# DEVELOPMENT OF A HIGH-QUALITY MARKETING PROGRAM FOR MISSOURI COW-CALF OPERATORS FY 2012

The goal of this project was to determine the economic implications associated with the production of high-quality cattle that result from the use of current reproductive and genetic technologies. Specific objectives were to:

1) Develop a producer education program and create a pilot high-quality marketing strategy tied to industry feed yards that specialize in feeding and management of high-quality cattle and that have access to marketing grids that reward producers on the basis of improved carcass merit.

2) Complete a comprehensive economic analysis and review of existing data to document the economic implications of producing high-quality calves.

3) Develop a Quality Beef (QB) initiative to create a marketing alliance or cooperative that works to maximize economic returns to participating Missouri beef cattle farms.

Selected Results

1) The QB program was successful in enrolling >14,000 beef cows into the program, and >1,500 feeder cattle participated in the QB feed yard program, providing a robust set of data to measure the added economic value of a focus on the use of better cattle genetics.

2) Cattle that grade prime tended to show the largest added income and the profit advantage created by a carcass grading prime held steady regardless of the average daily gain the animal attained. QB cattle added >$430 in added return if they graded prime. In all participating QB operations there was substantial variation from the most profitable to the least profitable animal.

3) Despite many more risk management tools in place today to reduce the risk of feeding cattle, it was difficult for many cow-calf producers to become comfortable with feeding their cattle. The use of risk management tools and feeding cattle were often cited as reasons why producers did not participate in the QB program. More education is needed for the QB program to grow beyond its current level.

4) Nearly all cow-calf producers who participated once in feeding at least a portion of their cattle through the QB program planned to feed more cattle in the program. They found two compelling reasons for their continued interest in the QB program: the added returns their cattle generated to their operation by participating in the program; and the information returned to them on carcass quality and feed efficiency allowed them to make better culling and breeding decisions for their herds.

**FINAL REPORT**

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**Proposal Title:** Development of a High-Quality Marketing Program for Missouri Cow-Calf Producers

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**Problem Outline:**

The U.S. beef cattle industry has entered a critical period as cattle numbers are at the lowest levels seen in decades. Beyond the issue of tight overall cattle supplies, an even larger concern that is developing is a shortage of cattle that will grade choice, premium choice, or prime. Animals of this type are needed to supply the growing domestic and global demand for high-quality beef. Both of these issues require a strategic long-range response if the U.S. beef industry hopes to compete against other meat products and sources of beef from major global competitors.

The U.S. beef industry operated for decades on the premise that cattle are commodities, sold at a uniform average price at nearly every stage of production. In the late 1990's, however, an effort was made to value cattle in the U.S. on an individual-carcass basis rather than on an average live-price basis. As a result, value-based grids support efforts to pull better beef through production chains from producer to consumer. Currently, more than half of all fed cattle are marketed on a grid, rewarding higher quality grade (marbling), cutability and uniformity. Iowa State University research shows marbling remains the most significant performance and carcass trait, regardless of cattle price levels. The economic collapse in late 2008 provided an interesting test case that supports consumer preference for high-quality beef. Based on data from *Certified Angus Beef® LLC* (*CAB®*), total revenues for Choice beef increased 5.6% from 2005 to 2009, while *CAB®* licensees increased revenues an additional 8.9% by selling a premium brand (***CAB®***, 2010).

Missouri plays a significant role in producing calves that grade Choice and higher under today's grading system. Currently, *Certified Angus Beef®* estimates that Missouri-sourced calves represent at least 10% of total *CAB®* supplies, and perhaps a higher share of *CAB®* Prime. That equates to more than 300,000 cattle yielding nearly 40,000 tons of boxed-product for the *CAB®* brand (Angus Journal, 2010a). The *Certified Angus Beef®* program marketed 807 million pounds of product in 2011 and anticipates need for a billion pounds by 2020. Clearly, there is a significant opportunity for beef producers who can meet this demand. However, given the current dilemma many producers face, with higher input costs and a bullish slaughter cattle market driven by declining inventory, more producers are leaving the industry and "cashing out" simply because of concern

regarding their ability to compete longer-term. Producers that are able to compete long-term will be those that are able to realize more revenue from each calf crop they produce. This places Missouri in position to increase supplies of high-quality cattle.

All pieces of the puzzle are available to correct this problem of short supplies of high-quality beef. Proven university research provides practical reproductive and genetic strategies to support high-quality cattle production. These strategies are ready and waiting for adoption by commercial cow-calf producers. Early adopters in Missouri already use many of these strategies in their herds. At the same time, feed yards seek progressive cow-calf producers who consistently produce high-quality calves. Feed yards find it difficult to economically justify feeding below-average cattle in today's high-feed-cost environment. The last remaining piece of the puzzle can be put in place: the linking of these various market participants to construct a partnership focused on the production of high-quality beef. This alliance will enable small- and medium-size farms to share economic benefits accruing from high-quality beef production. This project will provide an economic foundation and a real-life model to show this linkage assembled and successfully operated.

Compared to other sectors of agriculture, the U.S. beef cattle industry has shown slower growth toward larger operations. It remains critical for small- and medium-size beef-cow operations to adopt technologies allowing them to remain competitive in today's marketplace. In other livestock species, production has become dominated by fewer large-scale operations due in part to technology adoption that was not scale neutral -- or perhaps was perceived to not be scale neutral -- when it became available. This project will inform cattle producers of all sizes of the complete economic outcome of adopting new reproductive technologies and associated superior genetics.

The beef industry understands the need to provide a higher-quality product to reverse years of decline in beef demand from the mid-1970s through the late-1990s (Smith et al., 2000). Many industry participants concluded that providing a higher-quality beef product would allow beef to compete more effectively with alternative meats. In 1990 a National Cattlemen's Beef Association task force concluded that a value-based marketing system should be put in place to improve beef quality.

**Grant Approach:**

The objective of this project was to determine the economic implications associated with the production of high-quality cattle that result from the use of current reproductive and genetic technologies. This approach was accomplished by:

1) The development of a producer education program designed for producing high-quality cattle and the creation of a pilot high-quality marketing strategy tied to industry feed yards that specialize in feeding and management of high-quality cattle that had access to marketing grids that rewards producers on the basis of improved carcass merit.

2) A comprehensive economic analysis and review of existing data to document the economic implications of producing high-quality calves. The project tracked and estimated the economic value added to Missouri cattle that participated in the marketing strategy project.

3) The development of the Quality Beef (QB) initiative that created the marketing alliance or cooperative that worked to maximize economic returns to Missouri beef cattle farms participating in the production of high-quality cattle.

The project centered on establishing the QB program that would help Missouri cow-calf producers take advantage of higher-quality calves they produce to reap the maximum economic return. The supporting work for the establishment of QB focused on the development of protocols or management practices that producers should follow to increase the genetic potential in their herds and ultimately the calves they were selling. In addition, this project provided information on the additional economic returns available for those Missouri producers that participated in QB. There have been many cattle producers that were skeptical that the economic return of implementing many of the newer reproductive and genetic technologies would offset the additional cost of using these technologies. A comparison of costs and expected revenue on actual operations has provided producers with a better indication of the economic advantages of the QB approach combined with the adoption of these newer reproductive strategies.

The QB approach was largely developed as a result of the Show-Me-Select (SMS) heifer program. Missouri producers that participated in the SMS heifer program had seen the economic return from the bred heifers they produced in the program yet the steer calves they produced were often sold at average prices with producers not knowing much about how those steer calves fed or graded when slaughtered. The QB approach allowed them to gain more information about how their calves fed or graded. The approach allowed for better information flow and increased economic returns for those that followed the high-quality strategy.

**Public and Private Partnerships**

There were a number of entities that were partners in establishing QB. The first group were the artificial insemination (AI) companies. Accelerated Genetics, Genex Cooperative Resources International, and Select Sires were the AI partners in the QB project. These companies provided information on producers who had been using AI programs and likely had calves that would fit best into the QB program. The AI companies had often heard from producers that it was hard to see the added economic return from their AI programs when they tended to sell feeder calves for average prices at the local auction market.

The second set of partners were cooperating feed yards that had experience in feeding cattle that would grade well and willing to work with the QB program in returning the information on carcass quality and feed efficiency needed for Missouri cow-calf producers to make better information on the genetic growth of their cow herds. The participating feed yards have access to the marketing grids that pay larger premiums for high-grading cattle. Irsik and Doll Feed Yard, Garden City Kansas and Pratt Feeders Feed Yard in Pratt, Kansas were the two feed yards that partnered with the QB project.

The last QB partner was the *Certified Angus Beef*® program. *CAB*® provided data on cattle that originated from Missouri that met their program requirements and price and sales information on their products that was used to estimate aggregate demand functions by quality type.

**Results, Conclusions and Lessons Learned**

1) The QB program was successful in enrolling over 14,000 beef cows into the program. From those 14,000 enrolled cows, over 1,500 feeder cattle participated in the QB feed yard program. This provided a robust set of data to measure the added economic value of a focus on the use of better cattle genetics.

2) Cattle that grade prime tend to show the largest added income. The following table (table 1) shows the value created by reaching the Prime quality grade. You can see the profit advantage created by a carcass grading prime and that holds steady regardless of the average daily gain (ADG) the animal attained. QB cattle added over $430 in added return if they graded prime.

Table 1. Economic differences in QB cattle by quality grade.

| | Prime | Advantage Prime over CAB | Advantage Prime over NAB | Advantage Prime over lower 1/2 low choice | Advantage Prime over Select | Prime Advantage over 741 Head average Profit $298.96 |
|---|---|---|---|---|---|---|
| Average Profit | 443.27 | 144.31 | 139.30 | 139.58 | 208.25 | 144.31 |
| Over 4 lbs. ADG | 584.63 | 155.59 | 156.66 | 151.47 | 242.12 | 285.67 |
| 3.50 to 3.99 ADG | 512.72 | 148.81 | 170.51 | 163.75 | 212.27 | 213.76 |
| 3.00 to 3.49 ADG | 419.06 | 133.10 | 176.07 | 165.77 | 188.94 | 120.10 |
| 2.50 to 2.99 ADG | 378.51 | 154.16 | 218.85 | 172.01 | 243.00 | 79.55 |
| 2.00 to 2.49 ADG | | | | | | |
| ADG for grade | 3.34 | 3.39 | 3.59 | 3.56 | 3.46 | |
| | | 147.19 | 172.28 | 158.52 | 218.92 | 168.68 |

3) The two main drivers of profit in this data are quality grade and average daily gain (ADG). Looking at the data (table 2) profit differentials between different ADG categories are lower as ADG goes down in all quality grade categories. There are more differences between Low Choice and Select even though there was a relatively narrow choice select spread at the time of harvest. In every quality grade, when ADG goes below 3.50, profits go below average except Prime. The Prime grade cattle always

exceed average profit even those gaining 2.50 to 2.99 ADG. (Most of the cattle gaining under 2.00 ADG had a health issue).

Table 2. Average daily gain important to cattle feeding profitability.

| Average profit for all 741 head $298.96 | Prime | Head | CAB | Head | NAB | Head | Low Choice | Head | Select | Head |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Profit | $443.27 | 49 | $298.96 | 315 | $303.97 | 148 | $303.69 | 140 | $235.02 | 89 |
| Over 4 lbs. ADG | $584.63 | 4 | $429.04 | 45 | $427.97 | 36 | $433.16 | 31 | $342.51 | 19 |
| 3.50 to 3.99 ADG | $512.72 | 11 | $363.91 | 78 | $342.21 | 51 | $348.97 | 53 | $300.45 | 19 |
| 3.00 to 3.49 ADG | $419.06 | 25 | $285.96 | 116 | $242.99 | 38 | $253.29 | 35 | $230.12 | 35 |
| 2.50 to 2.99 ADG | $378.51 | 9 | $224.35 | 53 | $159.66 | 17 | $206.50 | 15 | $135.51 | 12 |
| 2.00 to 2.49 ADG | | | $120.36 | 14 | $22.57 | 4 | $190.94 | 3 | ($143.29) | 1 |
| Under 2.00 ADG | | | ($17.30) | 9 | ($76.83) | 2 | ($388.45) | 3 | ($191.89) | 3 |
| | | 6.6% | | 43% | | 20% | | 19% | | 12% |

4) In all participating QB operations there was substantial variation from the most profitable to the least profitable animal. There is an over $800 difference between the most profitable and least profitable animal that participated in the QB program. Many times producers would be surprised which cows had offspring that were the most profitable when fed. Cows that may have been below average when compared phenotypically might produce calves that were efficient converters of feed and produced a high-quality carcass.

