Estimating Preference Heterogeneity for Grass-fed Beef Cattle Traits

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This paper examines grass-fed beef producer preferences for cattle traits using data from a mail survey of 384 U.S. grass-fed beef producers. Conjoint analysis and Likert scale questions were used to determine preferences. Generally, results indicated that producers preferred easy-to-handle, heavy, black, and relatively lower-priced feeders raised from their own cows. The Kernel density figures for source, color, and temperament confirm the mixed logit standard deviation estimates that suggest heterogeneity in producer preferences.

Key Words: cattle traits, grass-fed beef, heterogeneity, preference

A resurgence of interest in finishing cattle on forage rather than grains has been observed in the U.S. in recent years, with the resulting beef typically marketed as "grass-fed." Like any beef producer purchasing animals for production, grass-fed beef (GFB) producers must decide among animals with a wide range of characteristics. While consumer preferences for the characteristics of grass-fed beef have been examined in stated preference studies (Umberger et al. 2002; Cox et al. 2006; Kerth et al. 2007), little research attention has been given to grass-fed beef producer preferences for production-related animal attributes such as body frame, gender, temperament. Grass-fed beef producers face a number of cattle attribute trade-offs in selecting animals for production. Observation of cattle raised by producers suggests a range of preferences by traits such as size and breed composition. This study provides information on animal attributes preferred by U.S. grass-fed beef producers.

In contrast to what has become the conventional U.S. beef production system of feeding grain to cattle in feedlots to raise them to slaughter weight, grass-fed beef production was defined in the *Federal Register* (2007) as requiring the feeding of only grass and other forage for the lifetime of the animal, with the exception of milk prior to weaning. The diet of the grass-fed beef animal is limited to forbs, grasses, the vegetation of cereal grain crops in their pre-grain state, and browse. Harvested forage, including baleage, crop residue

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without grain, hay, haylage, silage, and other roughage may be fed. Minerals and routine vitamin supplementation may also be provided. The American Grassfed Association's (2018) standards are similar for feeding, with additional requirements that no antibiotics or growth hormones may be used, the animals cannot be confined in feedlots, and the animals must be "born on American family farms."

We are unaware of previous research that has focused specifically on grass-fed beef producer preferences for feeder cattle traits. It is clear that animal attributes and management practices that affect the value of cattle can have significant economic impacts for producers (Lambert et al. 1989). Raising the animal to market weight faster and with minimum possible feed intake is likely to be a primary goal of most beef producers, including grass-fed beef producers who are required to comply with strict dietary requirements and may have to comply with requirements of no growth promotants or antibiotics. Animals raised entirely on forage generally reach slaughter weight slower than those raised on grains, lengthening the production period and therefore increasing production costs (Mathews and Johnson 2013). Selection of cattle with traits such as faster growth rates and higher feed efficiency would therefore likely be a priority for producers in this segment. Furthermore, most grass-fed beef production involves significant daily interaction between the producer and animals that are raised to over 1,000 pounds, as many are rotated among pastures on a regular basis. This, along with the finding that animal temperament is linked to meat quality (Kadel et al. 2006), suggests that identifying animals with milder temperament would be important. Effects of management and/or production related traits such as temperament, gender, body weight, and frame are addressed in this study.

Connecting grass-fed beef production practices and marketing are cattle prices. Though cattle prices are directly affected by a number of market-related factors such as prices of hay, grain, and competing meats (Lambert et al. 1989), factors affecting the market price of a specific group of feeder cattle are the characteristics of those cattle traded, such as gender, weight, body frame, color, and breed (Lambert et al. 1989). Outlaw, Anderson, and Padberg (1997) explained how consumer preference for commodity beef travels through the marketing system via price signals from packers to cattle feeders, and eventually to cow-calf producers who purchase breeding stock with the desired traits from seedstock producers. For both conventional and grass-fed beef, market price signals travel upstream from the consumer to the cow-calf producer in the form of implicit premiums and discounts paid on the basis of calf characteristics (Zimmerman et al. 2012). This leads us to ask if there is general agreement on what cattle traits are preferred. How much do calf traits matter in purchasing calves for grass-finishing? What are the implications for industry structure and meat quality? There is a need for extension educators to be able to provide information to existing and potential grass-fed beef producers on the type of animal generally preferred by other grass-fed beef producers and to be able to link that information with what is known about meat quality, etc., among different animal sizes, breeds, etc. Furthermore, is there consistency in preferences with what the conventional industry would use? While we cannot fully answer these questions in the context of the current study, we can provide insight on what grass-fed beef producers prefer. Conjoint analysis offers a framework that can be used as a foundation for addressing these questions.

Our experience working with grass-fed beef producers over a number of years suggests a wide range of preferences for animals by breed, but there does appear to be some general consistency on desired animal traits. Traits most desired for grain finishing may not be the same as for forage-finishing since the production environment differs, the beef is likely to be marketed direct to consumer rather than as a branded product, and significant time is likely to be spent by smaller-scale producers in managing the animals. Knowledge of the type of animal most desired for GFB production will provide cow-calf producers in areas with significant GFB production with knowledge of the most preferred calves for purchase by the GFB segment. Perhaps most importantly, the results will be useful to new GFB producers who desire information on the types of animals experienced producers in the segment consider to be the best for grass-finishing. Furthermore, animal scientists working in the area of GFB will benefit from knowing the most appropriate animal types to include in field trials and in responding to producer questions regarding animal selection. The objective of this study is to determine U.S. grass-fed beef producer preferences for cattle traits to be used for grass-finishing. We use both conjoint analysis and responses to Likert scale questions from a mail survey of U.S. grass-fed beef producers to determine GFB producer preferences for animal traits.

