were less likely to consider temperament as an important attribute in selecting animals to raise on their farms.

Table 8. Estimates from the Ordered Probit Model for Cattle Attributes.

Producer Attributes	Temperament	Disease Resistance	Reproductive performance	Body Frame	Carcass Yield
Cow-Calf	0.4720***	0.2209***	1.5001***	0.3493***	0.2343***
Total Number of Cattle Kept	0.0002**	0.0001	0.0002**	0.0004	0.0001***
Sell Grass-Fed Beef as Meat	-0.6748***	-0.0228	-0.4089***	-0.0079	0.2090***
% Income From Grass-Fed Beef	0.0204**	0.0397***	0.0186**	0.0138*	0.0159**
Age	0.0055***	0.0033***	0.0006	-0.0112***	0.0064***
Years of Operation	0.0003	0.0034**	0.0009	0.0118***	-0.0027
College Degree	0.0368	0.0153	-0.1030***	0.1702***	-0.0532**
Northeast	-0.3571***	-0.0672**	-0.0236	-0.0055	0.1680***
Southeast	0.0855	-0.0403	-0.1945***	0.1989***	0.3832***
Northwest	-0.3518***	-0.1049***	-0.1528***	-0.2638***	0.2251***
Southwest	0.1180**	-0.3296***	-0.1275***	0.2497***	0.6612***

(*), (**), and (***) denote significant variables at 10%, 5%, and 1% levels, respectively

Producer Attributes	Breed	Average Daily growth	Heat tolerance	Parent animal never grain-fed	Coat color
Cow-Calf	0.3491***	0.1745***	0.3102***	0.3314***	0.3895***
Total Number of Cattle Kept	0.0015***	0.0076***	-0.0001***	-0.0003***	0.0234
Sell Grass-Fed Beef as Meat	-0.2920***	0.1167*	0.4836***	0.0630	-0.5235***
% Income from Grass-Fed Beef	0.0185***	0.0153**	0.0566***	0.0319***	0.0862***
Age	0.0215***	-0.0007	0.0035**	0.0013	0.0346***
Years of Operation	0.0115***	0.0012	0.0001	0.0113***	-0.0309***
College Degree	0.0530**	0.0669***	0.1586***	-0.2721***	-0.2402***
Northeast	-0.1667***	-0.0401	-0.5081***	0.1177***	-0.0359
Southeast	0.0160	0.5442***	0.5827***	0.3106***	0.4976***
Northwest	0.0166	0.0347	-0.8380***	-0.0779	0.0406
Southwest	-0.0293	0.3753***	0.3834***	-0.6034***	-1.0425***

(*), (**), and (***) denote significant variables at 10%, 5%, and 1% levels, respectively.

Kadel et al. (2006) found that better temperament was genetically correlated with improved meat tenderness. Meat attributes (such as tenderness and flavor) have been widely studied in most consumer-related studies. Umberger et al. (2002) found flavor and tenderness as the most preferred attributes by 93% of respondents. Beef producers find such information about consumer preference helpful in making their production and marketing decisions. The strong correlation between better temperament and improved meat tenderness (Kadel et al., 2006), coupled with management related benefits (of mild temperament) raises the level of importance of the attribute to beef producers—especially to grass-fed beef operators. Grass-fed beef operators have a significant amount of interaction with their animals, especially those who operate rotational grazing systems which require regular movement of animals from one grazing unit to another. Temperament is thus a crucial trait valued by most grass-fed beef producers. Additionally, grass-fed beef takes a relatively longer period of time to produce, implying a significant duration of animal-operator interaction period.

The estimated coefficient for cow-calf producers is positive and highly significant at 1% level for body frame (Table 8). This indicates that cow-calf producers were more likely to consider body frame as an important attribute in animal selection. Lankister et al. (1999) underscored the importance of body frame in selecting animals to produce. Greiner (2009) and Gwin (2009) pointed out specifically the relevance of small body frames in reducing the length of time and feed (consequently reducing the total cost of production) required for an animal to attain market weight.

As indicated by a positive and significant coefficient, body frame is a more important attribute to producers specializing in grass-fed beef production (Table 8). Older, college-educated, and more experienced (in terms of the number of years operating the grass-fed beef enterprise) grass-fed beef producers were more likely to consider body frame as an important cattle attribute in selecting animals to raise on their farms (Table 8). Relative to producers from the Midwest, producers from the Southeast and the Southwest were more likely to consider body frame as an important attribute in animal selection. On the other hand, producers from the Northwest (relative to those from the Midwest) were less likely to consider body frame as an important attribute.

Older, larger-scale grass-fed beef producers, and those who sold grass-fed beef as meat were more likely to consider carcass yield as an important attribute in selecting animals for grass-finishing (Table 8). Similarly, college-educated producers with higher percentages of annual income from grass-fed beef were more likely to place more importance on carcass yield when selecting animals to raise on their farms. Relative to producers from the Midwest, those from the Northeast, Southeast, Northwest, and Northeast were more likely to consider carcass yield as an important trait in animal selection.

Older, more experienced, larger-scale cow-calf producers were more likely to consider breed as an important cattle trait in selection of animals to raise on their farms. On the other hand, producers who sold beef as meat were less likely to consider breed as an important trait when selecting animals. The genetic basis of cattle breeds and their comparison can be easily misunderstood. According to Bogart and Taylor (1983), “there is more variation within a breed than there is between breeds.” A given animal breed can represent a collection of genes responsible for a recognizable set of phenotypic traits (Scarpa et al., 2003). For instance, the Angus breed can be either black and polled or red and polled. It is important therefore to decompose breed into its constituent characteristics (black, red, polled, horned, bull, heifer) when analyzing producer preferences for cattle to raise on their farms. We will focus on a set of constituent characteristics of cattle breeds (trait levels) in the next section using conjoint analysis.

The estimated coefficient for average daily growth was positive and highly significant for college-educated, larger-scale, cow-calf grass-fed beef producers. The estimated coefficients for producers who sold beef as meat and those with higher percentages of net annual farm income from grass-fed beef were positive and significant at the 10 and 5% levels, respectively. A plausible reason for the latter could be that grass-fed beef production contributes more to annual net farm income (if operating multiple enterprises) and thus becomes of more economic importance relative to the other farm enterprises.

More experienced cow-calf producers were more likely to consider the attribute that the parent animal was never grain-fed as an important cattle trait during selection. On the other hand, college-educated, larger-scale grass-fed beef producers and those with higher percentages of total net income from the grass-fed beef operation were less likely to consider this as an important trait in animal selection. Relative to producers located in the Midwest, those producers in the Northeast and Southeast were more likely to consider “parent animal was never grain-fed” as an important trait in animal selection while those located in the Southwest were less likely (relative to the Midwest) to consider it important.

An analysis of the importance of coat color indicated that cow-calf producers placed more importance on the attribute. The positive and significant age coefficient indicated that older grass-fed beef producers placed more importance on the coat color attribute in selecting cattle to produce. On the other hand, experienced, college-educated grass-fed beef producers, and those who sold beef as meat were less likely to consider coat color as an important attribute in animal selection. Relative to producers from the Midwest, those from the Southeast were more likely to consider coat color as an important trait in animal selection.

Generally, the grass-fed finisher who simply purchases animals for finishing has to deal with the animal for a short time (few months) and then it is slaughtered. The cow-calf producer deals with the cow for a relatively longer time (say at least 10 years), as well as its offspring, so it is important that they select for the traits they want early-on. This may partially explain why cow-calf producers were more likely to rate all of the attributes as more important. Producers more specialized in grass-fed beef production were also more likely to find all of the listed attributes important. The likely reason could be that their livelihood is dependent upon selecting the best animals in all regards.

4.4 Conditional Logit Model (CLM) Results

The conditional logit model used to estimate grass-fed beef producer preferences for cattle traits was formulated as follows:

$$U_{ij} = \beta_1 Weight_{ij} + \beta_2 Bframe_{ij} + \beta_3 Temperament_{ij} + \beta_4 Gender_{ij} + \beta_5 Source_{ij} + \beta_6 Color_{ij} + \beta_7 Price_{ij} + \varepsilon_{ij}, \qquad (15)$$

where U_{ij} is the utility that the *i*th producer obtains for choosing alternative j. Equation 15 represents cattle attributes defined by the levels shown in Table 4 and Figure 3 (sample of choice experiment question). Six variables were dummy-coded, with price being the only continuous variable. Large body frames, difficult to handle, 550 pound-body weight, intact males, black coat color, and private treaty were used as the reference/base levels (Table 4), and thus were coded as zero. As specified in Table 4, $Weight_{ij}$ define the levels of attribute, weight; where 550 lbs = 0, 650 lbs = 1, and 750 lbs = 0 represents the 650-lb animal; and 550 lbs = 0, 650 lbs = 0, and 750 lbs = 1 represents the 750-lb animal. The variable $Bframe_{ij}$ defines the levels of attribute, body frame; where small = 1, medium = 0, and large = 0, represents a small body framed animal; and small = 0, medium = 1, and large = 0, represents medium body framed animal. The variable

$Temperament_{ij}$ defines the levels of attribute, temperament; where easy = 1 and difficult = 0 represents an easy-to-handle animal, and easy = 0 and difficult = 1 represents a difficult-to-handle animal. The variable $Gender_{ij}$ defines the levels of attribute, gender; where intact male = 0, steer = 1 and heifer = 0 represents steer; and intact male = 0, steer = 0 and heifer = 1 represents heifer. The variable $Source_{ij}$ defines the levels of attribute, source; where auction = 0, retained = 1, and private treaty = 0 represents retained; and auction = 0, retained = 0, and private treaty = 1 represents private treaty. The variable $Color_{ij}$ defines the levels of attribute, color; where black = 0, and non-black = 1 represents non-black; and black = 1, and non-black = 0 represents black. The variable $Price_{ij}$ defines the continuous variable, price (value of the animal per hundredweight).

The conditional logit model (CLM) provides a basic and relatively easy way of estimating preferences by the method of maximum likelihood. Use of the CLM is, however, limited by its assumption of independence of irrelevant alternatives—it precludes all irrelevant alternatives from analysis. Assumption of homogeneous preferences among respondents is another limitation with the use of the CLM. The latter assumes that the estimated taste parameters (coefficients) are the same for all grass-fed beef producers who responded to the choice experiment question. The reality is, however, that respondents are diverse by virtue of their socio-economic characteristics (age, education, religion, farm size etc.)—both quantifiable and non-quantifiable attributes.