5) The project proved it can be difficult to get Missouri cow-calf producers to change their marketing strategy. Many potential QB participants had difficulty in the changing cash flow for the operation that came with participation in the QB program. Even when participating feed yards were willing to provide a portion of expected funds to producers before their calves were sold to help with cash flow issues, many cow-calf producers still felt uncomfortable in participating in the program.

6) Missouri cow-calf producers had heard the old adage many times that feeding cattle was a risky proposition. Despite many more risk management tools in place today to reduce the risk of feeding cattle, it was difficult for many cow-calf producers to become comfortable with feeding their cattle. There has been additional interest in the QB program as non-participants have seen some of the new economic data available from participants.

7) The use of risk management tools and feeding cattle were often cited as reasons why producers did not participate in the QB program. There is more education needed to occur for the QB program to grow from its current level. The tradition and rigidity in cattle and

calf marketing that is commonplace by Missouri cow-calf producers made the concept offered by QB difficult for many of them to appreciate.

8) Nearly all cow-calf producers who participated once in feeding at least a portion of their cattle through the QB program were going to feed more cattle in the program. They found two compelling reasons for their continued interest in the QB program:

    a. The added returns their cattle generated to their operation by participating in the program.
    b. The information returned to them on carcass quality and feed efficiency allowed them to make better culling and breeding decisions for their herds.

**Current and future benefits**

The QB project was one of the first programs available to connect a producer's beef cow herd to the final harvest of calves to allow for a better assessment of an individual cow's economic success. This tie has allowed producers to make better decisions regarding future cow herd changes. This project shows that the additional information provided by the QB project allows a producer to make quicker advances in the genetic potential of their herd. This approach has long run benefits for those that have invested in the QB program.

The QB project has created an awareness in the Missouri cow-calf industry with large feed yards in other states. Many cow-calf producers find it difficult to send their calves hundreds of miles away to a feed yard where they cannot check on their calves every day. The project has created relationships that has opened new opportunities for Missouri cow-calf producers that will last for years to come. QB participating cow herds now realize they have other opportunities to market their calves.

The QB project has been successful in connecting the different industry participants together so that each segment economically benefits from the investment in better genetics by cow-calf producers. This economic connection ultimately allows for consumer signals in terms of the type of beef they prefer to reach all the way to cow-calf producers and result in preferred beef products reaching consumers.

**Future research**

The ability to track individual cattle information back to individual cows has been difficult for some cow-calf producers. Many cow-calf producers have poor to no tagging systems for their cow herd. The genomic tests, like the GeneMax™ test provided by the Angus breed, that are becoming more widely available may reduce the recordkeeping burden that is required in individual animal tracking. The QB project may be able to combine the information collected in the program to these genomic tests to confirm their use in culling decisions. Research at the Thompson Research

Center is beginning to provide some information relative to these tests but more work in this area may prove beneficial to the industry.

Continued research into the economic return of genetically superior calves will be necessary as many cow-calf producers do not focus at all on this area since they tend to sell calves for average prices at their local auction markets. The cattle cycle will likely continue for the foreseeable future. Although current cattle markets are at or near record prices, as the cow herd grows, prices will likely move lower. That will leave producers scrambling to remain economically viable. This research may provide one of the tools cow-calf producers can employ to maximize their economic return in a declining cattle market.

**Project Beneficiaries**

The QB project targeted all segments of the beef industry from cow-calf producers to consumers. The ability to connect beef market segments that have traditionally remained very disconnected allows benefits to flow throughout the industry. The demand for higher-quality beef has been growing from both domestic and international consumers and increasing the quantity of higher-quality beef produced benefits all market segments.

The focus of the QB project has been Missouri cow-calf producers. Providing added economic benefits to those producers that have calves that feed more efficiently and reap premiums from a quality carcass standpoint was the target audience for the QB program. The average size of a Missouri cow-calf operation is 36 cows today. The QB program focused on all sizes of operations. Combining smaller producers together into semi-trailer loads of calves allowed even those producers with less than a load of calves to participate in the QB program.

All beef industry segments are benefitting from the information generated in the QB project related to the economic value of individual cattle. Quantifying the added value for cattle of higher quality or those that feed more efficiently has allowed market participants to gain a better economic perspective on those cattle and their worth to the cattle industry.

**Additional Information Generated by the Grant**

The project established the website: http://www.quality-beef.com

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Steiner, J, and DS Brown, 2014. Should Beef Quality Grade be a Priority? Certified Angus Beef Partners Project, accessed March 2014 at http://www.cabpartners.com.

# QUALITY BEEF BY THE NUMBERS

## MISSION STATEMENT

The QB mission is to improve the profitability of beef cow-calf operations by facilitating the adoption of applied reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S. and contribute to improvements in beef quality to satisfy increasing domestic and global demand for high-quality beef.

## OBJECTIVES

- Support the adoption of reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S.
- Provide access to marketing grids that reward producers of high-quality cattle.
- Provide beef producers with access to a comprehensive data base that will support improvements in management and marketing of cattle from conception to harvest.

## PROGRAM FEES

- Participating farms and ranches will pay $300 each calendar year for membership in the program. Fees are to be paid prior to the time cattle are shipped to participating feed yards.
- A per head fee will be collected to ensure data retrieval and will be based on terms of ownership. Fees will be subtracted from the final producer payouts.

## OWNERSHIP

- Cattle feeding partners will offer $40 for AI-sired or $20 for natural service-sired calves on a per head basis over the negotiated price for the portion of the animals the feed yard purchases. Additionally weigh up and slides will be part of the negotiated price and sales terms.
- Outright sales of cattle will be negotiated with participating feed yards.

## PROGRAM MEMBERS

- Irsik & Doll Feed Services, Inc.
- Pratt Feeders, LLC
- Certified Angus Beef Program

CAFNR
College of Agriculture, Food and Natural Resources
University of Missouri

- Accelerated Genetics
- Genex Corporative, Inc.
- Select Sires MidAmerica

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# WEANING/RECEIVING HEALTH AND NUTRITION REQUIREMENTS

## Beef Quality Assurance (BQA)

Producers participating in the project shall be BQA certified. This will increase the likelihood that cattle enrolled in the program will be free from quality defects and adulterants, and ensures that cattle were managed according to recommended standards for care. BQA training and certification is available through University of Missouri area livestock specialists at no cost, or available at the Animal Care Training website - http://www.animalcaretraining.org/ - for $25.

## Pre-weaning Management

• Male calves will be castrated with a knife and healed or instead verified to be steers if another castration method is used

• Calves will be dehorned and healed

## Weaning Management

• Calves will be individually identified with an electronic ID tag.

•Age and source verification documents and tagging will be completed at weaning. Approval must be completed prior to shipping.

• Calves must be weaned a minimum of 45 days prior to feedlot shipping.

• Calves should not be implanted at weaning if they are retained on the farm of origin for less than 70 days after weaning.

• Heifers should be open at the time of shipping.

• Weaning supplement
- Minimum of 12% CP and 75% concentrate
- Contain a coccidiostat or an ionophore
- Fed to achieve a dry matter intake of 2% of body weight prior to shipping
- Feed grade antibiotic use is permitted to prevent respiratory disease

• Minimum weight at feedlot arrival
Steers – 500 pounds
Heifers – 450 pounds

* Quality Beef By The Numbers is a University of Missouri program, terms are subject to change.

## Minimum Animal Health Weaning Requirements

• A comprehensive herd health program starting at weaning age or before should be administered under the advice and guidance of a veterinarian in the context of a valid veterinary-client-patient relationship.

• Minimum health requirements for cattle enrolled in the program are in accordance with the most current Missouri Stocker/Feeder Quality Assurance Program - Level 2 standards.

• Cattle are to be vaccinated and boostered with a 7-way clostridial, IBR, BVD, PI3, and BRSV. Histophilus somni is optional.

• Initial vaccinations should be administered at an age determined by the participant's veterinarian.

• The time frame between the initial and booster vaccination must be a minimum of 21 days and all vaccinations must be completed at least 7 days prior to shipment.

• If a veterinarian recommends initial vaccinations be given to calves less than 4 months of age, booster vaccinations must not occur until calves are 5 months of age and older.

• One dose of Manheimia haemolytica with leukotoxoid is required if that dose is administered to calves 5 months of age or older.

• Internal and external parasite control products are required to be administered.

• Killed respiratory vaccine products can be used on nursing calves; however modified live vaccines are required at weaning.

• Processing information and individual calf treatments shall be recorded and include the date of the event, all products used, dosages, route of administration and locations on the animal where products were administered.

## Data Collection

• Feedlot performance and carcass data will be collected and shared with participating producers.

• Certified Angus Beef LLC will assist in gathering both feedlot and carcass information.

• Individual data will be handled confidentially and not shared without participating farm/ranch approval.

QUALITY BEEF
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# COMMERCIAL FEED YARD PROGRAM

## OVERVIEW

The QB initiative is intended primarily as a cattle producer retained ownership program. Beef producers are encouraged to become aware of the production practices, which take place in the finishing phase in addition to the knowledge of the entire cow-calf sector.

## FEED YARD SERVICES

Commercial cattle feeding services such as cattle & feed financing, risk management including feed coverage, hedging, processing, animal health & nutrition and finished marketing options are available.

## PRE-PLACEMENT

- All cattle must meet the QB program criteria as established by the University of Missouri prior to consideration of placement into a finishing yard, including the program fees.
- Electronic ear tags are required through the system beginning at the ranch level.

## MARKETING Feeder Cattle

- Although retained ownership is encouraged, feeder cattle can be sold to a program participant at a negotiated price level in whole or in part. If cattle are sold in part, the ideal arrangement is for a 50/50 partnership arrangement where the producer and feed yard own an undivided half interest.
- Weigh ups and slides are defined during the negotiating process.
- Less than load lots can be comingled with other customers up to a maximum of four (4) producers if desired, where individual animal identity will remain.

## MARKETING Finished Cattle

- Marketing grids are available from more than one processor.
- Cattle will be sold on individual carcass merit.
- Forward contracts are available if desired on retained ownership cattle.
- A beta agonist will not be fed to any of the program cattle.

## PREMIUMS

- Program premiums are added to the negotiated feeder price level on any cattle sold to the feed yard participant.
- Premiums are paid at the time cattle ship to the processor.
- Premiums equal $40 per head for A.I. sired and $20 per head on natural service-sired cattle.
- The premiums are paid by the feed yard participant directly to the producer.
- Only on partnered cattle will premiums be paid.

## DATA FEEDBACK

- Both feeding performance and close out information is provided if at least 50% of the cattle are retained by the producer customer.
- Carcass data is available, but if not retained by the producer the program charge is $10 per head.
- If the producer retains half ownership, the program fee equals $7.50 per head.
- If full retained ownership applies, the program fee is $5 per head.
- If cattle are entirely sold, the feeding performance and close out information will not be shared.
- Program fees are paid to the QB program at the University of Missouri, which includes the information previously outlined.