Methods

Conjoint Analysis and Cattle Traits

Conjoint analysis arose from the consumer theory developed by Lancaster (1966) that expresses that consumer utility is a function of the characteristics of a good. This suggests that it is possible to decompose the total utility associated with a good into separate "part-worth" utilities of its constituent characteristics (Louviere, Hensher, and Swait 2000). A number of beef demand valuation studies (Umberger et al. 2002; Loureiro and Umberger 2003; Lusk, Roosen, and Fox 2003; Lusk and Parker 2009; Steiner, Gao, and Unterschultz 2010) have used conjoint analysis to estimate consumer preference for various beef attributes.

For the case of cattle selection, conjoint analysis allows for analysis of producer preferences for cattle characteristics of the animals they purchase for finishing. These preferences are likely to be based primarily on the benefits they perceive to result from raising animals with those characteristics (Tano et al. 2003). Each beef producer has unique preferences for the traits embodied in cattle. Studies using conjoint analysis to estimate producer preferences for cattle traits include Sy et al. (1997), Scarpa et al. (2003), Ouma, Abdulai, and Drucker (2007), and Ruto, Garrod, and Scarpa (2008). None of these studies have focused on the grass-fed segment of cattle production. A more recent study using conjoint analysis to examine livestock producer preferences for breeding animal traits focused on the meat goat industry (Nyaupane et al. 2017).

A list of 15 cattle traits that could potentially impact producer choice of animals for grass-finishing was developed based upon discussion with Louisiana GFB producers who were cooperators in the study, knowledge of the industry, and literature review. With this many traits, however, use of a choice-based conjoint analysis where respondents choose among hypothetical product profiles would be infeasible due to the large number of choices respondents would have to make. To retain the most important traits while reducing the number of attributes and their levels, the most relevant attributes were determined by the authors who represent the fields of animal science and agricultural economics and have worked closely with project-cooperator and grass-fed beef producers since 2010. By considering the most important traits as well as overlap among several of the traits, the number of attributes was reduced to seven. Furthermore, the number of levels considered for each trait was reduced. Follow-up farm visits with four Louisiana GFB producers to discuss the selected attributes confirmed the appropriateness of these attributes and their levels for the study.

Of the seven attributes included in the final questionnaire, five consisted of three levels each and the remaining had two levels each. Selected attributes included: (1) *Weight* in pounds 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* (heifer, steer, or intact male); (5) the *Source* of the animal (retained from own cows, purchased at auction, or purchased via private treaty); (6) the animal's *Color*, referring to its coat color, which was generalized to two levels, black or non-black, on the basis of a general preference in the grain-fed beef sector for black angus cattle; and (7) *Price* representing the value of the animal per hundredweight (cwt)—the price to purchase the animal or the market value of the retained animal for producers raising their own animals. Based on market prices for calves in the year the survey was conducted and the previous two years, three price levels were chosen: $120, $140, and $160/cwt.

Given the five 3-level and two 2-level traits, a full factorial design would yield $(3^5 \times 2^2) = 972$ profiles. It would be impracticable to work with such a large number of profiles in a conjoint analysis, as the respondent would be requested to respond to too many questions, leading to respondent fatigue and response bias (Louviere, Hensher, and Swait 2000), as well as low response. To reduce the number to a manageable level, an orthogonal fractional factorial design including 18 profiles was used (Harrison, Stringer, and Prinyawiwatkul 2002; Hair et al. 2006). The orthogonal fractional factorial experimental design package in Statistical Product and Service Solutions (SPSS) was used to recover the main effects consisting of 18 cattle profiles. A randomized selection of nine choice sets (pair-wise comparisons of the 18 cattle profiles) to be presented to respondents was obtained. The fractional factorial design ensures that independence among the hypothetical product levels (orthogonality) is maintained (Hair et al. 2006).

For each of the nine choice sets, respondents were asked to select the animal they would retain/purchase for forage finishing. The survey question was framed as, "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." For example, each choice option shown in Figure 1 represents a hypothetical animal profile described in terms of animal traits and their levels. In this case, respondents were asked to select one of the three options: "Animal A," "Animal B," or "Neither." There were nine such choice sets.

Econometric Methods Used in Part-Worth Estimation

McFadden's (1986) random utility theory provides insight for designing a study to estimate producer preferences using conjoint analysis. We assume producers derive utility from cattle traits. A general utility functional form $U_{ij} = V_{ij} + \varepsilon_{ij}$ for producer i is specified where U_{ij} is the i^{th} producer's utility associated with choosing attribute j, V_{ij} is the non-stochastic portion determined by the cattle

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 1. Sample of a Choice Experiment Question.

attributes and their levels, and ε_{ij} is the identically and independently distributed (IID) error term.

We use a mixed logit model (MLM) to estimate producer preferences for cattle traits, assuming 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 kernel for the MLM 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 advantages of using the MLM to approximate a 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 multinomial logit models, MLMs are the most flexible (Revelt and Train, 1998; McFadden and Train, 2000; Bhat, 2003; Greene and Hensher, 2003).