Results of the CLM show that six of the seven cattle traits are significant determinants of choice of cattle to raise (Table 9). Cattle traits/attributes are the key features of the hypothetical profiles (Figure 3 and Table 4); levels of traits are the specific quantities of interest in a choice experiment. Using the CLM, Color and Weight (Non-black and 750 lbs levels, respectively) were found to be the only two attribute levels that were not statistically significant in influencing grass-fed beef producer choice of cattle to raise on their farms. However, as will be discussed later, the more advanced (random parameters/mixed logit and/or latent class) models generated significant estimates for these attribute levels.

Using the CLM, easy-to-handle animals with small body frames at 650 lbs were the preferred feeder cattle for grass-finishing (Table 9). Positive and highly significant estimates for steers and heifers indicate respondents' strong preference for steers and heifers relative to intact males. Gender determines the pattern of growth, behavior, and eventual carcass quality (color, taste, flavor, etc.) of beef (Bretschneider, 2005).

Table 9. A Comparison of CLM and MLM parameter estimates.

Cattle traits	Levels	CLM	MLM	SD[1]
Weight	650 lbs	0.3486^{**}	0.7534^{***}	0.5321
		(0.1431)	(0.1995)	(0.4045)
	750 lbs	0.0296	0.3330^{**}	0.2325
		(0.1540)	(0.1767)	(0.2915)
Body frame	Small	1.2150^{***}	1.0753^{***}	1.0214^{***}
		(0.1670)	(0.1953)	(0.1829)
	Medium	1.0262^{***}	0.7551^{***}	0.4062^{**}
		(0.1351)	(0.1443)	(0.1688)
Temperament	Easy	3.4100^{***}	3.5656^{***}	1.2610^{***}
		(0.1393)	(0.2007)	(0.1588)
Gender	Heifer	1.1326^{***}	1.2453^{***}	-0.9757^{***}
		(0.1726)	(0.2185)	(0.2426)
	Steer	1.1331^{***}	1.4222^{***}	1.1922^{***}
		(0.1274)	(0.1672)	(0.1605)
Source	Retained	1.0158^{***}	0.8231^{***}	-1.0607^{***}
		(0.1304)	(0.1645)	(0.1946)
	Auction	-1.0160^{***}	-1.1580^{***}	-0.7656^{***}
		(0.1570)	(0.1707)	(0.1727)
Color	Non-black	-0.0182	-0.2736^{**}	0.8006^{***}
		(0.1128)	(0.1339)	(0.1492)
Price		-0.0307^{***}	-0.0297^{***}	-0.0153^{***}
		(0.0011)	(0.0016)	(0.0011)
LR Test		3267.85^{***}	726.25^{***}	
Log likelihood		-4846.3568	-2347.5902	

Standard errors in parenthesis; (*), (**), and (***) denote significant variables at 10%, 5%, and 1% levels, respectively. SD[1] Mixed logit standard deviation

The estimated coefficient for auction was negative and statistically significant at the $P \leq 0.01$ level indicating that on average, grass-fed beef producers do not prefer to source their animals via auction relative to sourcing via private treaty (Table 9). The negative sign on the auction coefficient indicates disutility associated with auction as a source of feeder cattle for grass-finishing relative to private treaty. As expected, the estimated price coefficient was negative and highly significant at the $P \leq 0.01$ level, indicating disutility associated with increasing the prices of feeder cattle.

Consistent with the Likert scale results in Table 7, temperament was found to be the most important attribute in selecting the type of animals to raise on the farm. To determine this, the relative importance of each attribute was calculated. The range of each estimated attribute's levels (the difference between the highest and lowest estimated coefficients for the attribute) was divided by the sum of the ranges across all attributes (Mayen et al., 2007). Temperament accounted for 37% of the relative importance of the attributes (Table 10). Source was the second-most important attribute with 22% relative importance in cattle selection. Price followed with 13%, body frame 12%, gender 10%, and weight 4% (Table 10). The relative importance of coat color was slightly below 1%, consistent with the lower importance of coat color in the individual Likert scale attribute analysis.

Table 10. Relative Importance of Cattle Attributes.

	Relative Importance (%)	
Cattle Attributes	CLM	MLM
Temperament	37.5	34.8
Source	22.3	19.3
Price	13.5	11.6
Body Frame	12.3	10.5
Gender	9.7	13.9
Weight	3.8	7.3
Coat Color	1.0	2.7

4.4.1 Willingness to Pay Results from the CLM

The parameter estimates of the CLM provided the directional effects of the traits on preference. To obtain the magnitude of the effect, values for producer willingness to pay were estimated—the marginal rate of substitution between the traits and the monetary coefficient (Ouma et al., 2007). The best and easiest way to compare the estimated coefficients from the different models is by using behavioral attributes such as willingness to pay valuations (Greene and Hensher, 2003). The ratio of the estimated cattle traits and the Price coefficient was calculated using Equation 13. Respondents were willing to pay $111.15/cwt more for an easy-to-handle than for a difficult-to-handle feeder animal (Table 11). This suggests that easy-to-handle feeder cattle were highly valued by grass-fed beef producers. Feeder animals weighing 650 lbs were valued at $11.36/cwt more than 550-lb feeder animals (Table 11); heavier feeder cattle were preferred/valued more than lighter feeder cattle.

The CLM estimates for the 750-lb feeder animal and color were not significant, and thus their WTP estimates were not included in Table 11. Respondents were willing to pay $39.60 and $33.45/cwt more for small and medium-framed feeders, respectively, than for a large-framed feeder. This result suggests that grass-fed beef producers valued small-framed feeder cattle more than large-framed feeder cattle, a result that is consistent with the findings of Camfield et al. (1999) and Gwin (2009).

Table 11. Willingness to Pay Estimates from the Conditional Logit Model.

Cattle Attribute	Levels	WTP = $\boldsymbol{E(\beta_k/\beta_p)}$	Standard Error
Temperament	Easy	111.15	3.24
Body frame	Small	39.60	5.57
	Medium	33.45	4.54
Gender	Steer	36.93	3.63
	Heifer	36.92	5.53
Source	Retained	33.11	4.20
	Auction	-33.12	5.22
Weight	Weight 650	11.36	5.81

Respondents were willing to pay $36.93/cwt and $36.92/cwt more for steers and heifers, respectively, than for intact males. Intact males are more likely to be aggressive and difficult to handle than steers/heifers. Bretschneider (2005) found that intact males produce poorer quality meat in terms of color and tenderness than steers. Respondents valued animals retained from their own cows at $33.11/cwt more than those purchased via private treaty. On the other hand, respondents valued animals purchased via private treaty at $33.12/cwt more than those purchased via auctions.

4.5 Mixed Logit Model (MLM) Results

Preference for cattle traits may differ in a number of ways, both observable and unobservable. Limitations of the conditional logit model are its assumption of homogeneity of preferences and the IIA assumption. The conditional logit model ignores the underlying heterogeneity of tastes for cattle attributes by assuming that the effect of an attribute is the same for all respondents. More advanced simulated likelihood methods that allow researchers to account for unobserved taste variations have been developed (McFadden and Train, 2000). The mixed logit model accounts for unobserved heterogeneity in the estimated taste parameters. It extends the standard conditional logit model by allowing one or more of the parameters in the model to be randomly distributed. In this section, we estimated a parametric MLM with independent, normally distributed taste parameters, as proposed by Hole (2007).

To select the number of draws (Halton draws) required to secure a stable set of parameter estimates, MLM was estimated over a range of draws with a minimum of 50 and a maximum of 1,000 draws. Hensher and Greene (2003) discussed the importance of stability in selection of an optimum number of Halton draws in a MLM. Bhat (2001) and Train (2000) found a lower simulation variance using 100 Halton numbers than when using 1,000 random numbers. Both studies (Bhat, 2001; Train, 2000) found that simulation error increased as the number of Halton draws increased. The question then becomes, why select a larger number of Halton draws while a smaller number of draws could produce a better result? Hensher and Greene (2003) recommended a smaller draw as it greatly reduces the length of run time and the size of simulation error. To reduce estimation time, we used 50 draws for our initial specification search and 500 Halton draws for the final model.

The following random parameters MLM model was estimated:

$$U_{ijt} = \beta_1 Weight_{ijt} + \beta_2 Bframe_{ijt} + \beta_3 Temperament_{ijt} + \beta_4 Gender_{ijt} + \beta_5 Source_{ijt} + \beta_6 Color_{ijt} + \beta_7 Price_{ijt} + \varepsilon_{ijt}, \quad (16)$$

where *i* represents the *i*th respondent, *j* is the alternative chosen by respondent *i*, *t* is the choice occasion, and ε_{ijt} is a random term that is assumed to be an independently and identically distributed extreme value. The same cattle attributes used in the CLM in the previous section were used in the MLM. All variables were treated as random parameters.

As shown in Table 9 (from the values of the maximized log likelihood), we can safely reject the CLM for the MLM. Important to note is the difference in the magnitude of taste parameters (Pacifico et al., 2012). The estimated coefficients from the MLM are significantly larger than those from the CLM. This is a result of the bias induced by the IIA assumption of standard conditional logit models (Bhat, 2000). Given that the two models are nested, a comparison between the CLM and MLM using the log likelihood ratio test is plausible (Pacifico et al., 2012). If this difference is statistically significant, then the more flexible model (in our case, the MLM) fits the data significantly better than the more restrictive model (CLM). The value of the likelihood ratio test statistic calculated between the CLM and the MLM is 4997.53 (distributed chi-squared), with 11 degrees of freedom. The CLM is therefore rejected in favor of the MLM, indicating that the MLM fits the data better. Table 9 gives the results of the MLM with independent, normally distributed coefficients using 500 Halton draws.

All seven cattle traits were treated as random parameters for the MLM. Specification of random parameters in a MLM can take a number of predefined forms: normal, triangular, uniform and/or lognormal (Hensher and Greene, 2003). Decision on the type of distribution to use depends on the type of the expected response parameter and the data source (Hole, 2007). For instance, if a specific sign (non-negative) is expected on the response parameter, then a lognormal form will be used (Hensher and Greene, 2003). We used a uniform distribution with a (0, 1) bound for the dummy coded variables, implying that all traits may plausibly have either a positive or negative response parameter. Lognormal distributions will be used later in our computation of willingness to pay, which limits analysis to the non-negative domain.