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# BY THE NUMBERS - EPD

**PERCENTILE TABLES.** Average EPDs for most traits are not zero. The actual average will be different for each breed. Percentile tables must be used to determine where a bull's EPDs and indexes rank within the breed. EPDs and $ Indexes for bulls should be compared to percentiles for non-parent bulls of the same breed. Look up the bull's EPD in the table to determine where he ranks in his breed. Remember that for many traits, higher EPDs may be desirable. However, for Birth Weight, Carcass Fat, Ultrasound Fat, and Yield Grade, lower EPDs may be desirable depending upon your breeding objective. Percentile tables are available from the breed associations.

**ACCURACY.** Most EPDs are reported with an Accuracy (ACC) value, which ranges from 0 to 1. It is a measure of the reliability of the EPD. EPDs will change and become more accurate as additional data on the bull and his relatives are processed by the breed association. For most yearling bulls, ACC is low, because they have not sired any progeny. Some breeds report the accuracy of these EPDs as BK, I, P, P+, or PE. These indicate that the EPD is based on pedigree data, or is an interim EPD based on pedigree data and the bull's own performance.

## GROWTH AND MATERNAL TRAITS

- *Birth Weight*, in pounds, predicts the weight at birth of the bull's progeny compared to progeny of other bulls. A bull with an EPD of -1 is expected to have progeny which average 3 lb lighter than progeny of a bull with an EPD of +2.
- *Weaning Weight*, in pounds, is a measure of the weaning growth of the bull's progeny. Higher EPDs mean heavier calf weights.
- *Yearling Weight*, in pounds. Higher EPDs mean heavier weights for the bull's progeny.
- *Maternal Milk*, in pounds, is measured by the weaning weight of the calves. It predicts the milking ability of the bull's daughters, expressed as her calf's weaning weight. Higher EPDs mean heavier calf weights due to the daughter's milking ability.
- *Direct Calving Ease* is a measure of the ease with which a bull's calves are born to first calf heifers. Higher EPDs mean fewer assisted births.
- *Maternal or Daughters' Calving Ease* is a measure of the ease with which a bull's daughters calve as first-calf heifers. Higher EPDs mean fewer assisted births.

## CARCASS TRAITS

- *Carcass Weight*, in pounds. Higher EPDs mean heavier weights.
- *Marbling* is a measure of the marbling score of a bull's progeny. It is a subjective measure of % intramuscular fat. Higher EPDs mean higher marbling scores.
- *Fat Thickness*, in inches, measures the fat thickness at the 12th rib of the bull's progeny. Higher EPDs mean greater fat thickness.
- *Ribeye Area*, in square inches. Higher EPDs mean a larger ribeye area.
- *Yield Grade* is a measure of the relative proportion of closely trimmed, boneless retail cuts from the bull's progeny. Higher EPDs mean higher yield grades, and thus a lower proportion of retail cuts.
- *Percent Retail Cuts* is a measure of the percentage of closely trimmed, boneless retail cuts from the bull's progeny. Higher EPDs mean a higher percentage of retail cuts.
- *Days to Finish* is a measure of the number of days required to reach the constant fat endpoint. Higher EPDs mean progeny will take longer to finish.

# BY THE NUMBERS - ECONOMIC INDEXES

**$ INDEXES**. Multi-trait selection indexes combine EPDs for several traits into a single economic value. The index values are interpreted like EPDs; the difference in index value between two bulls is the expected difference in average dollar value of their progeny, when the bulls are bred to similar cows. Indexes are expressed in dollars per head, and higher indexes mean a higher dollar value per head. An index value only has meaning when it is compared to the index value of another animal of the same breed. Currently, indexes are calculated for Angus, Charolais, Gelbvieh, Hereford, Limousin, Simmental, and SimAngus bulls.

It is important to understand that in most cases indexes only encompass postweaning and carcass performance. Other factors drive profitability, especially fertility. Cow-calf producers keeping replacement heifers and selling calves at weaning should have a relative economic emphasis of 47% on reproduction, 24% on growth, and 30% on carcass traits, whereas producers in an integrated system should have a relative economic emphasis of 31% on reproduction, 29% on production, and 40% on carcass traits (Melton, 1995). This relative emphasis will depend on how much the value derived from genetic gain in feedlot and carcass traits is shared with the producer in the integrated system. (Melton, B. E. 1995. Conception to consumption: The economics of genetic improvement. Proc. Beef Improvement Fed. 27th Ann. Mtg. p 40-87, Sheridan, WY).

**ANGUS**

- *$W, Weaned Calf Value*. This is the expected average of future progeny for preweaning performance, within a typical beef cowherd. It accounts for the economic impact of birth weight, weaning weight, maternal milk, and mature cow size.
- *Cow Energy Value ($EN).* This is a component of $W and is measured in dollars of savings per cow per year, accounting for energy requirements due to mature size and milking ability.
- *$F, Feedlot Value*. This is the expected average of future progeny for postweaning feedlot performance, and includes EPD for weaning and yearling weight.
- *$QG*, Quality Grade. This is the quality grade segment of $G. The carcass Marbling and ultrasound % Intramuscular Fat EPDs contribute to $QG.
- *$YG*, Yield Grade. This is the yield grade segment of $G. It combines ribeye, fat thickness, and weight into an economic value for red meat yield.
- *$G*, Grid Value. This is the expected average of future progeny for carcass grid merit. It combines $QG and $YG, so it focuses on quality and red meat yield simultaneously.
- *$B*, Beef Value. This is the expected average of future progeny for postweaning performance and carcass value. The $B value combines information from $F and $G. This index includes EPD for yearling weight, carcass weight, and carcass and/or ultrasound traits.

**CHAROLAIS**

- *Terminal Sire Profitability Index.* The index is intended for use by commercial producers to address profitability and selection of sires depending on the cow base they would be bred to. The index allows producers to input data for their own cow herd profiled against the Charolais database to identify the most profitable sires (weighed economic values).

**GELBVIEH**

- *CV,* Carcass Value. This is the expected average carcass value of future progeny when sold on a grid. It incorporates carcass weight, yield grade, and quality grade information.
- *FM,* Feedlot Merit. This is the expected average of future progeny for postweaning feedlot performance.

**HEREFORD**

- *BMI$,* Baldy Maternal Index. This is the expected average performance of progeny of Hereford bulls used in rotational crossbreeding programs on Angus-based cows and heifers, with the progeny marketed on a Certified Hereford Beef LLC pricing grid.
- *CEZ$,* Calving Ease Index. This is similar to BMI$, except that the bulls are mated only to yearling heifers. It has increased emphasis on calving ease.
- *BII$,* Brahman Influence Index. This is similar to BMI$, except that the bulls are mated to Brahman-based cows. It puts more emphasis on fertility and age at puberty, and less on growth and calving ease.
- *CHB$,* Certified Hereford Beef Index. This is the expected average performance of progeny of Hereford bulls mated to British-cross cows, with all progeny sold as fed cattle on a Certified Hereford Beef LLC pricing grid. It is a terminal sire index, including growth and carcass information only, since all progeny are marketed and no females are retained in the herd.

**LIMOUSIN**

- *$MTI,* Mainstream Terminal Index. This is the expected average profit per carcass of progeny of Limousin bulls mated to British-cross cows, with all calves placed in the feedlot and sold on a mainstream grid. It is a terminal sire index, including growth and carcass information only, since all calves are marketed and no females remain in the herd.

**SIMMENTAL AND SIMANGUS**

- *API,* All-Purpose Index. This is the expected average performance of progeny of Simmental bulls used on the entire Angus cowherd, with a portion of the daughters being retained for breeding and the remaining progeny being put on feed and sold grade and yield.
- *TI,* Terminal Index. This is the expected average performance of progeny of Simmental bulls mated to mature Angus cows, with all offspring placed in the feedlot and sold grade and yield. It includes growth and carcass information only, since all progeny are marketed.

**SHORTHORN**

- *$CEZ,* $Calving Ease. This index assumes a bull will only be mated to heifers, not cows. The potential profitability of the sire is measured by the incidence of live calves at birth. Moderate mature size is also emphasized in the index, but performance is not a priority. This index is also a good measure of Shorthorn females' ability to produce calving ease sires. Over-emphasis of $CEZ may cause unwanted depression of weaning and yearling performance.
- *$F*, $Feedlot. Similar to a terminal sire scenario, $Feedlot places strong emphasis on growth and carcass traits. This multi-trait index assumes the sire will be mated to a mix of heifers and cows and attempts to measure profitability when progeny are sold on the fed market. On the female side, mature size should be monitored closely when selecting for $F. Over-selection may negatively impact longevity, reproductive efficiency, and fleshing ability.
- *$BMI*, $British Maternal Index. As the name implies, this multi-trait selection index attempts to measure a bull's potential profitability when complementing the British cow base (Angus, Red Angus, Hereford, etc.). Shorthorn females may likewise be gauged to add value to British or British-composite bulls of other breeds. A balance of growth and carcass traits is desired with a strong maternal component aimed at optimum reproductive efficiency and cow longevity.

## Collaborator Contacts

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## Collaborators

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College of Agriculture, Food and Natural Resources
University of Missouri

Accelerated Genetics

Irsik & Doll Grains Cattle Feeds

Cooperative Resources International

Partners in customer success. Pratt Feeders LLC Buffalo Ashland Hays

Select Sires Inc.

Since 1978 Certified Angus Beef® Brand

QB Quality Beef by the Numbers

*"Putting it all together" are the words that best describes the essence of the Quality Beef by the Numbers program. In these challenging times, connecting all aspects of the beef industry, from birth to the consumer, is increasingly important. Today's technology offers tools to significantly increase profits. Access to & implementation of these technologies becomes important to the longer-term survivability of producers.*

*It is an exciting time in our industry. What's the exciting part? The easy answer is the production, marketing and analysis tools available to us today. Fixed-time AI, EPD's, grid marketing, performance records and the ability to apply an economic analysis of these practices to our herds… that is what Quality Beef by the Numbers is all about.*
*This is the foundation of the QB mission.*

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## QB Mission Statement

The QB mission is to improve the profitability of beef cow-calf operations by facilitating the adoption of applied reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S. and contribute to improvements in beef quality to satisfy increasing domestic and global demand for high-quality beef.

## Objectives

- Support the adoption of reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S.
- Provide access to marketing grids that reward producers of high-quality cattle.
- Provide beef producers with access to a comprehensive data base that will support improvements in management and marketing of cattle from conception to harvest.

## Feed Yard Services

Commercial cattle feeding services such as cattle and feed financing, risk management including feed coverage, hedging, processing, animal health and nutrition and finished marketing options are available.

## Pre– Placement

All cattle must meet the QB program criteria as established by the University of Missouri prior to consideration of placement into a finishing yard, including the program fees.

** View the QB web page for Health Requirements*

## Data Feedback

- Both feeding performance and close out information is provided if at least 50% of the cattle are retained by the producer customer.
- Carcass data is available, but if not retained by the producer the program charge is $10 per head.
- If the producer retains half ownership, the program fee equals $7.50 per head.
- If full retained ownership applies, the program fee is $5 per head.
- If cattle are sold, the feeding performance and close out information will not be shared.
- Program fees are paid to the QB program at the University of Missouri, which includes the information previously outlined.

## Premiums

- Program premiums are added to the negotiated feeder price level on any cattle sold to the feed yard participant.
- Premiums are paid at the time cattle ship to the processor.
- Premiums equal $40 per head for AI sired and $20 per head on natural service-sired cattle.
- The premiums are paid by the feed yard participant directly to the producer.
- Only on partnered cattle will premiums be paid.

## Marketing—Feeder Cattle

- Although retained ownership is encouraged, feeder cattle can be sold to a program participant at a negotiated price level in whole or in part. If cattle are sold in part, the ideal arrangement is for a 50/50 partnership arrangement where the producer and feed yard own an undivided half interest.
- Weigh ups and slides are defined during the negotiating process.
- Less than load lots can be comingled with other customers up to a maximum of four (4) producers if desired, where individual animal identity will remain.