Introduction of the choice occasions slightly modifies the general McFadden (1986) random utility model. The utility that individual i derives from choosing alternative j on choice occasion t is defined as:

$$U_{ijt} = \beta_i x_{ijt} + \epsilon_{ijt}, \tag{1}$$

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 assumed to be IID extreme value. Each β_i in vector β' is assumed to be random with unconditional density $f(\beta_i|\varnothing)$ where $\varnothing$ is the distribution of parametersβ in the population—such as its mean and covariance (Train 2008). The traditional McFadden choice model provides the probability of a sequence of choices made by agent i:

$$Pr_i(\beta) = \prod_{t=1}^{T}\prod_{j=1}^{J}\left(\frac{\exp\left(\beta_i x_{ijt}\right)}{\sum_{l=1}^{M}\exp\left(\beta_i x_{ilt}\right)}\right)^{d_{ijt}}, \tag{2}$$

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):

$$L_{ijt}(\beta_i) = \frac{\exp(\beta_i x_{ijt})}{\sum_{l=1}^{M}\exp(\beta_i x_{ilt})} \tag{3}$$

Train (2000) discusses the relevance of Halton draws in MLM model estimation. To select the number of Halton draws required to secure a stable set of parameter estimates, the MLM was estimated over a range of draws from 50 to 1,000 during our initial specification search. Hensher and Greene

(2003) discussed the importance of stability in selecting an optimum number of Halton draws in a MLM. Bhat (2001) and Train (2000) found lower simulation variance using 100 than when using 1,000 Halton draws. Both studies found that simulation error increased as the number of Halton draws increased. Hensher and Greene (2003) recommended a smaller number of draws to reduce length of run time and simulation error. To reduce estimation time and simulation error, 500 Halton draws were selected for our final model.

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 example, if a non-negative sign 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 traits may plausibly have either a positive or negative response parameter.

The random parameters logit model can be used to estimate heterogeneous preferences by allowing model parameters to vary over respondents. A problem is that it cannot account for the sources of heterogeneity (Boxall and Adamowicz 2002). Latent class models (LCM) can be used to estimate both the observable and unobservable heterogeneity caused by factors that can and cannot be observed by the analyst, respectively (Greene and Hensher 2003).

Understanding the form and source of heterogeneity in cattle preferences among GFB producers is of interest to our study. Thus, the LCM is used to estimate the sources of preference heterogeneity among producers. Various segments are likely to be present among GFB producers, each segment characterized by relatively homogenous preferences. As discussed by Boxall and Adamowicz (2002), attitudinal measures and quantifiable demographic characteristics are the determinants of membership in different classes or segments.

To account for preference heterogeneity, some economists have included demographic characteristics in demand functions (Boxall and Adamowicz, 2002). A 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). Some researchers have taken advantage of their *a priori* knowledge of variables (Morey, Rowe, and Watson 1993) by explicitly incorporating them into 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) and some important individual-specific variables may be unobservable to the researcher. Latent class logit models have been developed to address this issue.

Using LCMs, we assume that preference heterogeneity across classes can be sufficiently explained by a discrete number of classes (Shen 2009). The probability of individual i belonging to class s choosing alternative j in the t^{th} choice situation is:

$$P_{ijt|s} = \prod_{t=1}^{T} \frac{\exp\left(\beta_s x_{ijt}\right)}{\sum_{l=1}^{M} \exp\left(\beta_s x_{ilt}\right)} \quad s = 1, \ldots, S, \tag{4}$$

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. Letting z_{it} denote individual i's specific choice made on the t^{th} occasion, a linear probability relation for the specific choice of individual i can be formulated as:

$$P_{ijt} = \text{Prob}(z_{it} = j | \text{class} = s). \tag{5}$$

This is a panel data application, since we assume that the same individual is observed on 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 $z_i = [z_{i1}, z_{i2}, \ldots, z_{iT}]$:

$$P_{i|s} = \prod_{t=1}^{T_i} P_{it|s}, \tag{6}$$

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 on T occasions.

The researcher must determine the optimal number of classes to use for the LCM. Roeder, Lynch, and Nagin (1999) suggest using Bayesian Information Criteria (BIC) to determine the optimal number of classes. Louviere, Hensher, and Swait (2000) suggested other information theoretic criteria that have been widely used, such as the Akaike Information Criteria (AIC) and its variant the Consistent Akaike Information Criteria (CAIC). The optimum number of classes is determined where the values of the BIC, AIC, and/or CAIC are minimized. The CAIC was used for this study because it provides a standardized way to balance sensitivity and specificity (Dziak, et al. 2012).

Using Likert Scale Questions to Assess Animal Selection

In addition to conjoint questions to assess why producers selected certain animals for grass-fed beef production, Likert scale questions were used to provide further insight. Respondents were asked, “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." Four responses were provided, including (1) Not Important at All, (2) Somewhat Important, (3) Very Important, and (4) Highly Important. Attributes assessed included 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 Were Never Fed Grain. These questions allowed us further insight into the cattle attributes most valued by grass-fed beef producers, with results to be compared and contrasted with those obtained via the conjoint analysis. Some attributes included in the Likert scale questions were not included in the conjoint questions. In several cases, these represented traits that would not be readily apparent when viewing an animal, such as average daily weight gain, parents were never fed grain, etc. While breed was also not explicitly included in the conjoint analysis, breed may be considered as a composite attribute since it is likely to be composed of a number of specific attributes such as body frame, coat color, and in some cases temperament.