All seven cattle traits were significant for the MLM, with Temperament being positive and highly significant (Table 9). Grass-fed beef producers generally preferred 650-lb animals that were small-to-medium framed and easy to handle for finishing. The estimated parameters for weight were positive and highly significant, implying that there is a preference for heavier (650 and 750 lbs) over lighter (550 lbs) feeder cattle. This result is consistent with Sy et al. (1997) who found (for an average producer) a positive marginal value for a steer with a weaning weight of 650 pounds and a negative marginal value for a steer with a weaning weight of 550 pounds. These findings suggests that heavier feeder animals were preferred by producers.

Relative to intact males, steers and heifers were preferred. Animals that were retained from their own calves were preferred. Black, lower-priced feeder cattle were also preferred. The negative sign on the auction coefficient indicates disutility associated with that method of procuring animals for grass-finishing relative to retaining one's own calves for finishing. As expected, the price estimate had a negative sign, implying existence of a negative relationship between the price of feeder cattle and the utility grass-fed beef producers obtain from purchasing feeder cattle—disutility is associated with highly priced feeder cattle.

The cumulative distribution of the ratio of the estimated taste parameters to their respective standard deviations (the ratio of the mean to its standard deviation) were used to calculate the share distribution of the responding population for the different cattle traits. For animal weight, 83% and 67% of respondents preferred animals weighing 650 and 750 pounds, respectively, for grass-finishing, both relative to those weighing 550 pounds (the base weight). Easy-to-handle feeder cattle were preferred to difficult-to-handle cattle by 88% of grass-fed beef producers. Relative to purchasing feeder animals via auction, 83% of respondents preferred finishing feeders retained from their own cattle while 77% preferred purchasing animals via a private treaty source. The formula used to compute these figures was $100 * \Phi(b_k/s_k)$, where Φ is the cumulative standard normal distribution, and b_k and s_k are the mean and standard deviation, respectively, of the *k*th coefficient. Small body frames were preferred to large frames by 83% of respondents, which corroborate the Gwin (2009) findings that tall, lanky cattle may take an extra year or more to finish without grain, thus increasing production costs. Camfield et al. (1999) showed that large-framed steers took a longer time to mature than medium-framed steers.

The estimated standard deviations of most coefficients were highly significant, indicating that parameters do indeed vary within the population. A likelihood-ratio test for the joint significance of the standard deviations (726.25) is associated with a small P-value ($P < 0.01$), implying rejection of the null hypothesis that all the standard deviations are equal to zero (Hole, 2007). The standard deviation associated with each parameter estimate reveals the presence and/or absence of preference heterogeneity in the sampled population (Hensher and Greene, 2003). The MLM can only indicate the presence of heterogeneity but does not provide information about the source of such heterogeneity. The most common source of heterogeneity highly documented in the literature has been the characteristics of respondents (Boxall and Adamowicz, 2002). According to Louviere et al. (2000), there are many other sources/causes of heterogeneity in the estimated taste coefficients other than differences in respondents. Other causes of variance may range from experimental designs used in data collection to the way collected data are prepared for analysis. If unaccounted for, such unobserved taste heterogeneity can bias population estimates (Train, 2003).

Except for the Weight taste parameters, the standard deviations of the estimated taste parameters were significant at the $P \leq 0.05$ levels, implying the presence of heterogeneity in the population. From the magnitudes of the standard deviations, preference for the temperament attribute was among the most heterogeneous across the population, as indicated by the highly significant and relatively large standard deviation (Table 9). There was also strong preference heterogeneity for steers and small body frames. These results are consistent with results illustrated in the kernel density plots (Figure 6) discussed in the next section. Results from the MLM (Table 9) indicate that heterogeneity in preference for the Weight attribute (650 and 750 lbs, relative to 550 lbs) was not found.

4.5.1 Distribution of Individual Level Coefficients

The estimated taste parameters (individual-specific parameter estimates) can be plotted parametrically using kernel densities to reveal information about their distributions across the sampled population (Hensher and Greene, 2003). Revelt and Train (2000) propose a method for approximating the distribution of individual taste parameters, $E[\beta|y_i, x_i]$, from a population distribution, θ. This approach can be implemented in Stata with the *mixlbeta* command after estimating the model (MLM) using *mixlogit.* Figure 6 presents plots of taste parameter (preference parameter estimates) distributions for the cattle traits. The distributions are fairly similar; color and temperament parameter distributions are less "peaked" with relatively flatter tails than the source parameter distributions. Source, color, and temperament distributions (A, B, C, and D in Figure 6) depict heterogeneity in the estimated parameters (variance in these cases is relatively large, indicating considerable preference heterogeneity among respondents).

On the other hand, plots E and F depict normal distributions of weight parameters relative to plots A, B, C, and D. Plots show distributions that are consistent with the values of standard deviations obtained in Table 9. There is relatively more heterogeneity in temperament (which is relatively the most-important attribute in our case) as indicated by its fat tailed plot (Figure 6, D). The magnitude associated with temperament was the largest.

4.5.2 Willingness to Pay from the MLM

Scale differences make the interpretation of MLM parameter estimates non-informative (Louviere et al., 2000). As Greene and Hensher (2003) indicated, contrasts of willingness to pay estimates could be very informative. Based on the mixed logit parameter estimates, implicit prices (a measure of willingness to pay) of the traits and their different levels were derived using Equation (13). Implicit prices for estimates of the MLM are given in Table 12. Model results indicate that grass-fed beef producers highly value both production-related and marketing-related cattle traits. Similar results were reported by Sy et al. (1997). About 39% of respondents were willing to pay \$120.14/cwt more for an easy-to-handle relative to a difficult-to-handle grass-fed beef animal (Table 12). In the previous section, 67% of respondents ranked temperament as a highly important attribute among the ten listed cattle attributes.

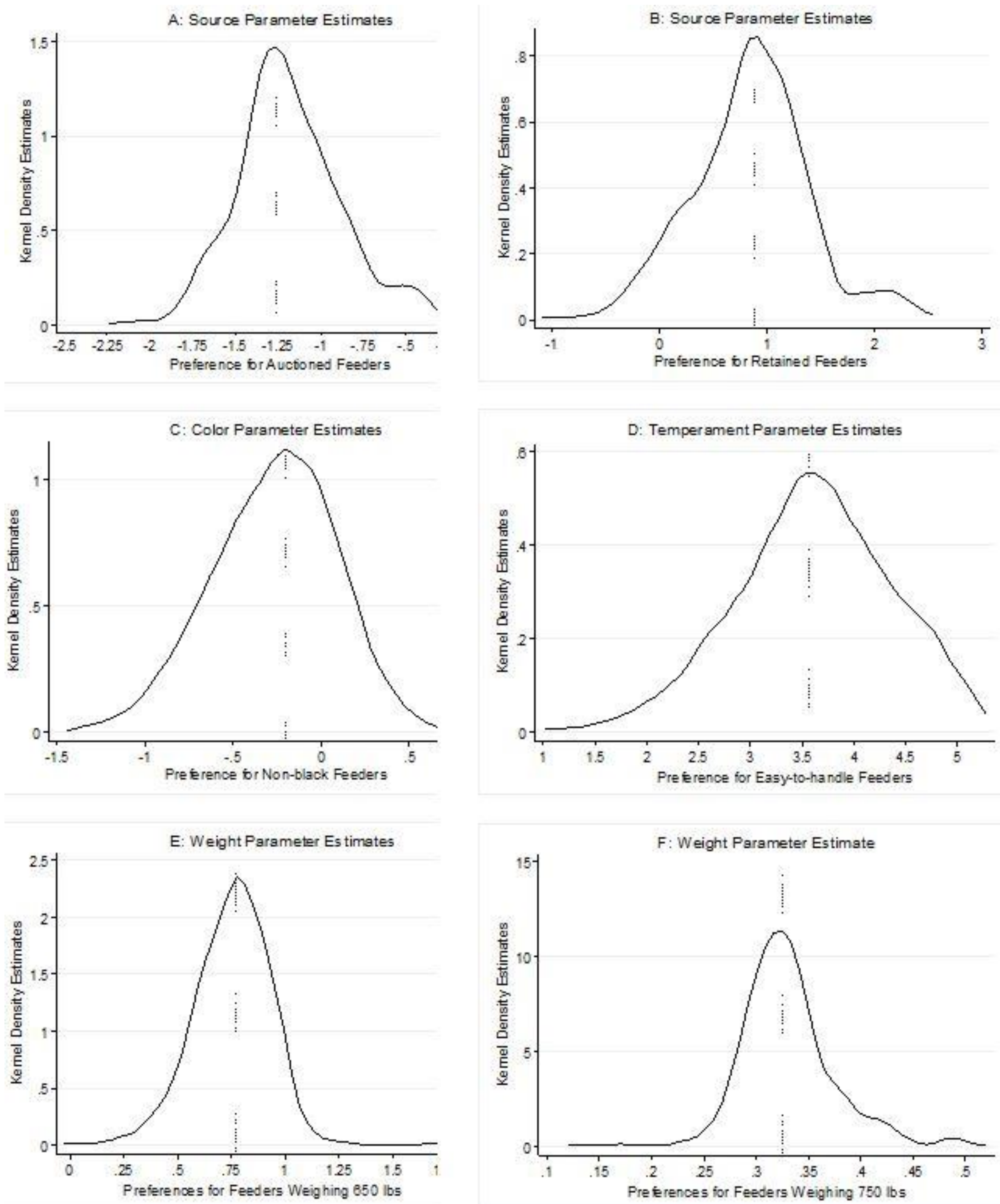

Figure 6. Mixed Logit Parameter Estimates

Respondents were willing to pay $47.92/cwt and $41.96/cwt more for steers and heifers, respectively, than intact males, indicating that they highly valued both steers and heifers relative to intact males. Among the reasons for castrating calves is to lower their aggressive behavior (Bretschneider, 2005). Bretschneider (2005) found a positive relationship between aggressive animal behavior and lower meat quality (lower tenderness and the dark color). Producers were willing to pay $36.23/cwt and $25.44/cwt more for small-framed and medium-framed animals, respectively, than large-framed animals. This result suggests a general preference for small to medium-framed animals relative to larger-framed animals. As expected, producers were willing to pay $25.38/cwt and $11.22/cwt more for 650- and 750-lb animals, respectively, than 550-lb animals. This suggests positive preference for the relatively heavy feeder animals. Likewise, respondents valued a black feeder animal at $9.22/cwt more than a non-black feeder animal. A negative sign on the WTP value for auction indicates that producers were willing to pay $39.08/cwt more for a feeder animal purchased via private treaty than a similar one purchased via auction.

Table 12. Willingness to Pay Estimates for Cattle Traits from the Mixed Logit Model.