## Marketing—Finished Cattle

- Marketing grids are available from more than one processor.
- Cattle will be sold on individual carcass merit.
- Forward contracts are available if desired on retained ownership cattle.
- A beta agonist will not be fed to any of the program cattle.

## Program Fees

- Participating farms and ranches will pay $300 each calendar year for membership in the program. Fees are to be paid prior to the time cattle are shipped to participating feed yards.
- A per head fee will be collected to ensure data retrieval and will be based on terms of ownership. Fees will be subtracted from the final producers' payout.

***QB data -***
***from conception to carcass...***

# THE MISSOURI BEEF PROJECT:
## An industry partnership designed to link economic incentives with technology adoption

DJ Patterson, DS Brown, SE Poock, and MF Smith
University of Missouri

2012. American Society of Animal Science. 90, Suppl.3:406.

# Challenges & opportunities facing the beef industry…

***Challenges……***

- A segmented industry, steeped in tradition, comprised of large numbers of small- to medium-sized farms
- Slow to adopt technology
- Rising input costs
- Declining inventory
- Increasing global competition
- Perceived lack of incentives

***Opportunities…….***

- On-the-shelf technology not being used *(that works)*
- Increasing domestic & global demand for high-quality beef
- Marketing incentives that will add value

# Developing a plan

1. Create an understanding of the importance of heifer development based on reproductive outcomes
2. Changes in heifer development spill over into the cow herd
3. Importance of reproductive management becomes apparent
4. Focus expands to genetic improvement
5. Creation of a value-added product requires a re-evaluation of marketing strategies

# Developing a plan

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# *Implementation through an existing program….*

## The Missouri Show-Me-Select Replacement™ Heifer Program

| Since 1997…..Participation and sales | |
|---|---|
| **737 farms** | **115 sales** |
| **222 veterinarians** | **24,361 heifers sold** |
| **101,424 heifers** | **$28,175,775 gross sales** |

**Tier Two: Heifers are eligible to qualify for Tier Two in the Show-Me-Select Replacement Heifer Program based on minimum accuracies of the heifer's sire at the time of sale.**

| TRAIT | ACCURACY |
|---|---|
| **Calving ease (direct)** | **.65** |
| **Calving ease (maternal)** | **.30** |
| **Weaning weight** | **.75** |
| **Carcass weight** | **.20** |
| **Marbling** | **.20** |

# So, can producers make money?

(data from Fall 2010, Spring & Fall 2011, Spring 2012)

| | | | | |
|---|---|---|---|---|
| Tier One | n=1166 | NS bred | (baseline) | **$1549** |
| Tier One | n=1003 | AI bred | +$146 | **$1695** |
| Tier Two | n=97 | NS bred | +$237 | **$1786** |
| **Tier Two** | **n=196** | **AI bred** | **+$357** | **$1906** |

# A unique point in time for the U.S. beef industry……

- We are now able to successfully AI cows & heifers at predetermined fixed times

- Markets are beginning to recognize and reward quality

# The focus of our field laboratory….
# (MU Thompson Research Center)
# Research & Breeding Program

- Develop fixed-time AI programs for beef cows AND heifers

- Produce premium quality……
  "White Table Cloth" beef

# MU Thompson Research Center Breeding Program

- **Emphasis on "high accuracy" AI sires**

- **$Value Indexes**
  - Multi-trait selection indexes, expressed in dollars per head, to assist beef producers by adding simplicity to genetic selection decisions.

  - The $Value is an estimate of how future progeny of each sire are expected to perform, on average, compared to progeny of other sires in the database if the sires were randomly mated to cows and if calves were exposed to the same environment.

# Steer Performance Data
# MU Thompson Research Center
# 2008-2011 steers

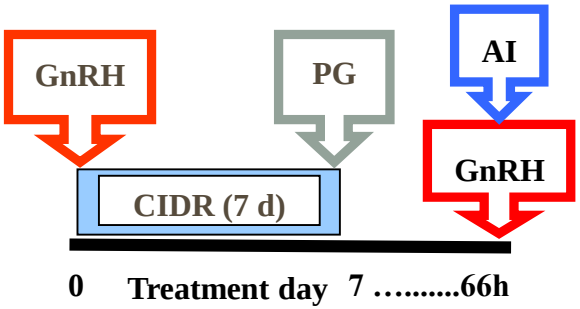
| Sire Group | Maternal Grand Sire | No. of steers | Choice or higher (%) | CAB® (%) | Prime (%) |
|---|---|---|---|---|---|
| High Accuracy | High Accuracy | 153 | 100 | 58 | 30 |
| High Accuracy | Low Accuracy | 64 | 100 | 61 | 34 |
| High Accuracy | Natural Service | 35 | 100 | 60 | 14 |
| Totals | | 252 | 100 | 59 | 29 |
| | | | | | |
| Natural Service | High Accuracy | 58 | 97 | 60 | 12 |
| Natural Service | Low Accuracy | 17 | 100 | 53 | 18 |
| Natural Service | Natural Service | 26 | 92 | 27 | 12 |
| Totals | | 101 | 96 | 50 | 13 |

# How many qualify for….. CAB® or Prime?

- **1 in 5** carcasses qualify for **CAB®**
- **3%** of all carcasses grade **Prime**

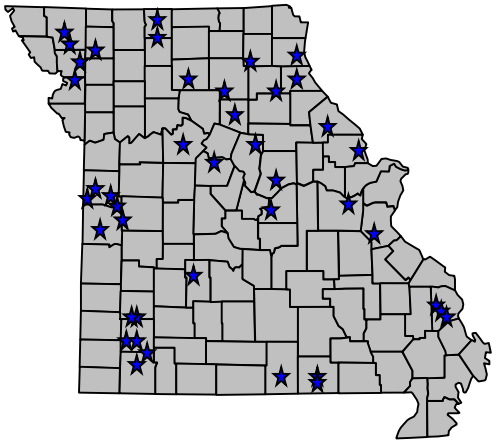
# On-farm demonstrations

## Fixed-time AI in postpartum beef cows




Fixed-time AI pregnancy rates

73 herds = 4327/7028 (62%)



Portable AI Barns

- MU Extension funding placed 8 barns across Missouri

Pregnancy determination with ultrasound

- Early diagnosis
- Fetal sexing

# Where do we go from here?

"As prices and costs increase, traits of efficiency and quality will become bigger drivers of profitability than ever before, and the commodity model of U.S. beef production will no longer be viable"

(BEEF Magazine, July 8, 2011)

# Future

- The long-term sustainability of the U.S. beef industry must be focused…..
- We cannot compete globally on a commodity basis
- We need to identify our strengths and develop them
  - U.S. produces 82-84% of high-quality beef in the global trade
- No state is better positioned than Missouri and its two million cows to capitalize on this opportunity

# CAB® tells us ….

- **Missouri-source calves represent** at least **10%** of **total CAB® supplies**, and perhaps an **even higher share of CAB® Prime**

- **2011, CAB® moved 807 M pounds of beef**

- **2020, demand will exceed 1B pounds**

**Could Missouri double its supply???**

# Moving forward….

- **Organize progressive producers, regardless of herd size, to take advantage of value-added opportunities**.

# THE MISSOURI BEEF PROJECT

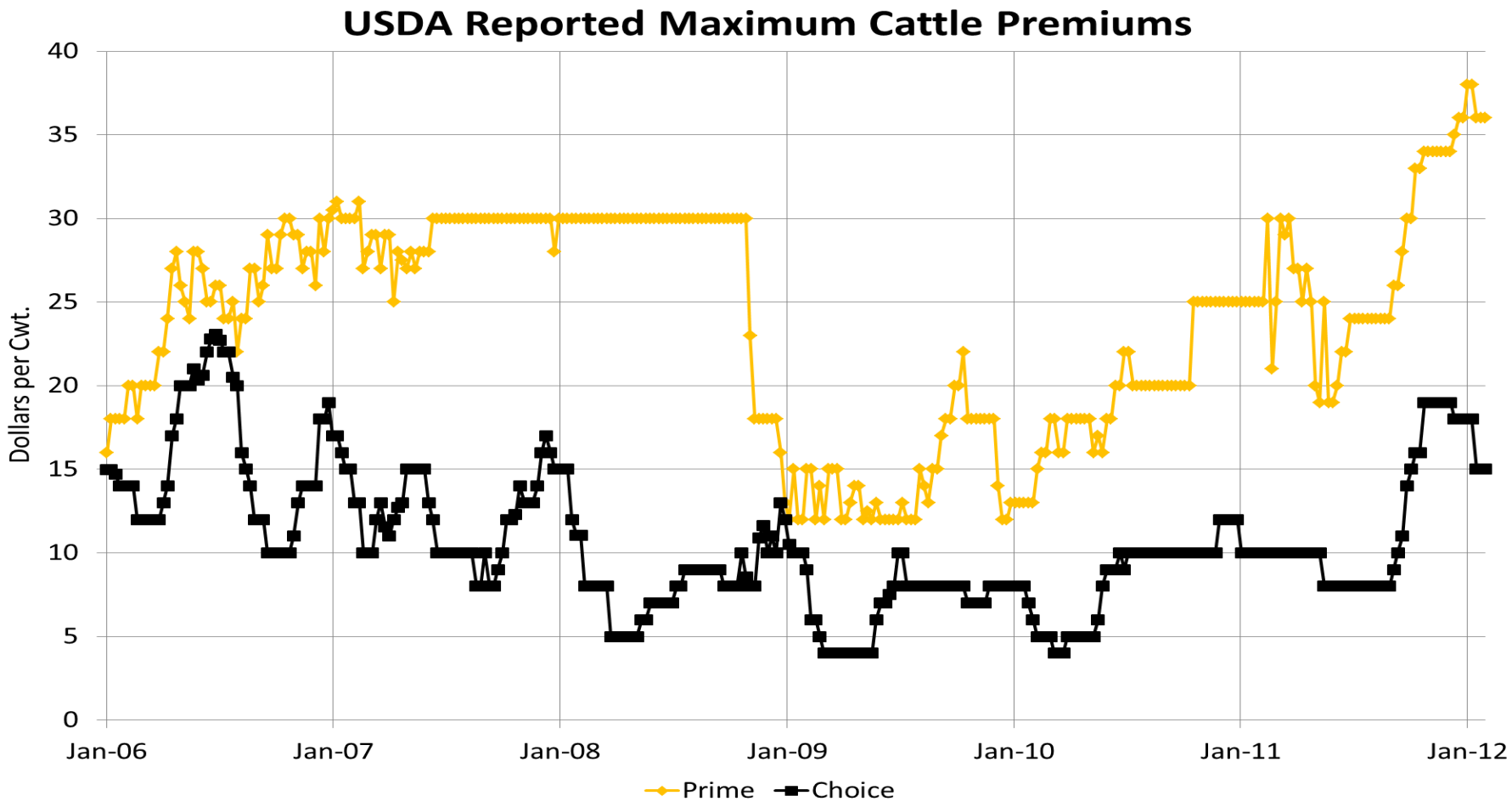
- *A partnership that delivers financial incentives for high-quality cattle producers*
- *Designed to supply the demand for high-quality beef*

College of Agriculture, Food and Natural Resources

# What's at stake?

- There are large premiums being paid for high-quality cattle
- Most Missouri cattle producers do not see quality-based premiums since they do not retain ownership
- Coordination among cattle market participants is a must to get premiums back to Missouri producers
- Shrinking cattle numbers provide incentive for feedlots to share premiums

# Cattle Premiums on the Rise



# Premiums Add to Cattlemen's Checks

- Cattle that grade prime gain an additional $450 - $500
- Cattle that grade choice gain an additional $200 - $250
- Other premiums exist – CAB, BCPR, etc.