Responses to Likert scale questions were analyzed using the ordered probit model. The use of ordered probit models has been rather common in the agricultural economics literature in recent years, so we refer the reader to Greene (2003) for a fuller discussion of the model. Independent variables used in the ordered probit models to determine the impact of producer demographics and farm characteristics on animal attribute importance were: *Cow-Calf,* whether the producer was a cow-calf producer, breeding cows and raising calves to weaning weight; *Number of Beef Animals,* indicating the size of the grass-fed beef operation; *Sell Grass-Fed Beef as Meat,* a dummy variable indicating whether or not the producer sold grass-fed beef as meat (as opposed to selling only grass-fed beef animals); *percent Income Grass-Fed Beef,* indicating the percentage of net farm income coming from the grass-fed beef operation; the producer's *Age; Years of Operation,* the number of years the producer had operated the grass-fed beef enterprise; *College Degree,* whether or not the producer held a college Bachelor's degree; and region of the U.S. where the farm was located including *Northeast* (MA, NY, PA), *Midwest, Southeast, Northwest*, and *Southwest.*

Data Collection

The survey questionnaire was mailed to 1,052 U.S. grass-fed beef producers on August 10, 2013, following the Tailored Design Method as recommended by Dillman, Smyth, and Christian (2009). The names of these producers had been collected via an extensive Internet search. Sources included www.eatwild.com, the American Grass-fed Association, Market Maker, and a search for individual farms advertising their beef online. The first mailing contained a personally addressed, signed cover letter explaining the purpose of the survey; the ten-page questionnaire; and a postage-paid return envelope. A postcard reminder was sent approximately 1.5 weeks later, followed by a third mailing, 1.5 weeks after the postcard, that included another personally addressed and signed cover letter, replacement questionnaire, and a postage-paid return envelope. Finally, another postcard reminder was sent approximately 1.5 weeks later.

A total of 384 usable responses were received. Returns from individuals no longer in the grass-fed beef business and incorrect addresses totaled 117. After adjusting for returns from incorrect addresses and those who were no longer in the grass-fed beef business, a 41.1 percent return rate was obtained. This rate is compared with past studies that have used similar approaches, such as for Louisiana crawfish producers, 15 percent (Gillespie and Nyaupane, 2010); dairy farmers, 15 percent (Paudel et al. 2008); and meat goat producers, 43 percent (Gillespie,Nyaupane, and McMillin 2013). We have a convenience sample with no known recent studies from which to compare for representativeness. Given our thorough search of the Internet for names and addresses of grass-fed beef producers and relatively strong return rate, we believe our sample reasonably represents grass-fed beef producers who advertise their product via the Internet.

Results and Discussion

Summary statistics in Table 1 provide characteristics of the surveyed grass-fed beef operations. The majority of the respondents (81 percent) produced their own calves for forage-finishing, followed by 17 percent obtaining feeder animals for forage-finishing via private treaty. Only 2 percent purchased their feeders via auction. About 80 percent were involved in the cow-calf segment and the average number of cattle on the farm was 127. Most of the respondents held four-year college degrees and about half of the average farm's annual net farm income came from grass-fed beef. Table 1 provides summary statistics of key drivers used in our analysis.

Mixed Logit Model Results

Using the maximized log likelihood values in Table 2, we can safely reject the conditional logit model (CLM) for the MLM. We present the results of both the CLM and MLM to reveal directional consistency of parameter estimates obtained using different models. Important to note is the difference in the magnitudes of taste parameters[1] (Pacifico et al. 2012). Estimated MLM coefficients are significantly larger than those from the CLM. This is likely a result of bias induced by the independence of irrelevant alternatives assumption of the standard CLM (Bhat 2000). Given that the two models are nested, a comparison between them may be made using the likelihood ratio

[1] Taste parameters or part-worths represent the value that the producer places on each cattle trait when choosing among traits (Revelt and Train 2000).

Table 1. 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 from private treaty, 0 otherwise	0.17	0.42
Auction	= 1 if feeders from auction, 0 otherwise	0.02	0.18
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
Sold GFB 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	–
Age	Age of the producer	54.66	13.73
Years of operation	# of Years operating grass-fed beef enterprise	11.32	8.05
College degree	= 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

test (Pacifico and Yoo 2012). The estimated likelihood ratio test statistic is significant (4,997.53, distributed chi-squared, 11 degrees of freedom), so the MLM fits the data better, further supporting rejection of the CLM in favor of the MLM.