Cattle Attribute	Levels	WTP = $\boldsymbol{E(\beta_k/\beta_p)}$	SD	Relative Importance
Temperament	Easy	120.14	4.97	39.30
Gender	Steer	47.92	4.81	15.68
	Heifer	41.96	7.18	
Body frame	Small	36.23	6.69	11.85
	Medium	25.44	5.00	
Weight	Weight 650	25.38	6.64	8.30
	Weight 750	11.22	5.64	
Source	Retained	27.73	5.44	21.85
	Auction	-39.08	5.98	
Color	Non-black	-9.22	4.49	3.02

The estimated coefficients from the MLM and their corresponding WTP estimates (Tables 9 and 12) indicate that producers preferred small-framed black feeder animals. These two traits closely match a black Angus breed which appeared to be the most popular breed in the study. The general perception that black animals produce higher quality beef, particularly the black Angus, could have been the reason for producer preference for black animals. It is also possible to associate preference for small body frames with preference for Angus or the British breeds.

4.6 Latent Class Model (LCM) Results

A nonparametric MLM was estimated using an expectation-maximization algorithm as proposed in Train (2008). The expectation-maximization algorithm (*lclogit*) can be used to estimate a non-parametric MLM—estimation of mixing distribution in discrete choice models (Pacifico 2011). The Stata written command *lclogit* fits latent class conditional logit models through an expectation-maximization algorithm proposed in Bhat (1997) and Train (2008). It is a step-by-step procedure for estimating LCM in Stata, as used in Pacifico and Yoo (2012). Included as determinants of segment membership are the same explanatory variables we used in the ordered probit models: age, education level, total number of cattle raised on the farm, percentage of total net farm income from the grass-fed beef enterprise, production system (whether or not it was a cow-calf operation), and the region of the U.S. where the farm was located.

Determination of the optimal number of classes to use in the LCM is the first step in this section. The choice of the appropriate number of classes is obtained by means of some information criteria (Greene and Hensher, 2003; Train, 2008). To choose the optimal number of classes, we employed the CAIC and BIC proposed by Boxall and Adamowicz (2002). The CAIC and BIC were both minimized at 4 classes as shown in Table 13. The higher the number of latent classes, the more difficult the empirical inversion of the Hessian matrix, with the possibility of singularity at some iteration (Train, 2008).

Table 13. Information Criteria for Determining the Number of Latent Classes.

	Classes	Log likelihood	CAIC	BIC
	2	-2354.90	4924.86	4893.86
	3	-2273.87	4901.56	4850.56
Minimizes CAIC & BIC	4	-2200.74	4894.05	4823.05
	5	-2169.41	4970.13	4879.13
	6	-2132.21	5034.49	4923.49
	7	-2125.53	5159.88	5028.88
	8	-2080.39	5208.35	5057.35
	9	-2062.10	5310.52	5139.52
	10	-2052.44	5429.95	5238.95

Table 14 shows that 37% of the GFB producers who responded have a fitted probability belonging to Class 1, which is strongly significant for those who chose neither alternative, the "opt out" option. The constant variable in Table 14 represents the "opt out" choice option. On the other hand 10%, 15%, and 38% of the respondents have a fitted probability belonging to Classes, 3, and 4, respectively. A post-estimation command in STATA, *lclogitpr*, is executed to obtain a quantitative measure of the model validity in differentiating multiple classes of preferences. As indicated in Table 14, the mean highest posterior probability is about 90%, suggesting that the model does very well in decomposing the different underlying taste patterns for the observed choice situation (Pacifico and Yoo, 2012).

Producer preferences can be influenced by various factors which may include production systems, infrastructural and environmental constraints, feed resources, geographical locations and demographic characteristics. Heterogeneity in producer preference can be attributed to such factors. The negative age and education coefficients for Class 2 members indicates that members of this class are likely to be younger with lower levels of education relative to Class 4 members (Table 14). The coefficient for cow-calf is negative and significant for Class 3 members, indicating that members of Class 3 are less likely to be cow-calf producers relative to Class 4 members.

Table 14. Latent Class Model Parameter Estimates of Cattle Traits.

	Class 1	**Class 2**	**Class 3**	**Class 4**
Utility/taste coefficients				
Wgt650	0.8144	0.2571	-0.3782	1.3213***
	(0.6606)	(1.2061)	(0.4397)	(0.4926)
Wgt750	0.2267	0.2652	0.3680	0.8217*
	(0.4304)	(0.9006)	(0.4251)	(0.5230)
Small	2.1499***	0.0275	1.9993**	0.6170
	(0.4670)	(0.9964)	(0.4856)	(0.5688)
Medium	1.1736***	0.0183	0.5096	0.6322*
	(0.4023)	(0.6011)	(0.4344)	(0.4082)
Easy	3.4256***	1.9626***	1.7258***	1.9260***
	(0.4030)	(0.5444)	(0.5631)	(0.4370)
Heifer	-0.1667	1.1744**	0.4819	0.9294
	(0.4761)	(0.7156)	(0.6172)	(0.6604)
Steer	0.7535**	1.7984***	0.5613	1.3378***
	(0.3393)	(0.4730)	(0.4645)	(0.3772)
Retained	0.4989	0.6562**	0.1883	0.9462***
	(0.3187)	(0.2733)	(0.4294)	(0.3270)
Auction	-1.6502***	-0.5294	-0.3979	-2.1131***
	(0.3950)	(0.6944)	(0.5501)	(0.6747)
Non-black	-0.1156	-1.8239**	-0.6502	1.1012***
	(0.3433)	(0.3889)	(0.5272)	(0.3939)
Price	-0.0205***	0.0072	-0.0246***	-0.0296***
	(0.0033)	(0.0055)	(0.0041)	(0.0028)
Class coefficients				
Constant	2.1596**	1.6644	-1.0272	
	(0.9672)	(1.1233)	(1.3059)	
Age	-0.0171	-0.0267**	0.0256	
	(0.0131)	(0.0165)	(0.0165)	
Education level	-0.1978	-0.3737**	-0.2457	
	(0.1819)	(0.2090)	(0.2349)	
Cow-calf	-0.4280	-0.0156	-1.0242**	
	(0.4086)	(0.5380)	(0.4854)	
NW	-0.2504	0.3610	1.0030**	
	(0.5061)	(0.6003)	(0.5358)	
Latent class probability	0.370	0.100	0.153	0.377
Log likelihood	-2200.743			
Highest posterior probability	0.8979			

Standard errors in parenthesis; (*), (**), and (***) denote significant variables at 10%, 5%, and 1% levels, respectively

Presence of strong heterogeneity in preferences across the latent classes is shown by the differences in the magnitudes and significance of the parameter estimates. As indicated in Table 14, there is a strong positive preference for feeders weighing 650 and 750 pounds relative to those weighing 550 pounds for members in Class 4. Generally, latent Class 4 revealed significant taste parameters for the weight trait consistent with the MLM results in Table 9. Relative to Class 3, Class 4 members were more likely to be cow-calf producers, implying that cow-calf producers had strong positive preference for feeders weighing 650 and 750 pounds relative to those weighing 550 pounds. Similar results were obtained by Sy et al. (1997) in their evaluation of typical Canadian cattle producer preferences for cattle traits. They estimated preference heterogeneity for cattle traits using three different production systems: purebred breeders, commercial cow-calf producers and cattle feeders. Sy et al. (1997) found that a typical cow-calf producer preferred steers with weaning weight of 650 pounds relative to steers with weaning weights of 550 pounds, implying that producers preferred heavier rather than lighter steers. Generally, for both steers and bulls, Sy et al. (1997) obtained a negative part-worth for lighter animals and positive parameter estimates for the heavier animals. Negative part-worth is associated with disutility—decreased preference for a trait.

Strong positive preference for small-to-medium framed and easy-to-handle feeder cattle was obtained for Latent Class 1. Heterogeneity revealed by the differences in magnitudes and significance of the estimated taste parameters is seen for these two trait-levels. The easy-to-handle parameter estimate is significant for all four latent classes with a particularly strong preference for the trait by Latent Class 1.

A strong negative coefficient was found for purchasing calves via auction relative to via private treaty, implying negative preference or disutility associated with auction purchasing.

There is significant heterogeneity in preference for this trait with members in Latent Class 4 having the strongest negative preference for the trait. This result indicates that cow-calf producers (who are more likely to be Class 4 members) exhibit strong negative preference for auction as the source of feeder animals.

Calculations of the relative importance of the cattle traits across the latent classes show marked differences in preference structure (Table 15). About 33% and 26% of respondents in Class1 and 2, respectively, attach high value to the temperament attribute relative to other cattle attributes. On the other hand, about 28% of respondents in Classes 3 and 4 attach high value to the body frame and source attributes, respectively (Table 15). Results reported in Table 15 are consistent with the MLM results in Table 9 (the estimated standard deviations). Both results provide enough evidence for the existence of preference heterogeneity for cattle traits across the sample.

Table 15. Class-Specific Values of Relative Importance of Cattle Attributes.

	Relative Importance (%)			
Cattle Attributes	Class 1	Class 2	Class 3	Class 4
Temperament	32.9 (1)	26.0 (1)	26.4 (2)	17.6 (2)
Source	21.7 (2)	15.7 (4)	8.3 (5)	28.0 (1)
Body Frame	20.9 (3)	1.4 (7)	28.2 (1)	7.2 (7)
Price	7.9 (4)	4.8 (5)	13.9 (3)	10.8 (5)
Weight	7.8 (5)	3.5 (6)	6.1 (7)	14.1 (3)
Gender	7.2 (6)	23.8 (3)	7.9 (6)	12.2 (4)
Color	1.5 (7)	24.8 (2)	9.2 (4)	10.1 (6)

Note: Numbers in parenthesis represent the rankings of the seven cattle attributes

A comparison of the three models (CLM, MLM, and LCM) based on the estimated parameter estimates is not informative. However, contrasts of their willingness to pay estimates is very informative (Louviere et al., 2000). Summaries of WTP estimates for cattle traits obtained from the three models are given in Table 15. The WTP estimates in Table 15 differ substantially among the three models.

The LCM estimates suggest stronger willingness to pay attitudes for temperament and body frame attributes than do the CLM and MLM. For instance, results from the LCM suggest that respondents were willing to pay $162.23/cwt more for an easy-to-handle relative to a difficult-to-handle animal, which is about $42 and $51/cwt more than the WTP estimates obtained using the MLM and CM, respectively. In all three models, the WTP estimates for body frame tend to decrease as body frame increases. There is directional consistency in the WTP as we move from small to large body frames, which is consistent with Gwin (2009) and Camfield (1999) findings that large-framed animals may take longer to mature, thus increasing production costs. All three had lower WTP values for auction especially the LCM.