- MU Thompson Research Center ~30% Prime and over 90% Choice or better
- The recipe for high-quality cattle is available

# A Unique Opportunity

- Leverage success of the Show-Me-Select Heifer Program
- Missouri is the number 3 beef cow state
- High-quality cattle produced in Missouri
- MU Thompson Research Center shows working results
- Animal Sciences faculty in place to provide future program development
- Multi-disciplinary collaboration underway in CAFNR & Vet Med
- MU Extension Livestock Specialists already on board

# Industry Collaborators

- New MU relationships with other cattle market participants will allow market coordination
- Three major AI companies with quality genetics and access to producers using best management practices
- Two Kansas feedlots with access to premium pricing grids and knowledge in feeding high-quality cattle
- These groups willing to provide financial backing to the project

# More Details to Come

- Program roll-out – August 30, 2012
- Details regarding participation will be coming
- Project will complement the Show-Me-Select Heifer program

# ACKNOWLEDGEMENTS

College of Agriculture, Food and Natural Resources

PRATT FEEDERS LLC

Accelerated Genetics

Genex Cooperative, Inc.

SELECT SIRES

2013. J. Anim. Sci. 91. E. Suppl. 2:404.

**Quality Beef by the Numbers: Linking economic incentives with technology adoption.**

D.J. Patterson*, J.M. Thomas, M.F. Smith, D.S. Brown; University of Missouri

The beef industry is a leading segment of our nation's economy and efforts to increase the value of beef cattle have widespread effects. In Missouri, the Show-Me-Select Replacement Heifer Program changed production practices related to management of beef heifers. Impacts of these changes are realized by producers, veterinary practices, feed dealers, the pharmaceutical and AI industries, and related local economies. The recent addition of Tier Two to the Show-Me-Select Program encourages expanded use of fixed-time AI with genetically superior high-accuracy sires. Adoption of these technologies is resulting in two significant outcomes: Increased numbers of genetically superior females, and a similar increase in numbers of genetically superior steer mates. Increased domestic and global demand for high-quality proteins, coincident with the decline in the U.S. beef cow inventory, offers the potential to increase premiums for high-quality beef products. Stacking reproductive and genetic technologies sets the stage for a new programming effort. Quality Beef by the Numbers (QB) streamlines production and marketing of cattle with a focus on high-quality endpoints. The program involves a partnership including the University of Missouri, Irsik and Doll Feed Yard (Garden City, KS), Pratt Feeders (Pratt, KS), Accelerated Genetics, Genex Cooperative, Select Sires Mid-America, and Certified Angus Beef. The program is intended to: 1) Support the adoption of reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S.; 2) Provide access to marketing grids that reward producers of high-quality cattle; and, 3) Provide beef producers with access to a comprehensive data base that will support improvements in management and marketing of cattle from conception to harvest. The QB mission will improve the profitability of beef cow-calf operations by facilitating the adoption of applied reproductive and genetic technologies that add value to beef cattle produced and marketed in the U.S. and contribute to improvements in beef quality to satisfy increasing domestic and global demand for high-quality beef.

**KEYWORDS**
High-quality beef
AI
high accuracy sires

# Tracking & Capturing Added Value: *"Quality Beef by the Numbers"*

D.J. Patterson, Ph.D.
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Columbia, MO

American Veterinary Medical Association Annual Meeting. July 27, 2014. Denver, CO.

# In today's market environment, everything works!

Despite, amazingly high cattle prices .....what are producers doing to ensure they can weather all of the next cattle cycle?

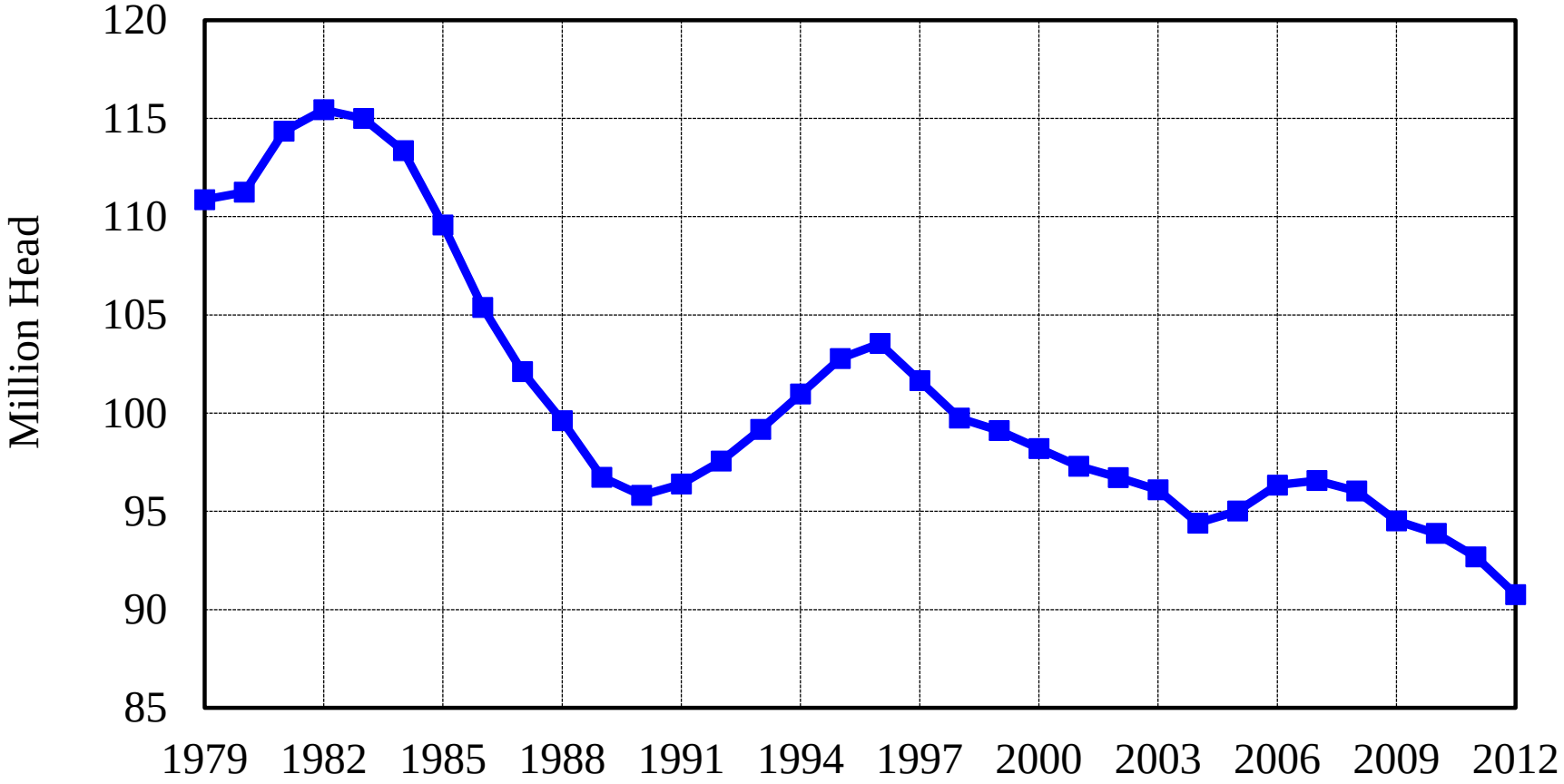
Does a focus on quality fit in your herd?

- Other ways to distinguish your cattle?

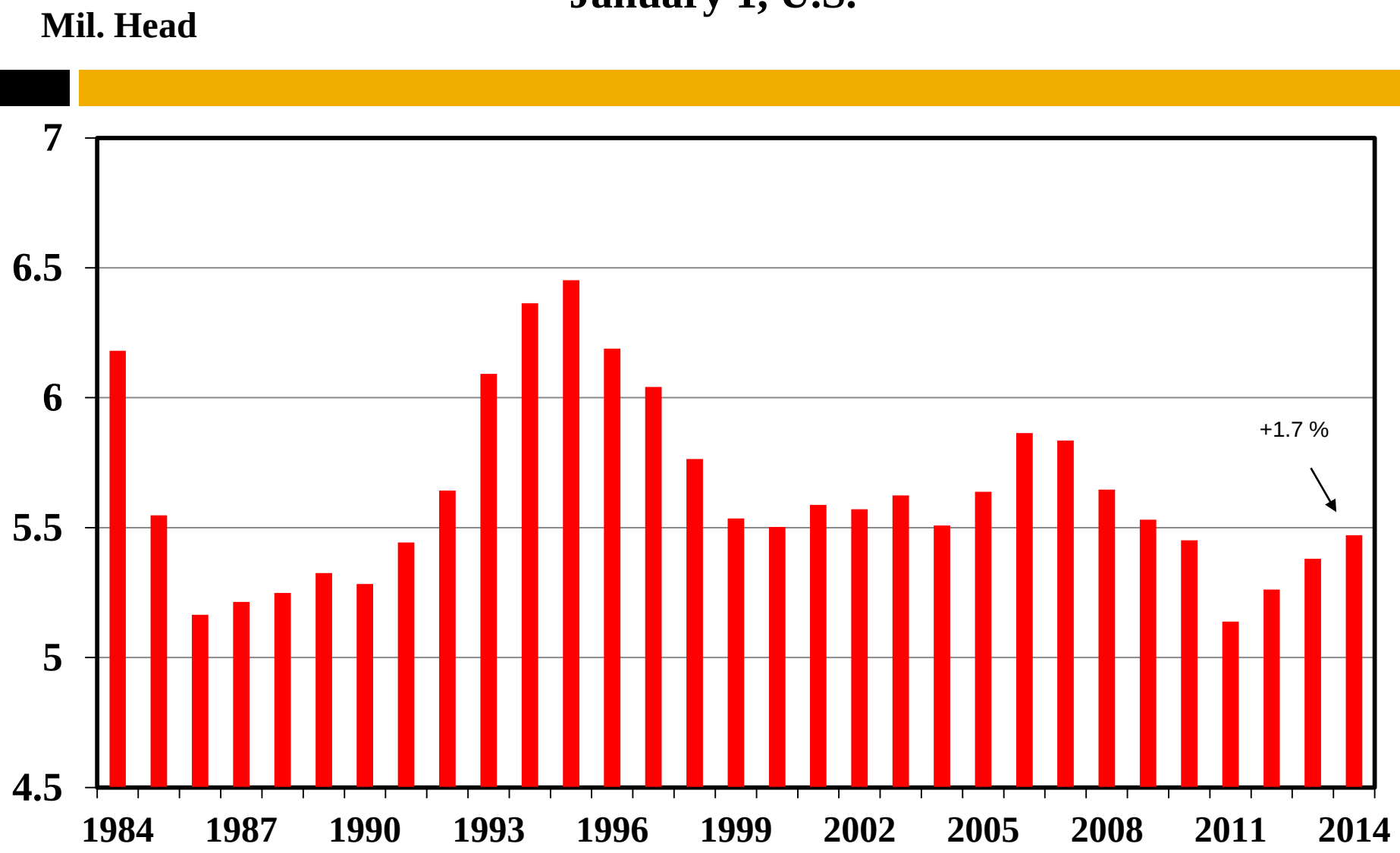
Do you have a plan?

- Doing nothing different is a plan!!!