All seven cattle traits were statistically significant for the MLM. Producers generally preferred 650-lb and 750-lb animals to 550-lb animals (Table 2). This may be particularly important for grass-fed beef animals that generally require a longer time than grain-fed beef animals to reach slaughter weight. Grass-fed beef animals are typically ready for slaughter at mean weights in the range of 980–1,047 pounds (Lozier, Rayburn, and Shaw 2005; Gillespie et al. 2016). Furthermore, lower death loss is expected from animals coming

Table 2. A comparison of CLM and MLM parameter estimates

Cattle traits	Levels	CLM	MLM	SD[a]
Weight	650 lbs	0.3486** (0.1431)	0.7534*** (0.1995)	0.5321 (0.4045)
	750 lbs	0.0296 (0.1540)	0.3330** (0.1767)	0.2325 (0.2915)
Body frame	Small	1.2150*** (0.1670)	1.0753*** (0.1953)	1.0214*** (0.1829)
	Medium	1.0262*** (0.1351)	0.7551*** (0.1443)	0.4062** (0.1688)
Temperament	Easy	3.4100*** (0.1393)	3.5656*** (0.2007)	1.2610*** (0.1588)
Gender	Heifer	1.1326*** (0.1726)	1.2453*** (0.2185)	−0.9757*** (0.2426)
	Steer	1.1331*** (0.1274)	1.4222*** (0.1672)	1.1922*** (0.1605)
Source	Retained	1.0158*** (0.1304)	0.8231*** (0.1645)	−1.0607*** (0.1946)
	Auction	−1.0160*** (0.1570)	−1.1580*** (0.1707)	−0.7656*** (0.1727)
Color	Non-black	−0.0182 (0.1128)	−0.2736** (0.1339)	0.8006*** (0.1492)
Price		−0.0307*** (0.0011)	−0.0297*** (0.0016)	−0.0153*** (0.0011)
Observations		379	379	
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 percent levels, respectively.
[a]SD Mixed logit standard deviation.

into the system at heavier weights (Avent, Ward, and Lalman 2004). *Body Frame* estimates were significant, indicating that producers preferred small-to-medium framed animals to large-framed animals. Camfield et al. (1999) showed that large-framed steers required more time to mature than medium-framed steers. *Temperament* was significant, indicating grass-fed beef producers preferred easy-to-handle animals for finishing, a result that is consistent with expectations.

Relative to intact males, steers and heifers were preferred. Animals retained from their own calves were preferred to animals purchased via private treaty, and the negative sign for *Auction* indicates disutility associated with the auction as a source for procuring animals for grass-finishing relative to purchasing via private treaty—a result that is consistent with the fact that only 3 percent of respondents obtained their calves via auction. Black cattle were preferred to non-black cattle, perhaps reflective of the higher perceived quality of Angus beef. As expected, *Price* had a negative sign, suggesting disutility associated with paying higher prices for cattle.

The cumulative distributions of the ratios of the estimated taste parameters to their respective standard deviations were used to calculate the share distributions of the responding population for the different cattle traits. 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 kth coefficient. For animal weight, 83 percent and 67 percent of respondents preferred animals weighing 650 and 750 lbs, respectively, relative to those weighing 550 lbs (the base weight). Small body frames were preferred to large frames by 83 percent of respondents, which may be explained by the Gwin (2009) findings that tall, lanky cattle may take an extra year or more to finish without grain, increasing production costs. Based on the magnitudes of the standard deviations, preferences for *Temperament* were among the most heterogeneous across the population (Table 2). Easy-to-handle feeder cattle were preferred to difficult-to-handle cattle by 88 percent of producers. Relative to purchasing feeder animals via auctions, 83 percent of respondents preferred finishing feeders retained from their own cattle and 77 percent preferred purchasing animals via a private treaty source.

The estimated standard deviations of all coefficients other than those for *Weight* 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), significant at $p < 0.01$, leads us to reject the null hypothesis that all of the standard deviations are equal to zero (Hole 2007). The standard deviation associated with each parameter estimate reveals the presence or absence of preference heterogeneity in the sample population (Hensher and Greene 2003). The MLM can only indicate the presence of heterogeneity but does not provide information about the source of heterogeneity. The most common source of heterogeneity documented in the literature has been the characteristics of respondents (Boxall and

Adamowicz 2002). According to Louviere, Hensher, and Swait (2000), there are many other sources/causes of heterogeneity in the estimated taste coefficients other than differences in respondents. Other sources or causes may result from the bias or errors in measurement techniques used and could 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 the estimated parameters (Train, 2003). A more detailed discussion of sources of heterogeneity is provided in our later discussion of LCM and Likert scale model results.

The estimated MLM taste parameters can be plotted parametrically using kernel densities to reveal information about their distributions across the sampled population (Hensher and Greene 2003), and thus preference heterogeneity. 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. Results in Figure 2 indicate fairly similar distribution patterns. *Color* and *Temperament* parameter distributions are less "peaked" with relatively flatter tails than the *Source* parameter distributions. *Source, Color,* and *Temperament* distributions (panels A, B, C, and D in Figure 2) 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 for *Weight* parameters. Plots show distributions that are consistent with the values of the standard deviations shown in Table 2. There is relatively more heterogeneity in *Temperament* as indicated by its fat-tailed plot (Figure 2, D).

Relative Importance of Beef Attributes

The first column of Table 3 shows the relative importance of each of the seven attributes using MLM results. These results suggest that grass-fed beef producers were most concerned about the *Temperament* of the animal, with this attribute contributing 34.8 percent to the animal selection decision. The attribute of second-highest importance was *Source*, which contributed 19.3 percent to the decision. The third, fourth, and fifth most important attributes were *Gender, Price,* and *Body Frame*, respectively, each contributing between 10.5 and 13.9 percent to the decision. *Weight* was the sixth most important attribute, and *Color* was the least important, contributing only 2.7 percent to the animal selection decision.