Table 16. A Summary of Willingness to Pay Estimates from the CLM, MLM, and LCM.

		Willingness to Pay		
Cattle Attribute	Levels	CLM	MLM	LCM
Temperament	Easy	111.15	120.14	162.23
Gender	Steer	36.93	47.92	38.76
	Heifer	36.92	41.96	-
Body frame	Small	39.60	36.23	98.93
	Medium	33.45	25.44	56.56
Weight	Weight 650	11.36	25.38	-
	Weight 750	-	11.22	-
Source	Retained	33.11	27.73	-
	Auction	-33.12	-39.08	-76.95
Color	Non-black	-	-9.22	-

Note: - (small dash) implies not statistically significant

CHAPTER 5: SUMMARY AND CONCLUSIONS

5.1 Summary

Grass-fed beef is a differentiated product that is gradually growing its market share in the U.S. beef industry. Grass-fed beef is preferred by an increasing number of consumers. Some of the reasons that have led to increased consumer demand for grass-fed beef include: increased consumer awareness of food safety and nutrition, animal welfare considerations, and increasing corn prices (important input in grain-fed beef production) that have directly increased the cost of producing grain-fed beef. Increased consumer interest in healthy food, animal welfare considerations, and environmental sustainability has made grass-finishing a desirable option for many beef producers. The discovery of Bovine Spongiform Encephalopathy (BSE) in 2003 in a cow imported from Canada dramatically altered the U.S. beef market in 2004. Both local and international demand for locally produced conventional beef dropped in the periods following the occurrence of BSE in the United States. On the other hand, demand for grass-fed beef was expected to rise given that it is believed to be BSE-free.

Another factor that has promoted the rapid growth of the industry is the establishment of the American Grass-Fed Beef Association in 2003. Through its certification process, farmer meetings, and conferences, AGA has been able to highlight and promote potential market opportunities for the U.S. grass-fed beef industry. It has boosted the growth of the industry through establishment of good industry-government relations and through research and public education.

In spite of the growing interest in the industry, little recent research has been conducted on specific farm level strategies on how to efficiently and profitably finish beef cattle on pasture, beef breeding programs, and post-farm gate methods of marketing grass-fed beef. Of interest to this study was the determination of grass-fed beef producer preferences for cattle traits when selecting animals to raise on their farms. This study was motivated by the fact that it takes a longer time to produce grass-feed beef relative to the conventionally produced beef (the grain-fed beef). In addition, most studies conducted in the field of agricultural economics and food science have focused mostly on comparing consumer preferences for the final product (grass-fed versus grain-fed meat) and not the process leading to that product. Selection of animals having desired characteristics such as shorter maturity period, smaller body frames, and the ability to gain weight faster is crucial for the grass-fed beef industry. It is rare to find a particular animal having all the desired characteristics—an ideal animal. Livestock breeders have been able to partially satisfy producer preferences for cattle traits by developing animal breeds that have at least some desired traits through their cross-breeding programs.

An important question facing new grass-fed beef producers is, "which animal should I choose to produce on my farm?" This study sought to address this important question using a set of seven cattle attributes considered when selecting animals to produce. Grass-fed beef producers, like other beef producers, always face attribute trade-offs in selecting animals to raise on their farms. Animals having desired beef attributes could also have some of the undesired attributes. For instance, animals having high average daily growth rates could be difficult to handle (having temperament issues). Using farm and farmer characteristics, it is possible to link preferences for common cattle traits with specific farm and farmer characteristics. Findings from this study can be useful to farmers having characteristics similar to those of the study sample in their animal selection. Livestock breeders and extension officers can use the findings from this study to advise their clientele. Given that this is the first study known to us in determining grass-fed beef producer preferences for cattle traits, it provides a contribution to the limited empirical literature on the U.S. grass-fed beef industry and more specifically selection of animals for grass-finishing. The method can be replicated using different sets of hypothetical profiles to investigate producer preferences for diverse attributes in both crop and livestock products.

We conducted a nationwide mail survey of U.S. grass-fed beef producers in Fall, 2013, following recommendations by Dillman et al. (2007). Names and addresses of farmers were obtained from extensive Internet search. A personally addressed and signed cover letter explaining the purpose of the survey, a ten-page questionnaire, and a postage-paid return envelope were mailed to the farmer. A postcard reminder followed two weeks later. After a second round of mailing and postcard reminder, 384 usable responses were obtained. The adjusted response rate was 41%, considering the 384 completed responses and 117 from producers no longer in grass-fed beef business and non-deliverable addresses.

Information on farm management practices such as breeding, animal selection, and pasture management; marketing information; goal structure of grass-fed beef producers; and producer opinions of major challenges facing the industry were solicited. Additional information regarding farm size, other farm enterprises operated, major breeds kept, and certified organic status were also solicited in the survey. Important to this study was the choice experiment question asking respondents to select animals they would retain/purchase for forage finishing. Respondents were presented with hypothetical profiles describing animals having different attribute levels. The hypothetical profiles consisted of three alternatives *Animal A, Animal B*, and *Neither*. The *Neither* alternative was an "opt-out" option for those producers who preferred neither *Animal A* nor *Animal B.*

The vast majority of respondents, 81%, produced their own calves for forage-finishing; 22% and 3% used private treaty and auction as a source of animals for grass-finishing, respectively. These values reflect general preferences of the responding population. As will be explained later, producers valued retained calves and those obtained via private treaty higher than those obtained via the auction. The average number of cattle raised on the farm was 127 animals. The large standard deviation value of 371.69 for the average number of cattle raised suggest that farm size varies widely. About 85% of respondents accessed the Internet for grass-fed beef information. This suggests that most respondents relied on the Internet for information regarding marketing and production technologies used in the industry. The average age of responding producers was 55 years, 70% held a 4-year college degree, and 10% were certified organic producers. The majority of the respondents (32%) were located in the Midwest, 21% were in the Northeast, 17% were in the Northwest, 14% were in the Southeast, and 9% were in the Southwest. Region is an important variable in understanding the sources of heterogeneity in preferences of producers. Regional variables in the analysis tell us whether or not there was regional differences in producer preferences.

Greater percentages of respondents raised British breeds and British crosses with continental and Brahman, 66 and 18% of respondents, respectively. Knowledge of dominant breed (in terms of their distinguishing characteristics/attributes) raised was important in understanding producer preferences in selecting animals to raise on the farm. For instance, the Angus breed was the most popular British breed among the respondents. Some of the common distinguishing characteristics/attributes of the Angus breed include: small body frame, naturally polled, black coat color, matures quite early, adaptable to most environments, and are known to be animals with mild temperament. This study included some of the listed attributes in evaluating producer preferences for cattle traits. It is therefore possible, using results from the different models used in this study, to determine the most likely breed that is preferred by most of the respondents.

Of the ten cattle attributes (listed in our survey) considered in selecting animals to raise on the farm, eight were deemed important by some respondents, the remaining two (parents of animals were never grain-fed and coat color) were found to be not important at all. Temperament and expected reproductive performance yielded modal responses of “Highly Important” and had mean responses of 3.59 and 3.03, respectively. Disease resistance, body frame, expected carcass yield, breed, expected average daily weight gain, and heat tolerance yielded “Very Important” as the modal response.

We used the ordered probit model to determine the drivers of farmer perception on the importance of the selected ten attributes. Given that our dependent variable was ordinal, the ordered probit model was useful in the analysis of the impact of potential drivers on the dependent variable. The model revealed that the production system operated (whether or not a cow-calf producer), total number of cattle raised on the farm, selling grass-fed beef as meat (whether or not selling beef as meat), percentage of annual net farm income from the grass-fed beef operation, operator education level, number of years operating the grass-fed beef enterprise, and the regional variables were significant drivers of producer perception on the importance of most of the ten listed cattle attributes in selecting animals to raise on the farm. For instance, cow-calf producers and the more specialized producers were more likely to consider all of the listed attributes to be important. The most likely reason for this is that a cow-calf producer deal with the cow for a relatively longer time as well as its offspring. It is, therefore, plausible to argue that animal selection is of greater importance to a cow-calf producer. An easy-to-handle cow, for example, has good maternal traits which are essential for reduced calf morbidity. Selection of animals with mild temperament therefore greatly reduces calf mortality on cow-calf farms.

Older, larger scale grass-fed beef producers and those who received higher percentages of net farm income from grass-fed beef production were more likely to consider temperament as an important attribute in animal selection. The farm size result was expected given the increased management demands with more animals on the farm. Mild temperament has been found to be positively related with meat quality attributes such as tenderness and flavor. Older, college-educated, larger scale grass-fed beef producers considered carcass yield to be an important attribute.

Older, more experienced, larger-scale cow-calf grass-fed beef producers considered breed to be an important attribute in selecting animals to raise on the farm. Breed is a specific attribute indicating the type of animal (Angus, Hereford, Brahman, etc.). Different breeds generally display particular cattle attributes such as temperament, body frame etc. Particular attributes can thus serve as identifiers of specific breeds of animals. It is possible to link/relate the premiums that cattle and meat buyers are willing to pay for specific attributes (cattle and meat attributes) to a specific breed. For instance, a high amount of marbling has been widely associated with meat from the black Angus cattle. Meat consumers and cattle buyers are thus willing to pay a certain premium to obtain black Angus meat and animals, respectively. The higher the amount of marbling, the higher the quality of beef. Generally, the certified Angus beef is associated with high amounts of marbling, which is good for marketing and enterprise profitability. Factors affecting prices for different breeds can therefore be used as indicators of buyer perceptions relative to growth rate, carcass traits, and other factors that may affect animal performance and producer profitability.

The CLM, MLM, and LCM were used to estimate grass-fed beef producer preferences for specific cattle attributes. Results from these three models were compared with those from the ordered probit model. The CLM provided a basic and relatively easy way of estimating preferences by the method of maximum likelihood. The MLM revealed the presence of heterogeneity in producer preferences, and the LCM was used to identify the possible sources of heterogeneity in producer preferences. The ordered probit and the LCM model complemented each other in identifying the potential sources/causes of heterogeneity in producer preferences.