# U.S. Cattle Inventories in Decline



# HEIFERS HELD AS BEEF COW REPLACEMENTS
## January 1, U.S.



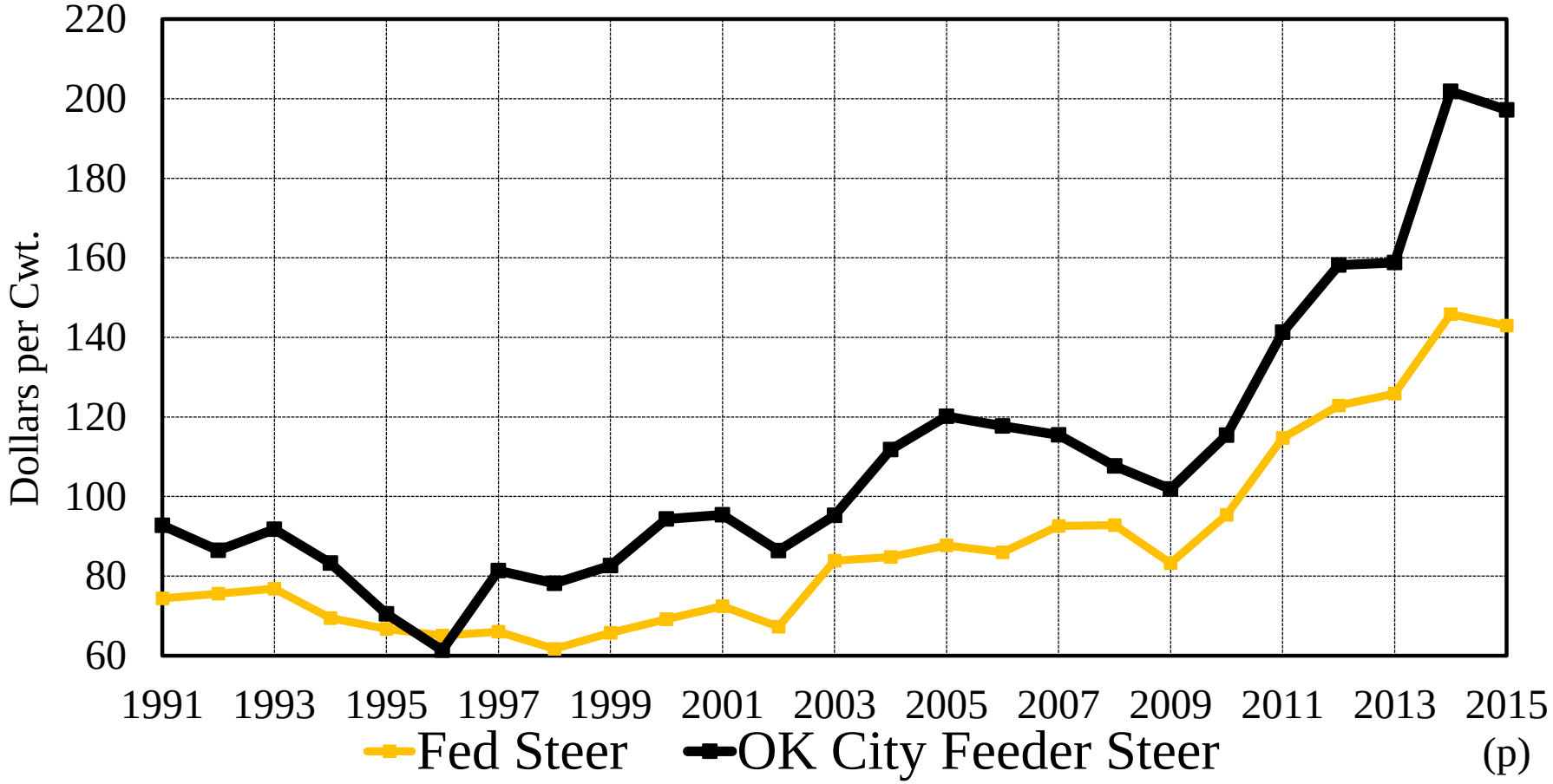

College of Agriculture, Food and Natural Resources

Data Source: USDA-NASS

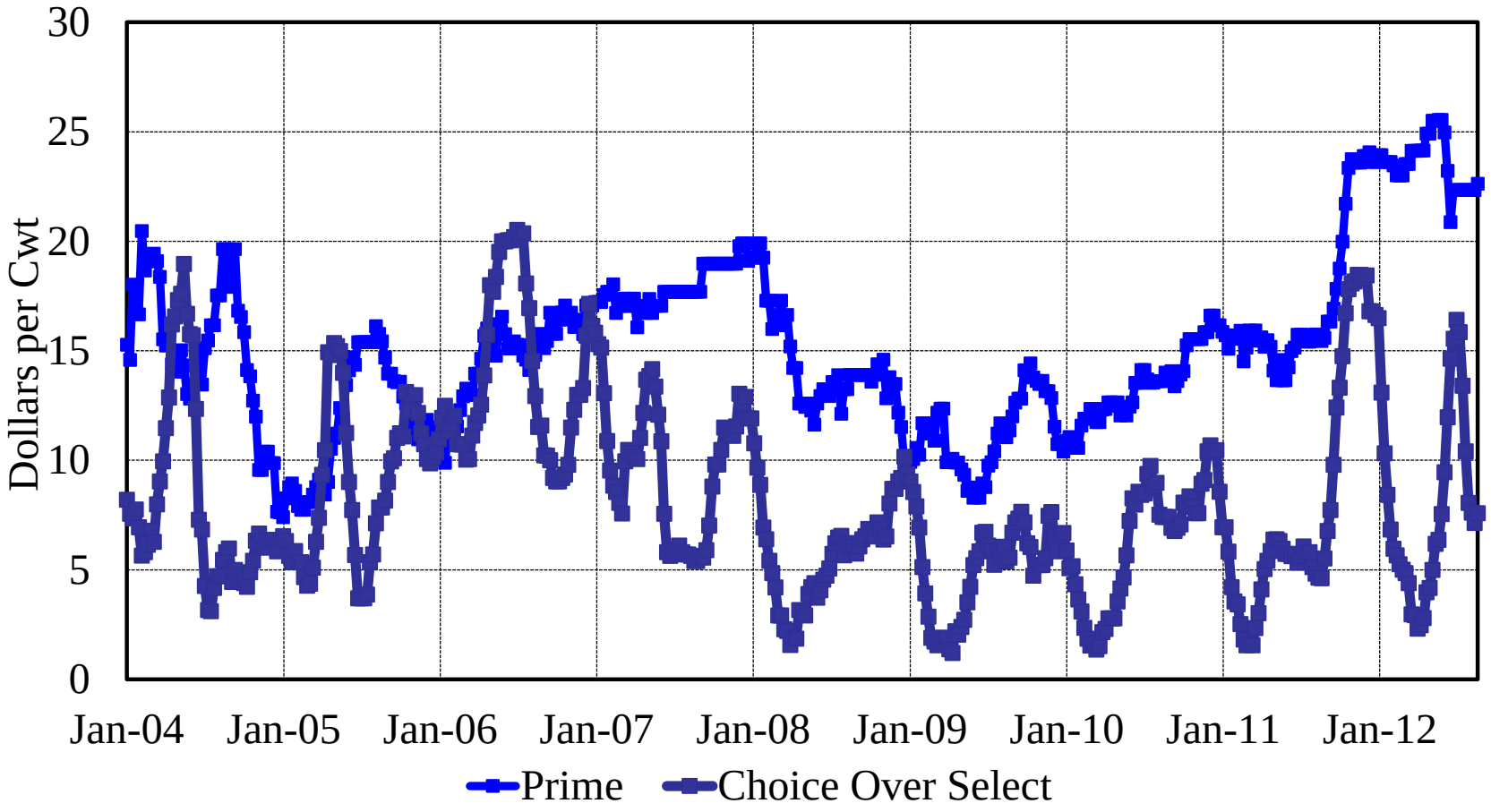
Livestock Marketing Information Center

C-N-38
06/23/14

# Cattle Prices – Record Prices Continue



# Cattle Premiums on the Rise



QUALITY BEEF
BY THE NUMBERS

# How did we get here and why?

UNIVERSITY OF MISSOURI Extension

# The Missouri Show-Me-Select™ Replacement Heifer Program

UNIVERSITY OF MISSOURI Extension

# BEEF & Missouri's Economy

- ~ 2 million beef cows on 60,000 farms & ranches
  - 3rd in the U.S. in beef cow numbers
- Revenue from cattle production contributes > 1 billion dollars to Missouri's economy annually
- A 1% increase in number of calves produced in one year would add $12 million to the state's economy

UNIVERSITY OF MISSOURI Extension

# Developing a plan

1. Create an understanding of the importance of heifer development based on reproductive outcomes.
2. Changes in heifer development spill over into the cow herd.
3. Importance of reproductive management becomes apparent.
4. Focus expands to genetic improvement.
5. Creation of a value-added product requires a re-evaluation of marketing strategies.

UNIVERSITY OF MISSOURI Extension

# Show-Me-Select ™ Program Objectives

- **Improve existing development programs through a *Total Quality Management* approach**
- **Provide a reliable source of quality replacements (genetics and management)**
- **Increase marketing opportunities for and add value to Missouri-raised heifers**

UNIVERSITY OF MISSOURI Extension

# Partnerships & program delivery

- University of Missouri Extension
  - State Specialists
    - Animal Science
    - Agriculture Economics
    - Veterinary Extension
  - Regional Extension Livestock Specialists
- College of Agriculture, Food, and Natural Resources
- College of Veterinary Medicine
  - Veterinary Practitioners
- Missouri Cattlemens Association
- Missouri Beef Cattle Improvement Association
- Missouri Department of Agriculture
- Missouri Livestock Marketing Association

UNIVERSITY OF MISSOURI Extension

# Show-Me-Select™
## Accomplishments and Impacts

- ***Since 1997……***
  - **743 farms**
  - **222 veterinarians**
  - **104,918 heifers enrolled**
  - **10 regional livestock coordinators**
  - **17 regional livestock specialists**
  - **Contributed > $65 M to Missouri's economy**

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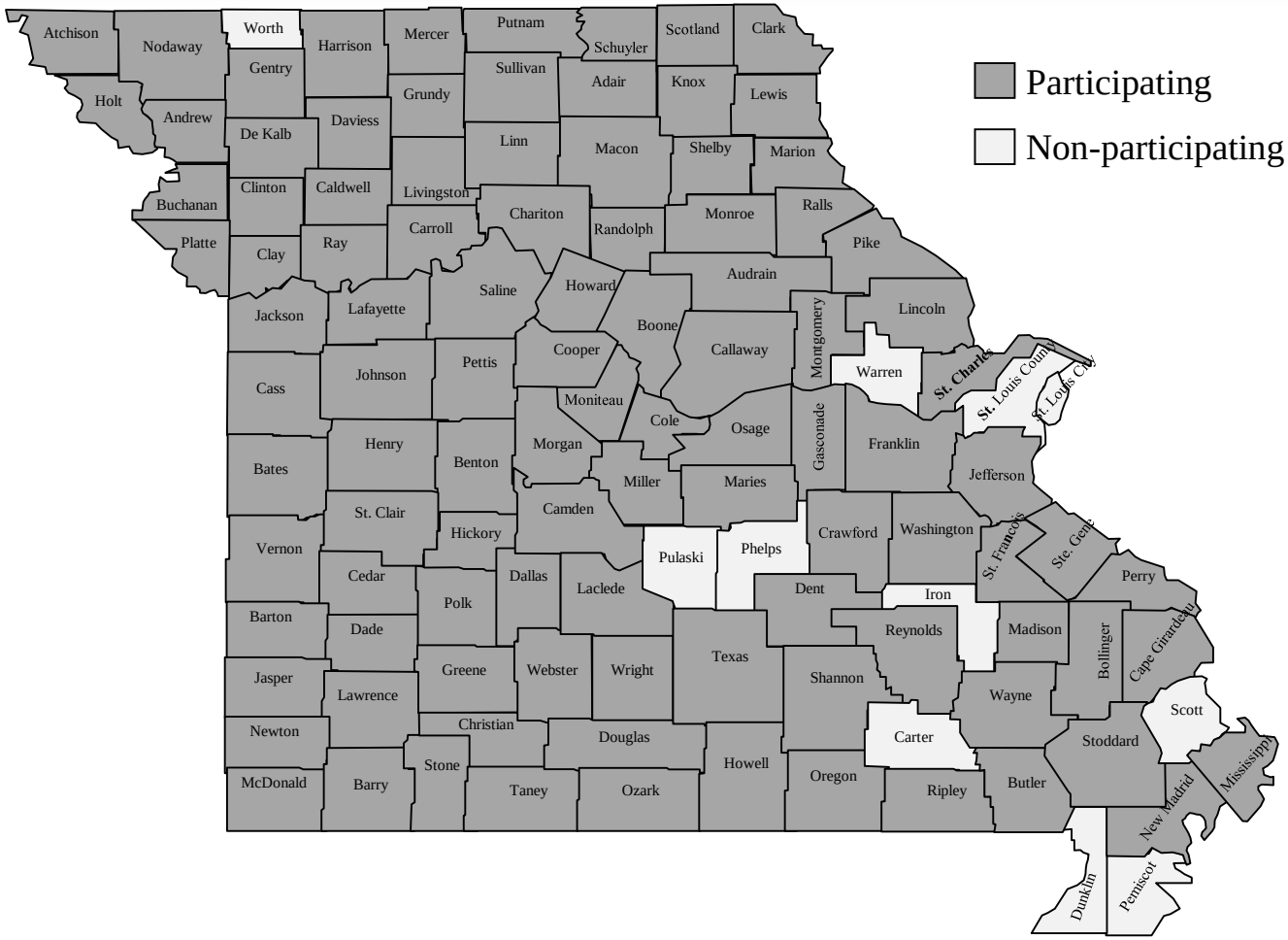
# Show-Me-Select™ Producer participation