Sources of Preference Heterogeneity

Using the LCM, 37, 10, 15, and 38 percent of respondents had fitted probabilities of belonging to Classes 1, 2, 3, and 4, respectively. As indicated in Table 4, the highest mean posterior probability is about 90 percent, suggesting that the model does very well at decomposing the different

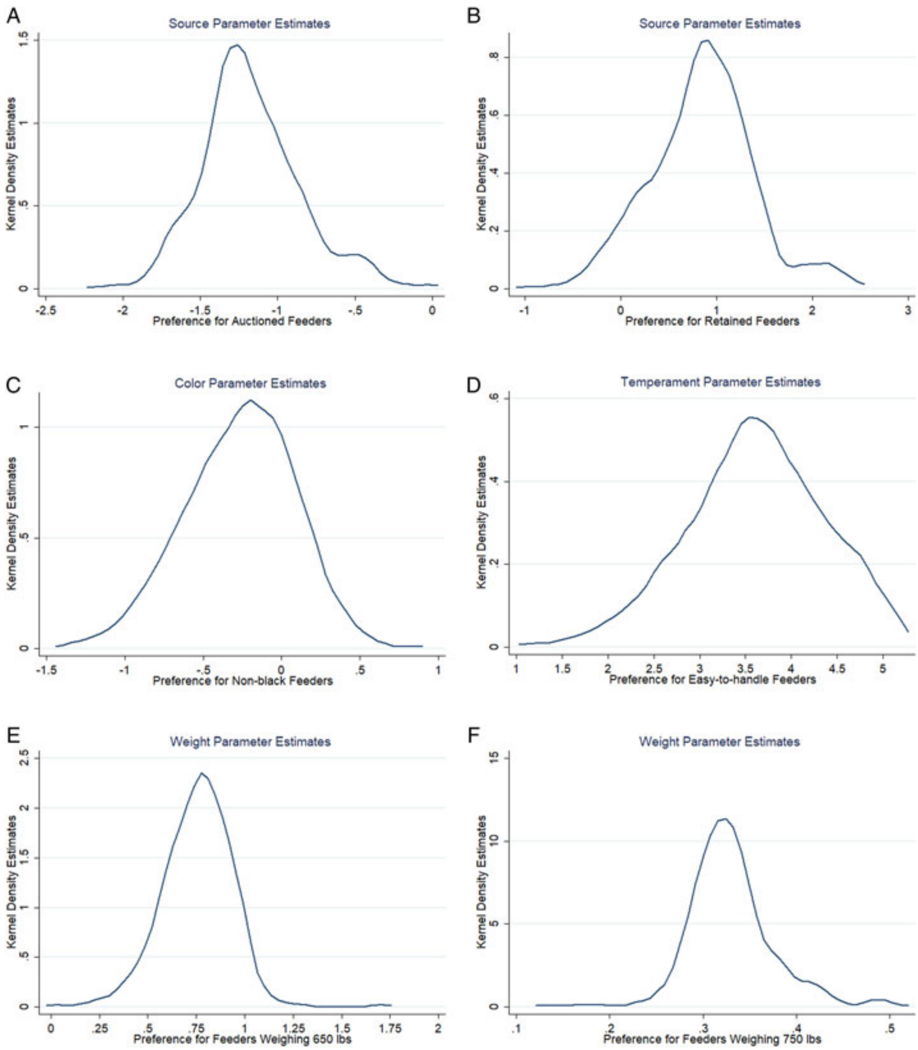

Figure 2. Mixed Logit Parameter Estimates.

underlying taste patterns for the observed choice situation (Pacifico and Yoo 2012).

The constant variable for Class 1 in Table 4 represents the "opt out" choice option, so its highly significant status for Class 1 suggests that relative to Class 4 individuals, the individuals in this class were more likely to have responded with "Neither" in the choice sets. Examining results in Table 3, Class 1 producers were relatively more concerned about *Temperament* and less concerned about *Color* than producers in the other classes. The negative *Age* and *Education* coefficients for Class 2 members indicate that members of

Table 3. Class-specific values of relative importance of cattle attributes

Cattle attributes	MLM	Relative importance (%) Class 1	Class 2	Class 3	Class 4	Overall ranking
Temperament	34.8 (1)	32.9 (1)	26.0 (1)	26.4 (2)	17.6 (2)	1
Source	19.3 (2)	21.7 (2)	15.7 (4)	8.3 (5)	28.0 (1)	2
Price	11.6 (4)	7.9 (4)	4.8 (5)	13.9 (3)	10.8 (5)	3
Body frame	10.5 (5)	20.9 (3)	1.4 (7)	28.2 (1)	7.2 (7)	4
Gender	13.9 (3)	7.2 (6)	23.8 (3)	7.9 (6)	12.2 (4)	5
Color	2.7 (7)	1.5 (7)	24.8 (2)	9.2 (4)	10.1 (6)	6
Weight	7.3 (6)	7.8 (5)	3.5 (6)	6.1 (7)	14.1 (3)	7

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

this class were likely to be younger and have lower levels of education relative to Class 4 members. This group placed the least importance on the *Weight, Body Frame,* and *Price* attributes and the most importance on the *Gender* and *Color* attributes. The coefficient for *Cow-calf* was negative and significant for Class 3 members and *Northwest* was positive and significant, indicating that members of Class 3 were less likely than Class 4 members to be cow-calf producers and more likely to farm in the Northwestern U.S. This group placed the greatest importance on *Body Frame* and *Price* and the least importance on *Source.* Finally, Class 4 members placed the greatest importance on the *Weight* and *Source* attributes and the least importance on *Temperament.* A drawback of the LCM is its inability to reveal the specific drivers of preference heterogeneity. It only points out the likelihood of a particular respondent belonging to Class X relative to base Class Y but does not identify clearly who the members of a particular class are.