Lancasterian utility theory was used to guide this process. The theory assumes that utility is derived from the characteristics of a good/service rather than a good/service itself (Lancaster, 1966). In this case, utility was derived from seven cattle attribute levels: weight, body frame, temperament, gender, source, color, and price. The CLM indicated coat color and weight as the only two attribute levels that were not significant in influencing grass-fed beef producer choice of cattle to raise on the farm—perhaps because of the IIA associated with the CLM. Easy-to-handle animals with small body frames were preferred for grass-finishing. Bretschneider (2005) found strong correlation between temperament and animal attributes such as pattern of growth, animal behavior, and carcass quality. Regarding animal size, small body frames can attain maturity earlier than large body frames implying that animals having larger body frames require more feed and labor before they are ready for the market. Positive and highly significant estimates for steers and heifers indicate respondents' strong preference for steers and heifers relative to intact males.

The MLM model results indicate that steers and heifers were generally preferred to intact males. Lower-priced, black animals that were retained from own calves were preferred to higher-priced, non-black animals sourced via the auction. A negative sign on the auction coefficient indicated disutility associated with the auction as a method of procuring animals for grass-finishing relative to retaining one's own calves for finishing. As expected, the price estimate was negative, implying disutility associated with higher prices. Greater percentages of respondents (88%) preferred easy-to-handle animals to difficult-to-handle animals. Similarly, animals weighing 650 and 750 pounds were preferred by 83% and 67% of respondents, respectively, relative to those weighing 550 pounds.

The estimated standard deviations of most coefficients were highly significant indicating that the estimated MLM parameters varied within the population. The standard deviations were significant at the $P \leq 0.05$ level, except for the weight taste parameters. Preference for the temperament attribute was highly heterogeneous across the sample as indicated by the magnitude of its standard deviation. There was also strong preference heterogeneity for the gender attribute across the sample.

Interpretation of CLM, MLM, and LCM parameter estimates is non-informative. Values for relative importance were calculated to determine how important each attribute was relative to other cattle attributes considered in the study. Temperament was found to be the most important attribute followed by source, price, body frame, gender, and weight (in decreasing order of importance). Both the CLM and MLM indicated temperament as the most important cattle attribute to consider in animal selection followed by the source attribute.

Willingness to pay estimates provide more information regarding the value that producers place on cattle attributes. Producers were willing to pay more for an easy-to-handle animal than a difficult-to-handle animal. Mild temperament surfaced as the most valued attribute in all the three models. Results from the CLM, MLM, and LCM indicate that producers were willing to pay \$111.15, \$120.14, and \$162.23/cwt more, respectively, for an easy-to-handle than a difficult-to-handle feeder animal. The LCM suggests stronger willingness to pay attitudes for temperament attribute than do the CLM and MLM.

5.2 Limitations with the Conjoint Analysis Model

One potential problem with using conjoint analysis to estimate producer preference and willingness to pay is the hypothetical nature of the experiment. Respondents may fail to place sufficient cognitive effort into their decisions (selection of attributes) due to a lack of financial rewards and/or consequences on the decisions they make, a situation referred to as hypothetical bias (Scarpa et al., 2003). Methods have been developed to address this problem. Lusk et al. (2008) compared results from an incentive compatible conjoint experiment with those from a traditional hypothetical conjoint experiment. Incentive compatible conjoint analysis was used to motivate respondents to reveal their true preference rankings—money was used as an incentive. Different parameter estimates were obtained in the two experiments (Lusk et al., 2008). Results indicated that utility from having a steak significantly decreased when the task was incentive compatible (Lusk et al. 2008). One challenge for using this approach is the bias induced by the notion of “play money” which may affect the validity of results.

5.3 Implications and Recommendations

On a theoretical basis, this study adds to the growing body of literature in conjoint analysis employing a novel methodology in estimating producer preferences for cattle traits in the U.S. grass-fed beef industry. This is the first study known to us to use choice-based conjoint analysis in estimating preferences for cattle traits in the grass-fed beef industry. Knowledge of the type of animal to keep is very important to producers engaged in any beef production segment. Whether a cow-calf producer, a stocker-grazier, a seed stock producer, or a finisher, information on the general characteristics of beef breeds should not be overlooked. Attributes such as frame size, body weight, temperament, adaptation to local climate, and carcass traits are crucial for a beef production enterprise.

Finishers who buy cattle directly from commercial cow-calf producers or from public auctions need to be knowledgeable in their animal selection. This study provides insights to cattle sellers as to what types of animals are demanded and to extension personnel as to what type of animals grass-fed beef producers deem to be the most desirable. Results from this study can help a cow-calf producer design a breeding program that aims to produce calves having the most desired/valued attributes. Important decisions such as whether or not to castrate bull calves can be guided by the willingness to pay estimates obtained from the sample. Attribute trade-off is a common challenge facing new producers. For instance, mild, easy-to-handle cattle may have low feed efficiency scores. This study provides an alternative approach that can help in solving the producer’s breed selection problem.

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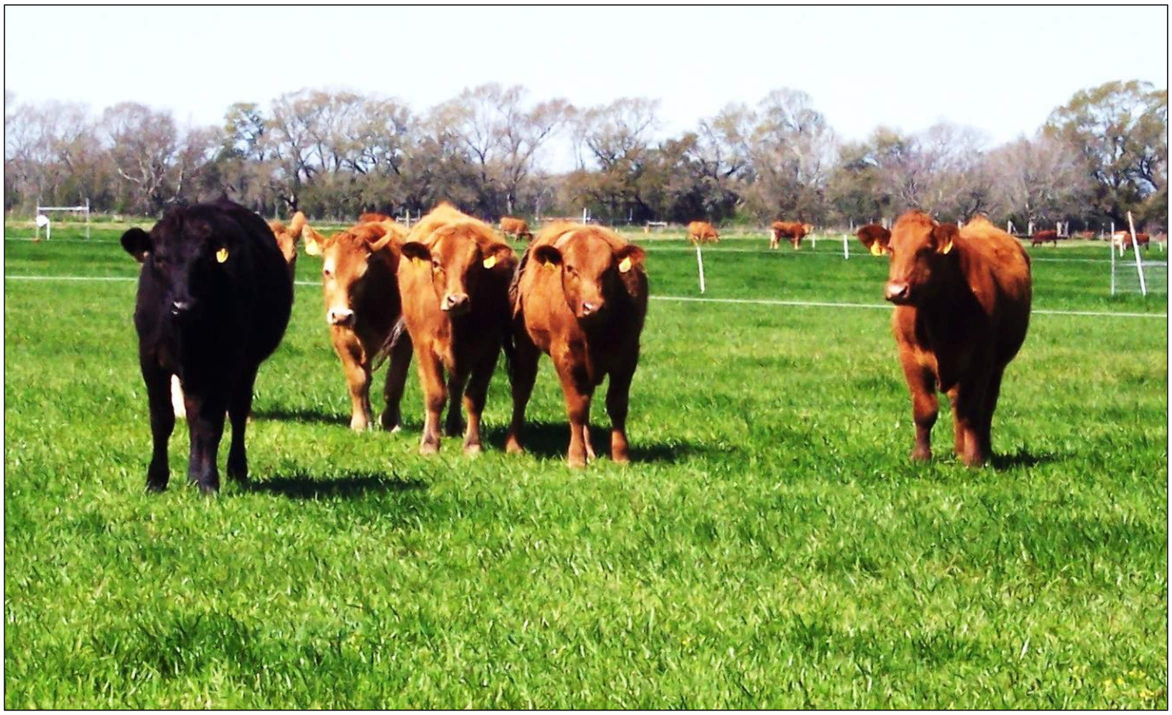
APPENDIX A: U.S. GRASS-FED BEEF PRODUCER QUESTIONNAIRE

U.S. Grass-fed Beef Production

Survey



LSU AgCenter Research & Extension

Throughout this survey, you will be asked questions about your grass-fed beef farm and how you make production decisions. Please circle the answers that best reflect your situation. All information will be held as *strictly confidential*. This is a condition of the grant funding for this project. Thank you!

Section I. Farm Operation

Definition of grass-fed beef – *Grass-fed/finished beef refers to beef from cattle whose lifetime diet consists only of grass and other forage (no grains are fed, no ionophores, no implants), with the exception of milk consumed prior to weaning. Some would call this forage-fed/finished beef.*

1. Did this farm raise any grass-fed beef cattle at any time during 2012? (Please circle one)
   (a) Yes → **[Please continue with 2]**
   (b) No → **[Please stop and return the questionnaire in the envelope provided. Thank you]**

2. How many years have you been operating your grass-fed beef enterprise? ______ (years)

3. The following production segments may be present on a grass-fed beef farm:
   Cow calf segment - *Producing weaned calves*
   Seedstock segment - *Producing livestock with documented pedigrees for eventual sale as breeding stock*
   Stocker segment - *Keeping weaned/lightweight feeder calves on forage up to a pre-finishing weight phase*
   Finishing segment - *The forage feeding phase to produce cattle that are ready for harvest*

   Please select the production system(s) you have on your farm. (Circle all that apply)
   (a) Cow-calf segment (b) Seedstock segment
   (c) Stocker segment (d) Finishing segment

4. Approximately how many acres of land do you farm in total? _____ (acres)

5. How many acres of your farm were exclusively devoted to the **grass-fed beef cattle** operation in 2012, including pasture and other land that supports this operation? ____ (acres)

6. Please select any other farm enterprises that you were involved in last year. (Circle all that apply)
   (a) Dairy (b) Horses (c) Sheep (d) Goats (e) Poultry
   (f) Field crops (g) Fruits and/or vegetables (h) Forestry (i) Other livestock

Section II. Breeding and Other Management Practices

1. Of the beef cattle you finished on grass in 2012, how many were from the following breed types?
   (a) British ____
   (b) Continental ____
   (c) Brahman ____
   (d) Cross British, Continental, & Brahman ____
   (e) Cross British and Continental _____
   (f) Cross British and Brahman _____
   (g) Cross Brahman and Continental _____
   (h) Other (specify) _____ _______

2. Is there a specific breed or cross that comprises more than half of your total grass-fed beef herd? (a) Yes (b) No **[Please skip to 4.]**

3. If "**yes**" to 2 above, what is the breed or cross? _______________

4. Is your grass-fed beef enterprise certified organic? (a) Yes **[Please skip to 6.]** (b) No

5. If you answered "**No**" to (4), are you currently transitioning to certified organic? (a) Yes (b) No

6. Did you breed cows in 2011 to produce calves? (a) Yes (b) No **[Please skip to 9.]**

7. **[If Yes to 6]** What was your calving rate in 2012, measured in calves weaned per exposed cow or heifer? ________%

8. If you answered "**yes**" to (6), please indicate all reproductive management practices you use on your farm (Circle all that apply)
   (a) Artificial insemination
   (b) Embryo transfer
   (c) Breeding records
   (d) Sexed semen
   (e) DNA marker-assisted selection
   (f) Pregnancy checking
   (g) Bulls test
   (h) Defined breeding season
   (i) Expected progeny differences

9. Which other animal management practices do you use? (Please select all that apply)
   (a) Vaccination (b) Animal ID system (c) Deworming
   (d) Body condition scoring (e) Insect control (f) Dehorning
   (g) Regular vet consultation (h) Implanting (i) Castration

10. Do your cows have access to shade (natural or artificial) during summer? (a) Yes (b) No
11. Do you test the quality of your forage? (a) Yes (b) No
12. Do you keep individual animal records? (a) Yes (b) No
13. Do you access the internet for grass-fed beef information? (a) Yes (b) No
14. Do you lock in beef input prices (feeds, etc.) prior to purchasing? (a) Yes (b) No
15. Do you negotiate price discounts with dealers or suppliers of inputs? (a) Yes (b) No

Section III. Selecting Animals for Grass Finishing

Suppose you are selecting animals to bring into your herd to raise to slaughter/harvest weight. These could be either *purchased* or could have been *produced from your own cows (retained)*. **Animal A** and **Animal B** will represent hypothetical profiles of animals that could be brought into your herd for forage finishing. You will be asked to choose between these two animals based on the characteristics provided. Other than the characteristics provided, imagine that the animals are identical. If neither is acceptable, then the "neither" option can be chosen.