**Producers from 103 (90%) of 114 counties enrolled heifers in the Show-Me-Select Replacement Heifer Program from 1997-2012.**

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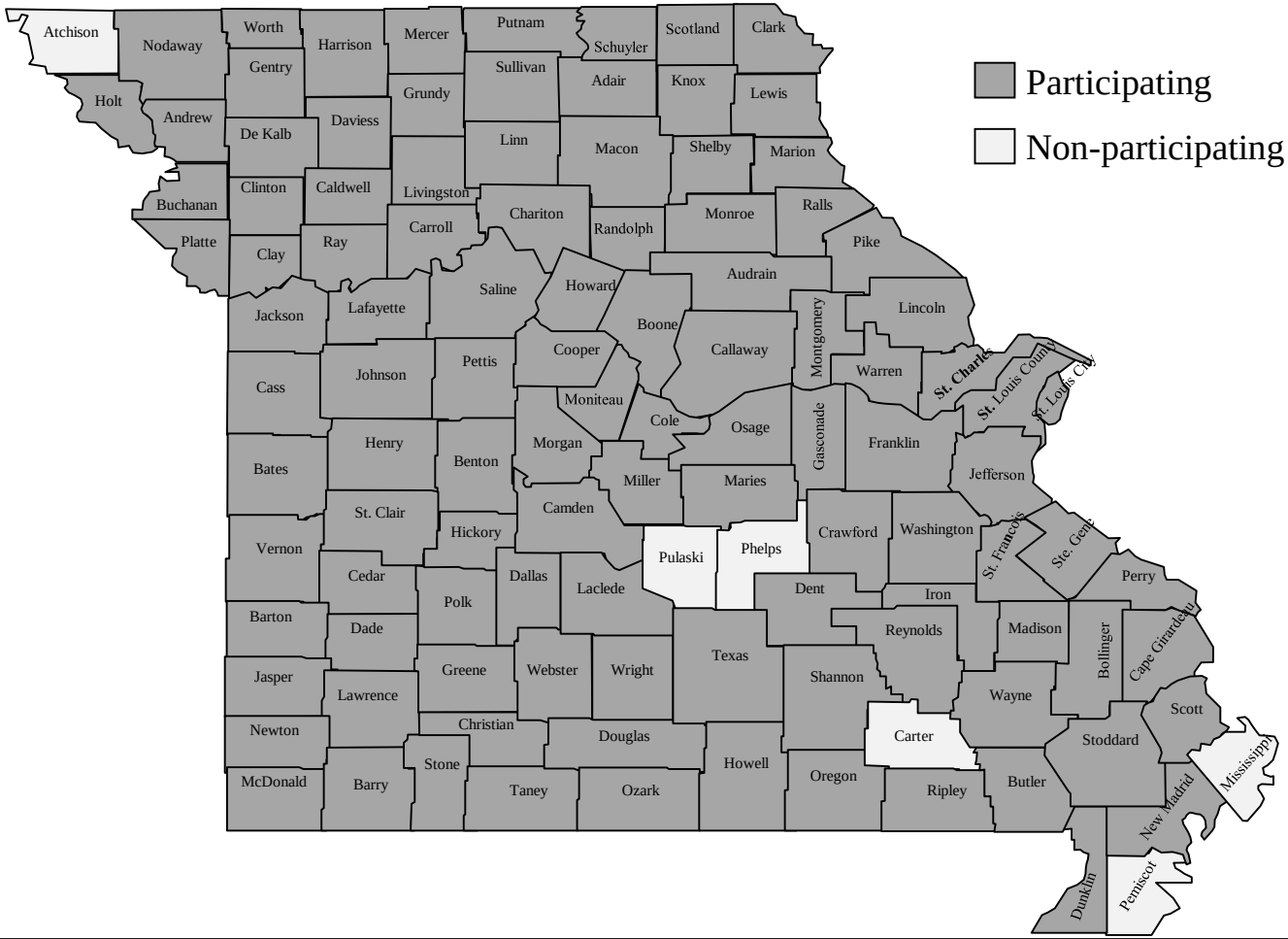
# Show-Me-Select™ Actual buyers



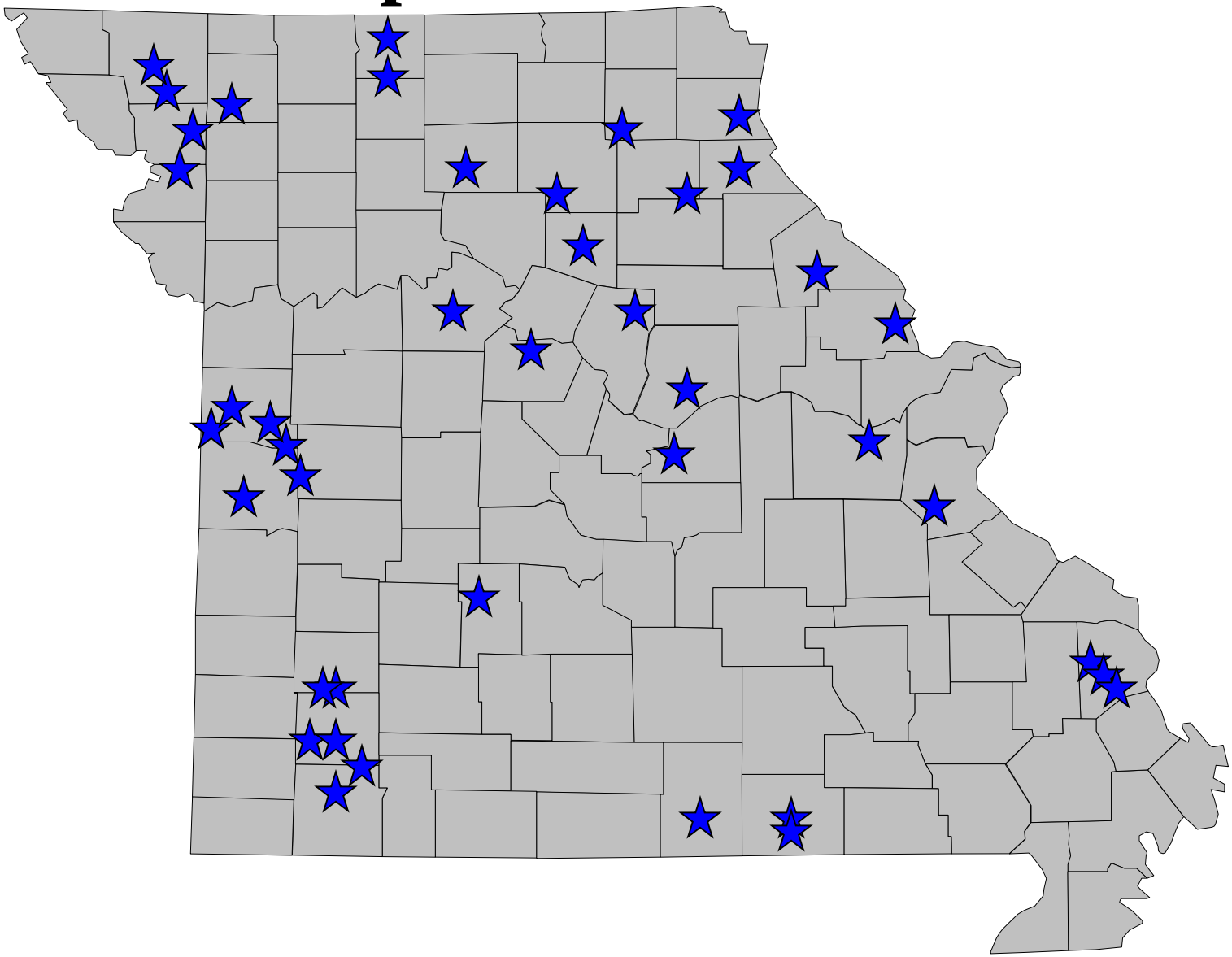

**Buyers from 108** (95%) of **the 114 counties purchased heifers from 1997-2012 sales.**

# USDA-NIFA Competitive Grants Program 2007-2011

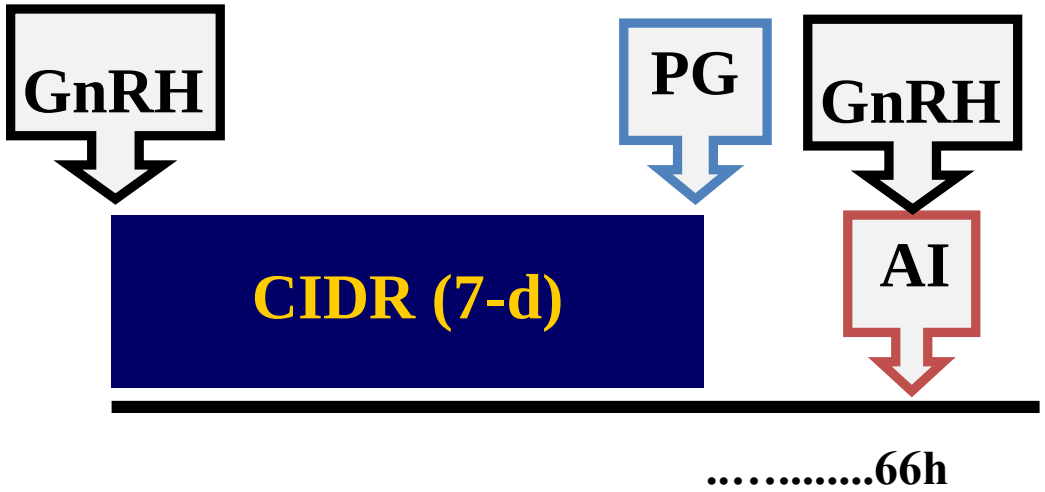
"An integrated approach to expand marketing opportunities for small- and medium-sized beef producers from value-added heifers and steers"

*Comprehensive extension education program focused on fixed-time AI of beef cows ("high accuracy sires")*

# On-farm Demonstrations with Fixed-time AI in Postpartum Beef Cows



# CO-Synch + CIDR in Cows with FTAI @ 66 hours




- 73 herds
- FTAI pregnancy rate = 4327/7028 (62%)
  - Range = 38-86%
  - 7 of 73 herds FTAI pregnancy rate < 50%

# What we learned …

- The concept of fixed-time AI made sense
- Selection of sires to use in AI programs for many commercial producers was overwhelming
  - How do I begin to choose?