Likert Scale Model Results

A summary of results of the ten cattle traits evaluated using Likert scale responses is provided in Table 5. Means, modes, and percentages of responses for each category are provided. Consistent with conjoint results, Likert scale results indicate the most important attribute considered by grass-fed beef producers in selecting animals for grass-finishing was temperament. The mean response for temperament was 3.59, with 67 percent of respondents indicating it was highly important in their animal selection. Disease resistance followed with a mean of 3.19 and "Very Important" as the modal response. Body frame and expected carcass yield tied with means of 3.02 each and modal responses of "Very Important." Body frame's ranking in the "middle of the pack" for the Likert scale questions is consistent with results of the conjoint analysis, where it was ranked fourth of seven attributes.

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Table 4. Latent class model parameter estimates of cattle traits

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

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Table 5. Likert scale results of the 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
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

Note: Values for calculating means were 4 = highly important, 3 = very important, 2 = somewhat important, and 1 = not important at all.

Breed is an attribute indicating whether the animal is Angus, Hereford, Charolais, Brahman, or one of the many other breed types or crossbreeds. Different breeds generally are associated with particular cattle attributes such as temperament, body frame, etc., so breed may be considered as a composite attribute. The mean response for breed was 2.94, with 35 percent of respondents indicating that it was a very important attribute in animal selection (Table 5). Lozier, Rayburn, and Shaw (2005) found breed to be the most important criteria grass-fed beef producers used when selecting animals to purchase. 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. 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. Color was also among the least important attributes in the conjoint analysis.

Ordered probit results showing the influence of farm and farmer characteristics on the importance of cattle attributes are presented in Table 6. There are a number of significant results in the tables, but we will discuss a few that are particularly noteworthy. First, both cow-calf producers and producers who secured greater percentages of their net farm income from the grass-fed beef enterprise tended to rate all of the attributes higher. It is difficult to discern whether this is because these segments tend to find these attributes more important or because this particular sample of producers simply tended to provide higher ratings if they were cow-calf or less diversified producers. It is plausible, however, that producers who have stronger preferences for particular animal attributes tend to opt to produce animals from their own stock (thus involvement in cow-calf production). This would ensure that they could obtain animals for grass-finishing that meet their preferred attributes. Larger-scale producers tended to rate productivity measures such as carcass yield and average daily growth as more important, which is consistent with the fact that larger-scale producers tend to have more economically at stake in the enterprise. Those who sold grass-fed beef as meat tended to be more concerned with carcass yield (more meat produced) and average daily gain (more meat produced per day of grazing). These producers tended to be less concerned about animal traits that did not necessarily influence the meat quantity or quality, such as breed and coat color.

Producer age, experience (number of years operating the grass-fed beef enterprise), and education influenced perceived importance of a number of animal attributes. For instance, breed was more important to older, more experienced, and more highly educated producers. On the other hand, coat color was more important to older producers but less important to more experienced and more highly educated producers. The region where the farm was located also influenced the importance placed on a number of attributes. Notable, though not surprising, is that both Southeastern and Southwestern producers tended to place greater emphasis on heat tolerance. Furthermore,

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Table 6. Results of the ordered probit models using the Likert scale assessments of importance of grass-fed beef attributes