Note:

Price represents the value of the animal per hundredweight (cwt). This could be the price paid to purchase the animal or the market value of the animal produced from your cows.

Temperament refers to how easy or difficult the animal is to handle.

Source refers to how you obtain the feeder animals for grass-finishing.

Gender refers to whether the animal is a heifer, steer, or intact (non-castrated) male.

Weight refers to the weight in pounds (lbs) at which the animal is introduced to the forage-finishing phase.

Body Frame refers to the animal's skeletal size based on its hip height (how big the animal is).

Color refers to the coat color of the animal, generalized as either black or non-black.

Choice 1

Attributes	**Animal A**	**Animal B**
Weight	550 lbs	650 lbs
Body frame	Small	Small
Temperament	Easy	Difficult
Gender	Heifer	Heifer
Source	Retained	Private treaty
Color	Non-black	Non-black
Price	$120/cwt	$160/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 2

Attributes	**Animal A**	**Animal B**
Weight	750 lbs	650 lbs
Body frame	Small	Medium
Temperament	Difficult	Easy
Gender	Intact male	Intact male
Source	Auction	Auction
Color	Black	Non-black
Price	$140/cwt	$140/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 3

Attributes	Animal A	Animal B
Weight	750 lbs	750 lbs
Body frame	Large	Medium
Temperament	Difficult	Difficult
Gender	Steer	Steer
Expected ADG	Auction	Private treaty
Color	Non-black	Black
Price	$160/cwt	$120/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 4

Attributes	Animal A	Animal B
Weight	650 lbs	550 lbs
Body frame	Large	Large
Temperament	Easy	Easy
Gender	Heifer	Steer
Source	Retained	Private treaty
Color	Non-black	Non-black
Price	$120/cwt	$120/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 5

Attributes	Animal A	Animal B
Weight	550 lbs	550 lbs
Body frame	Medium	Small
Temperament	Easy	Difficult
Gender	Intact male	Heifer
Source	Private treaty	Private treaty
Color	Black	Black
Price	$140/cwt	$120/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 6

Attributes	Animal A	Animal B
Weight	650 lbs	750 lbs
Body frame	Small	Small
Temperament	Easy	Easy
Gender	Steer	Intact male
Source	Auction	Private treaty
Color	Non-black	Black
Price	$160/cwt	$160/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 7

Attributes	**Animal A**	**Animal B**
Weight	750 lbs	750 lbs
Body frame	Large	Large
Temperament	Difficult	Difficult
Gender	Steer	Intact male
Source	Auction	Retained
Color	Black	Non-black
Price	$140/cwt	$160/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 8

Attributes	**Animal A**	**Animal B**
Weight	650 lbs	650 lbs
Body frame	Large	Medium
Temperament	Difficult	Easy
Gender	Heifer	Heifer
Source	Retained	Retained
Color	Black	Non-black
Price	$120/cwt	$140/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

Choice 9

Attributes	**Animal A**	**Animal B**
Weight	550 lbs	550 lbs
Body frame	Large	Large
Temperament	Easy	Difficult
Gender	Intact male	Steer
Source	Private treaty	Retained
Color	Black	Black
Price	$160/cwt	$140/cwt

❖ Which animal would you retain/purchase for forage finishing if these were the only feeders available?

□ Animal A
□ Animal B
□ Neither

1. How important are each of the following attributes in your selection of grass-fed beef animals to produce on your farm? For each attribute, please circle the number that best represents your opinion.

Attributes	Not Important at All	Somewhat Important	Very Important	Highly Important
Breed	1	2	3	4
Expected average daily weight gain	1	2	3	4
Frame score/body frame	1	2	3	4
Expected carcass yield	1	2	3	4
Disease resistance	1	2	3	4
Expected reproductive performance	1	2	3	4
Temperament	1	2	3	4
Heat tolerance	1	2	3	4
Hide/coat color of the animal	1	2	3	4

2. What is your main source of the feeder animals for grass-finishing?
   (a) Calves from own cows (b) Buy from auctions (c) Private treaty (d) Other_____

Section IV. Pasture and Grazing Management for the Grass-fed Beef Operation

1. Please indicate the maximum number of animals and acres that were devoted to the following grazing systems in 2012.

   Number of Beef Animals | Acres | Grazing System

   ____________ ________ *Rotational Grazing (RG)* is a management-intensive system of raising livestock on subdivided pastures called paddocks. Livestock are regularly rotated to fresh paddocks at the right time to prevent overgrazing and optimize grass growth.

   ____________ ________ *Continuous Grazing (CG)* is a method of grazing livestock where animals have unrestricted and uninterrupted access to all pasture throughout the time period when grazing is allowed.

2. Please list all of the types of forages that you used on your farm in 2012 and indicate whether they were for hay, pasture or both as shown in the three examples below.

Type	**Description of Forage/ Hay**	**Purpose**	**Number of Acres**
		Pasture only, hay only, or both	
Example 1	*Bermudagrass, ryegrass*	*Both*	*20*
Example 2	*Orchardgrass*	*Pasture*	*40*
Example 3	*Alfalfa*	*Hay*	*55*
Field Type 1			
Field Type 2			
.			
Field Type 10			

3. (If you rotate animals) During the season(s) that you rotate animals, how often do you generally rotate them among pastures?
   (a) More than once per day to once per every other day (b) Once or twice a week
   (c) Once or twice a month (d) Once in more than a month to twice a year

4. How do you believe the profitability associated with using a management-intensive rotational grazing (RG) system compares to that of using a continuous grazing system (CG) in your area?
   (a) RG lowers farm profit by > 20% relative to CG
   (b) RG lowers farm profit by1-20% relative to CG
   (c) RG does not change farm profit relative to CG
   (d) RG increases farm profit by1-20% relative to CG
   (e) RG increases farm profit by >20% relative to CG

5. If you produced hay from pasture in 2012, how many bales of hay did you produce? ___bales
6. Of the total hay produced, what percentage did you sell?
   (a) None (b) 1-20% (c) 21-40% (d) 41-60%
   (e) 61-80% (f) 81-99% (g) All hay was sold

7. If you purchased hay to feed animals, how many bales did you purchase in 2012?_____bales

Section V. Reasons for Selecting the Grass-fed Beef Enterprise

1. To what extent do you agree or disagree that your **selection of a grass-fed beef enterprise as opposed to other potential farm enterprises** is because of the following reasons? Please rate each reason on the scale provided below.

Reason	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Grass-fed beef production is profitable	1	2	3	4	5
Producing grass-fed beef is low-cost	1	2	3	4	5
I want to produce healthy beef	1	2	3	4	5
Producing grass-fed beef is enjoyable	1	2	3	4	5
I have ample land suitable for grazing	1	2	3	4	5
Producing grass-fed beef is good for the environment	1	2	3	4	5
There is strong demand for grass-fed beef in my area	1	2	3	4	5
Raising grass-fed beef is a good activity for my family	1	2	3	4	5
Grass-fed beef systems are more sustainable than grain-fed beef systems	1	2	3	4	5

2. Do any other family members work on your grass-fed beef farm? (a) Yes (b) No **[Please skip to 4.]**

3. If you answered “**yes**” to (2), how many total hours do other family members (besides you) work on your grass-fed beef operation per week?
   (a) 1-10 hrs (b) 11-20 hrs (c) 21-30 hrs (d) 31-40 hrs (e) 42-50 hrs (f) > 50 hrs

4. Do you use hired labor on your grass-fed beef operation? (a) Yes (b) No

   (a) Do any of your children or other family members plan to take over your farm operation upon your retirement? (a) Yes (b) No

5. Do you plan to expand or reduce your herd size in the next 12 months? Please check the one that applies.
   (a) Yes, I will expand my herd by > 30%
   (b) Yes, I will expand my herd by 16-30%
   (c) Yes, I will expand my herd by 1-15%
   (d) No, I will keep the same number of cattle
   (e) No, I will reduce my herd by 1-15%
   (f) No, I will reduce my herd by 16-30%
   (g) No, I will reduce my herd by > 30%
6. Relative to other investors, how would you characterize yourself? (Please check one).
   (a) I tend to take on substantial levels of risk in my investment decisions
   (b) I neither seek nor avoid risk in my investment decisions.
   (c) I tend to avoid risk when possible in my investment decisions.

Section VI. Goal Structure of Grass-fed Beef Producers

1. Grass-fed beef producers may have a number of goals with respect to their operations. Below are some potential goals that you may have for your farm operation. Some goals are likely to be more important to you than others. In this section, **you will be asked to compare each of eight goals with each of the other goals**. We are interested in how important each goal is to you when compared to the other goals. Questions will be worded in a similar manner to the one in the following example.

> Example: Assume you are asked to compare two goals, **maximize profit** and **produce healthy beef**. If the goal **maximize profit** is much more important to you than the goal **produce healthy beef**, then you would place an “**X**” very near the goal **maximize profit**, as shown below
>
> Maximize profit --**X**-------------------------I---------------------------- Produce healthy beef.
>
> On the other hand, if the goal **produce healthy beef** is slightly more important to you than the goal **maximize profit**, then you would place an “**X**” nearer to the goal **produce healthy beef**, but close to the middle, as shown:

Maximize profit ----------------------------I--**X**---------------------- Produce healthy beef.

If both goals are equally important, you would place an "**X**" at the middle of the line.

Maximize profit ----------------------------**X**---------------------------- Produce healthy beef.

Where the "X" is marked on the line will indicate how much more important one goal is than the other.

As shown above, please indicate your preferences for each of the following goals by placing an "**X**" **at the point on the line that best represents your preferences** for each comparison.

Maximize profit ---------------------**I**-------------------- Produce healthy beef
Maximize profit ---------------------**I**-------------------- Maintain and conserve land
Maximize profit ---------------------**I**-------------------- Increase farm size
Maximize profit ---------------------**I**-------------------- Increase net worth
Maximize profit ---------------------**I**-------------------- Avoid years of loss/low profit
Maximize profit ---------------------**I**-------------------- Have time for other activities
Maximize profit ---------------------**I**-------------------- Have family involved in agriculture
Produce healthy beef ---------------------**I**-------------------- Maintain and conserve land
Produce healthy beef ---------------------**I**-------------------- Increase farm size
Produce healthy beef ---------------------**I**-------------------- Increase net worth
Produce healthy beef ---------------------**I**-------------------- Avoid years of loss/low profit
Produce healthy beef ---------------------**I**-------------------- Have time for other activities
Produce healthy beef ---------------------**I**-------------------- Have family involved in agriculture
Maintain and conserve land ---------------------**I**-------------------- Increase farm size
Maintain and conserve land ---------------------**I**-------------------- Increase net worth
Maintain and conserve land ---------------------**I**-------------------- Avoid years of loss/low profit
Maintain and conserve land ---------------------**I**-------------------- Have time for other activities
Maintain and conserve land ---------------------**I**-------------------- Have family involved in agriculture
Increase farm size ----------------------**I**-------------------- Increase net worth
Increase farm size ----------------------**I**-------------------- Avoid years of loss/low profit
Increase farm size ----------------------**I**-------------------- Have time for other activities
Increase farm size ----------------------**I**-------------------- Have family involved in agriculture
Increase net worth ----------------------**I**-------------------- Avoid years of loss/low profit
Increase net worth ----------------------**I**-------------------- Have time for other activities
Increase net worth ----------------------**I**-------------------- Have family involved in agriculture
Avoid years of loss/low profit ---------------------**I**-------------------- Have time for other activities
Avoid years of loss/low profit ---------------------**I**-------------------- Have family involved in agriculture
Have time for other activities ---------------------**I**-------------------- Have family involved in agriculture

Section VII. Marketing

1. How important are the following factors in your decision of when to harvest or sell your cattle?

Factors	Not Important at all	Somewhat Important	Very Important	Highly Important
Market price	1	2	3	4
Immediate need for cash	1	2	3	4
Age of the animal	1	2	3	4
Weight of the animal	1	2	3	4
Body frame	1	2	3	4
Availability of pasture for grazing	1	2	3	4
Consumer demand	1	2	3	4

2. At what average live weight are your grass-fed beef animals ready for harvest/slaughter? ______ (lbs)

3. How many grass-fed beef animals were raised to slaughter weight in 2012? ______ (number)

4. Did you sell grass-fed beef as meat in 2012? (a) Yes **[Please continue with 5]** (b) No **[skip to section VIII.]**

5. **[If yes to 4]**, in which form was the beef sold? (Circle all that apply)
   (a) Whole carcass (b) Whole side (c) Quarter (d) Mixed quarter
   (e) Box-different sized (f) Individual cut (g) Hamburger (h) Other

6. Do you sell your beef seasonally or year-round? (Please circle one) (a) Seasonally (b) Year-round

7. How do you advertise your beef product?
   (a) Word-of-mouth (b) Radio and/or TV (c) Newspaper or Magazine
   (d) Internet (e) Email (f) Direct mail
   (g) Telephone (h) I do not advice (i) Other ______

8. What are your primary sources of information for market prices for grass-fed beef? (Circle all that apply)
   (a) Other farmers (b) Extension service (c) Farm organizations
   (d) TV, radio or magazines (e) Internet (f) Other __________

9. Which of the following marketing channels do you use to sell your beef? (Please circle all that apply)
   (a) Direct sale to consumers (b) Online/Internet (c) Cooperative
   (d) Grocery store (e) Farmer's market (f) Wholesalers
   (g) Restaurant (h) Dealers, brokers or meat packers

Section VIII. Important Challenges Currently Facing Grass-Fed Beef Producers

1. To what extent do you agree or disagree that the following challenges are having significant negative impacts on grass-fed beef producers in your area? Please select a number in each category based on the headings provided.

Challenges	**Strongly Agree**	**Somewhat Agree**	**Neutral**	**Somewhat Disagree**	**Strongly Disagree**
High cost of grass-fed beef production	1	2	3	4	5
Lack of a clear marketing system for grass-fed beef	1	2	3	4	5
Strong market competition from feedlot beef	1	2	3	4	5
Lack of steady demand for grass-fed beef	1	2	3	4	5
Pasture management problems	1	2	3	4	5
Limited land available for grazing	1	2	3	4	5
Diseases	1	2	3	4	5
Long period of time required to get animals to slaughter weight	1	2	3	4	5
Shortage of processors close by that will handle grass-fed beef	1	2	3	4	5
Grass-fed beef production is labor intensive relative to cow-calf production	1	2	3	4	5

Section IX. Demographic and Financial Information

1. What is your gender? (Circle one)   (a) Male   (b) Female

2. Which of the following best describes your ethnic background? (Circle one)
   (a) American Indian   (b) Asian or Pacific Islander   (c) Black (African American)
   (d) Hispanic/Latino   (e) White (Caucasian)   (f) Other ___________

3. Please indicate your age. (Circle one)
   (a) ≤30 years   (b) 31-45 years   (c) 46-60 years   (d) 61-75 years   (e) ≥76 years

4. Please indicate your highest level of education. (Circle one)
   (a) Less than high school
   (b) High school diploma/GED
   (c) Technical college
   (d) Bachelor's degree
   (e) Advanced degree (M.D., DVM. M.S., Ph.D., etc.)

5. What is your debt-to-asset ratio? (100*total debts / total assets).
   (a) 0-30% (b) 31-60% (c) > 60%

6. Do you have an off farm job?
   (a) Yes (b) No **[skip to 8]**

7. **[If yes to 6]** How many hours per week do you work off the farm? ____ (hours per week)

8. Which of the following best describes your 2012 annual **net household income** from **all sources**? (a) < $50,000 (b) $50,000-$100,000 (c) > $100,000

9. Approximately what percentage of your **net household income** comes from **off-farm sources**? (Circle one)
   (a) 0 to 19% (b) 20 to 39% (c) 40 to 59%
   (d) 60 to 79% (e) 80 to 100%

10. What percentage of your annual **net farm income** comes from your grass-fed beef operation? (Circle one)
   (a) 0-19% (b) 20-39% (c) 40-59% (d) 60-79% (e) 80-100%

Within the next few months, we will be sending a follow-up survey on production costs to those who indicate they are willing to participate. This will allow us to analyze industry profitability. We would <u>greatly appreciate</u> your participation in that survey. Would you be willing to participate in that 4-page survey?
(a) Yes ***(b) No***

THANK YOU FOR YOUR PARTICIPATION IN THIS SURVEY!

APPENDIX B: IRB APPROVAL FORM

LSU AgCenter Institutional Review Board (IRB)
Dr. Michael J. Keenan, Chair
School of Human Ecology
209 Knapp Hall
225-578-1708
mkeenan@agctr.lsu.edu

Application for Exemption from Institutional Oversight

All research projects using living humans as subjects, or samples or data obtained from humans must be approved or exempted in advance by the LSU AgCenter IRB. This form helps the principal investigator determine if a project may be exempted, and is used to request an exemption.

- Applicant, please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the LSU AgCenter IRB. Once the application is completed, please submit the original and one copy to the chair, Dr. Michael J. Keenan, in 209 Knapp Hall.

- A Complete Application Includes All of the Following:
  (A) The original and a copy of this completed form and a copy of parts B through E.
  (B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1 & 2)
  (C) Copies of all instruments and all recruitment material to be used.
    - If this proposal is part of a grant proposal, include a copy of the proposal.
  (D) The consent form you will use in the study (see part 3 for more information)
  (E) Beginning January 1, 2009: Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing and handling data, unless already on file with the LSU AgCenter IRB.
  Training link: (http://grants.nih.gov/grants/policy/hs/training.htm)

1) Principal Investigator: Jeffrey Gillespie Rank: Professor Student? No
Dept: Agricultural Economics & Agribusiness Ph: 225-578-2759 E-mail: jmgille@lsu.edu
2) Co-Investigator(s): please include department, rank, phone and e-mail for each

- If student as principal or co-investigator(s), please identify and name supervising professor in this space

Ph.D. Students Isaac Sitienei and Basu Bhandari will be assisting in this, but I am the principal investigator.

3) Project Title: U.S. Grass-fed Beef Production Survey
4) Grant Proposal?(yes or no) No If Yes, Proposal Number and funding Agency N/A
Also, if Yes, either: **this application completely matches the scope of work in the grant Y/N__**
OR
more IRB applications will be filed later Y/N___
5) Subject pool (e.g. Nutrition Students) Grass-fed Beef Farmers

- Circle any **"vulnerable populations" to be used:** (children<18, the mentally impaired, pregnant women, the aged, other). Projects with incarcerated persons cannot be exempted.

6) PI signature [signature] ****Date** 6/27/13 (no per signatures)
****I certify that my responses are accurate and complete.** If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU AgCenter institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at the LSU AgCenter for three years after completion of the study. If I leave the LSU AgCenter before that time the consent forms should be preserved in the Departmental Office.

Committee Action: Exempted ✓ Not Exempted____ **IRB#** HE13-8

Reviewer Michael Keenan **Signature** Michael Keenan **Date** 7-15-2013

VITA

Isaac Sitienei was born and raised in Nandi County, Kenya. He obtained his Bachelor of Science degree in Agricultural Economics from Egerton University, Kenya in 2005. He travelled to the U.S. to join graduate school at Texas State University starting August, 2009 and received a Master of Education degree in Agricultural Education in August, 2011. In August of 2011, Isaac began pursuing a PhD in Agricultural Economics at Louisiana State University and obtained a Master of Science degree in Agricultural Economics in December, 2014.