	Temperament	Disease resistance	Body frame	Carcass yield	Breed	Average daily growth	Heat tolerance	Parent animals never fed grain	Coat Color
Cow-calf	0.4720*** (0.1605)	0.2209*** (0.1546)	0.3493*** (0.1385)	0.2343*** (0.1484)	0.3491*** (0.1454)	0.1745*** (0.1462)	0.3102*** (0.1526)	0.3314*** (0.1613)	0.3895*** (0.2818)
Total number of cattle	0.0002** (0.0007)	0.0001 (0.0001)	0.0004 (0.0001)	0.0001*** (0.0002)	0.0015*** (0.0001)	0.0076*** (0.0011)	−0.0001*** (0.0001)	−0.0003*** (0.0033)	0.0234 (0.0002)
Sell grass-fed beef as meat	−0.6748*** (0.4023)	−0.0228 (0.3241)	−0.0079 (0.3882)	0.2090*** (0.2450)	−0.2920*** (0.3485)	0.1167* (0.3588)	0.4836*** (0.2933)	0.0630 (0.2737)	−0.5235*** (0.4216)
% Income from grass-fed beef	0.0204** (0.0433)	0.0397*** (0.0380)	0.0138* (0.0370)	0.0159** (0.0384)	0.0185*** (0.0373)	0.0153** (0.0359)	0.0566*** (0.0367)	0.0319*** (0.0379)	0.0862*** (0.0637)
Age	0.0055*** (0.0056)	0.0033*** (0.0045)	−0.0112*** (0.0047)	0.0064*** (0.0044)	0.0215*** (0.0045)	−0.0007 (0.0043)	0.0035** (0.0043)	0.0013 (0.0042)	0.0346*** (0.0076)
Years of operation	0.0003 (0.0097)	0.0034** (0.0082)	0.0118*** (0.0075)	−0.0027 (0.0086)	0.0115*** (0.0087)	0.0012 (0.0088)	0.0001 (0.0085)	0.0113*** (0.0080)	−0.0309*** (0.0169)
College degree	0.0368 (0.1387)	0.0153 (0.1309)	0.1702*** (0.1367)	−0.0532** (0.1310)	0.0530** (0.1186)	0.0669*** (0.1246)	0.1586*** (0.1336)	−0.2721*** (0.1263)	−0.2402*** (0.2164)
Northeast	−0.3571*** (0.1723)	−0.0672** (0.1642)	−0.0055 (0.1592)	0.1680*** (0.1545)	−0.1667*** (0.1505)	−0.0401 (0.1608)	−0.5081*** (0.1594)	0.1177*** (0.1461)	−0.0359 (0.2895)
Southeast	0.0855 (0.2425)	−0.0403 (0.1784)	0.1989*** (0.1787)	0.3832*** (0.1829)	0.0160 (0.1799)	0.5442*** (0.1942)	0.5827*** (0.1962)	0.3106*** (0.1888)	0.4976*** (0.3013)
Northwest	−0.3518*** (0.1836)	−0.1049*** (0.1720)	−0.2638*** (0.1779)	0.2251*** (0.1675)	0.0166 (0.1655)	0.0347 (0.1639)	−0.8380*** (0.1623)	−0.0779 (0.1854)	0.0406 (0.2687)
Southwest	0.1180** (0.2769)	−0.3296*** (0.2237)	0.2497*** (0.2125)	0.6612*** (0.2444)	−0.0293 (0.2637)	0.3753*** (0.2439)	0.3834*** (0.2269)	−0.6034*** (0.2665)	−1.0425*** (0.3900)

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

coat color was more important to Southeastern producers, which is not surprising since coat color can impact animal well-being on hot, sunny days.

Conclusions

Grass-fed beef is a differentiated product with an increasing market share in the U.S. beef industry. Despite the growing interest of producers and consumers in grass-fed beef, little research has been conducted in the U.S. context on farm-level strategies to finish beef cattle on forage. Results of this study provide insights that contribute to enhanced understanding of the traits of cattle that grass-fed beef producers prefer when selecting an animal for forage-finishing.

Results of the choice-based conjoint analysis suggest that grass-fed beef producers prefer to bring animals into the forage-finishing phase of their operations that are heavier but with smaller body frames, are mild in temperament, are not intact males, are black, and are retained from their own calves. The significant amount of time grass-fed beef producers are likely to spend with their cattle rotating them among pastures and the fact that easier-to-handle animals generally produce higher-quality beef are likely reasons why temperament is the most important attribute relative to the other seven. Most grass-fed beef producers sell beef as meat as opposed to live animals, so factors that influence meat quality are of particular importance. Source of feeder animals is the next most important attribute, as animals reared from one's own cows have known genetics and health regimes.

These attributes are followed in importance by body frame size and gender, which are of roughly equal importance. Weight of the animal is next in importance, with heavier animals coming into the herd requiring fewer resources to reach slaughter weight. Finally, the least important attribute is animal color, which may be explained by the fact that most grass-fed beef producers sell meat rather than animals, and grass-fed beef is generally not sold under the Certified Angus Beef label. Though results suggest these to be the most important attributes on average, there are at least four groupings of grass-fed beef producers by preference, with some having different preference orderings. Among all groupings, however, temperament was of strong importance; otherwise, attribute rankings varied significantly.

Answers to Likert scale questions were generally consistent with those from the conjoint analysis, with temperament being the most important of the attributes considered and hide/coat color being the least important. The attributes considered for Likert scale questions are not identical to those used for the conjoint analysis, which allows us to provide some additional insight into the types of animals most desired by grass-fed beef producers. Like the results of the latent class models for the conjoint analysis, the ordered probit results of the Likert scale responses provide evidence that preferences for these attributes vary significantly, and in these cases, one can determine which attributes grass-fed beef producers of specific segments are most concerned about when selecting animals.

Overall, temperament appears to be the overwhelmingly most important attribute for grass-fed beef producers and color of the animal does not appear to be of great importance in most areas of the U.S. Other than these two attributes, factors that can impact productivity such as body frame, gender, disease resistance, and expected carcass yield, breed, expected average daily weight gain, and heat tolerance have significant importance to grass-fed beef farmers. As expected, heat tolerance is important to producers in the Southern U.S. It is noteworthy that preferences differ significantly among farmers. This is consistent with the authors' experiences interviewing grass-fed beef farmers throughout Louisiana, where different producers tended to use different breeds on the basis of their perceptions of animal productivity by breed.

Results of this study will be of interest to producers and animal scientists who are currently involved or considering becoming involved in grass-fed beef work. They will be of particular use for extension presentations by animal scientists at gatherings of grass-fed beef producers. Because the grass-fed beef segment is not extensively developed in the U.S., farmers have questions about production practices, including animal selection, in this segment that will lead to greater profitability. Knowledge of which animals existing producers prefer can shed significant light on what producers need to look for in selecting animals for their farms.

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