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# Show-Me-Select™ Tier Two

## Minimum Accuracies for Sires of Tier Two Heifers

| Trait | Accuracy |
|---|---|
| Calving ease (direct) | .65 |
| Calving ease (maternal) | .30 |
| Weaning weight | .75 |
| Carcass Weight | .20 |
| Marbling | .20 |

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# Can producers make more money? Absolutely, using proven genetics! (data from Fall "10" thru Fall "12")

Tier 1 NS bred ……BASELINE AVG. $1,638

Tier 1 AI bred ……added **$192** = $1,830

Tier 2 NS bred ……..added **$216** = $1,854

**Tier 2 AI bred ……...**added **$329 = $1,967**

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# Show-Me-Select™
## Accomplishments and Impacts

- First statewide, on-farm beef heifer development and marketing program in the nation
- Producers are utilizing available technologies for on-farm heifer development that are now spilling over into the cowherd
- Increased interest & adoption of estrus synchronization and AI
  - Successful application
  - Differential in sale prices
- A growing interest in expanded use of AI to the entire herd
  - Reproductive management
  - Genetic improvement

***"Use and application of what we know to create knowledge"***

QUALITY BEEF
BY THE NUMBERS

# But, what about the steers?

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Extension

- We are now able to successfully AI cows & heifers at predetermined fixed times

- Markets are beginning to recognize and reward quality

# Research & Breeding Program

The focus of our field laboratory….
(MU Thompson Research Center)

- Development of **fixed-time AI programs** for beef cows & heifers

- Produce premium quality…….
  "**White Table Cloth BEEF**"

# Breeding Program
## MU Thompson Research Center

- **Emphasis on "high accuracy" AI sires**

- **$Value Indexes**
  - **<u>Multi-trait selection indexes</u>**, expressed in dollars per head, to assist beef producers by adding simplicity to genetic selection decisions.

  - The $Value is an estimate of how future progeny of each sire are expected to perform, on average, compared to progeny of other sires in the database if the sires were randomly mated to cows and if calves were exposed to the same environment.

# Adding value with HIGH ACCURACY
# MU Thompson Research Center

| Sire Group | Maternal Grand Sire | No. of steers | Choice or higher (%) | CAB® (%) | Prime (%) |
|---|---|---|---|---|---|
| High Accuracy | High Accuracy | 153 | 100 | 58 | 30 |
| High Accuracy | Low Accuracy | 64 | 100 | 61 | 34 |
| High Accuracy | Natural Service | 35 | 100 | 60 | 14 |
| **Totals** | | **252** | **100** | **59** | **29** |
| Natural Service | High Accuracy | 58 | 97 | 60 | 12 |
| Natural Service | Low Accuracy | 17 | 100 | 53 | 18 |
| Natural Service | Natural Service | 26 | 92 | 27 | 12 |
| **Totals** | | **101** | **96** | **50** | **13** |

# How many qualify for CAB® or grade Prime?

- ✓1 in 5 carcasses qualify for CAB®
- ✓3% of all carcasses grade Prime

## Beef Market Prices

| | Current Week | Previous Week | Previous Year |
|---|---|---|---|
| Prime Cutout[1] | $285.49 | $279.79 | $228.54 |
| CAB® Cutout[2] | $253.50 | $253.20 | $201.30 |
| Choice Cutout[2] | $246.00 | $246.60 | $192.90 |
| Select Cutout[2] | $239.20 | $239.20 | $186.50 |
| [1] USDA, [2] Urner Barry Yellow Sheet | | | |
| CAB® - CH spread | $7.50 | $6.60 | $8.40 |
| Prime - Select spread | $46.29 | $40.59 | $42.04 |

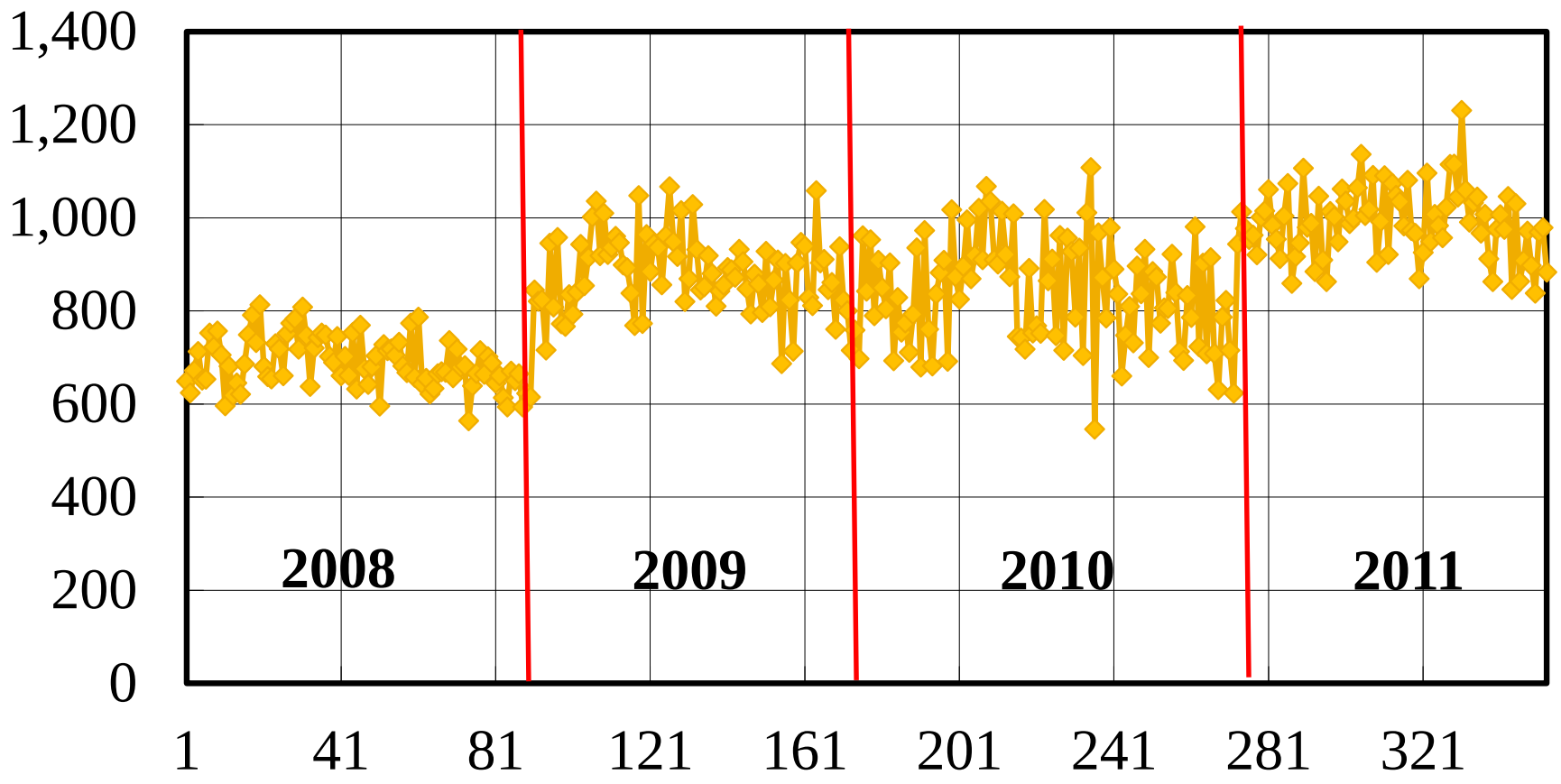
## Grid Premiums Paid

| REPORTS FROM FEEDLOTS REPRESENTING FOUR PACKERS | |
|---|---|
| Prime over Choice -- | $19.68/cwt. |
| Choice over Select -- | $8.10/cwt. |
| CAB® over Choice -- | $4.00/cwt. |

*Source: Feedlot reports representing 4 packers*

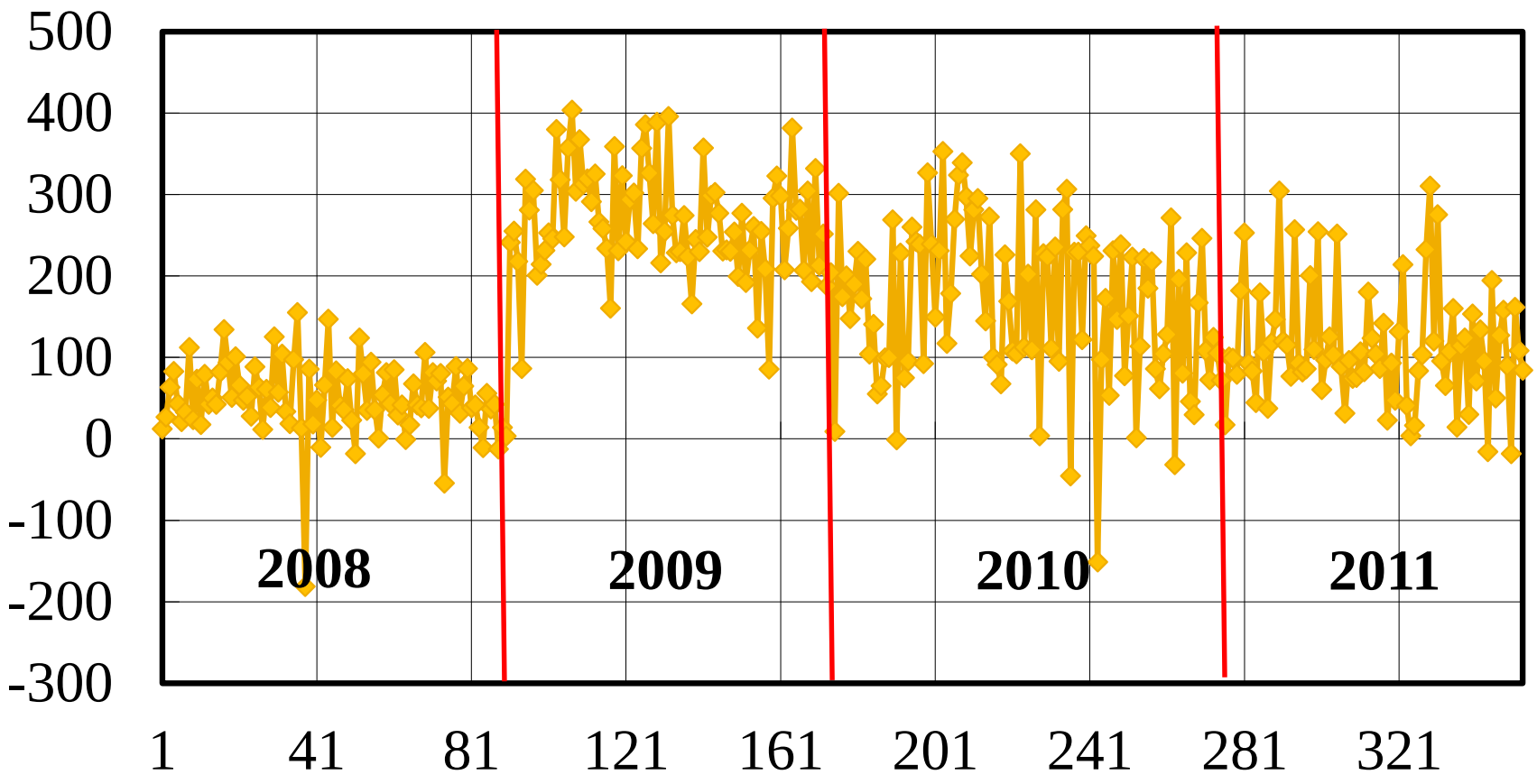
# Feedyard returns per cow

## MU Thompson Research Center



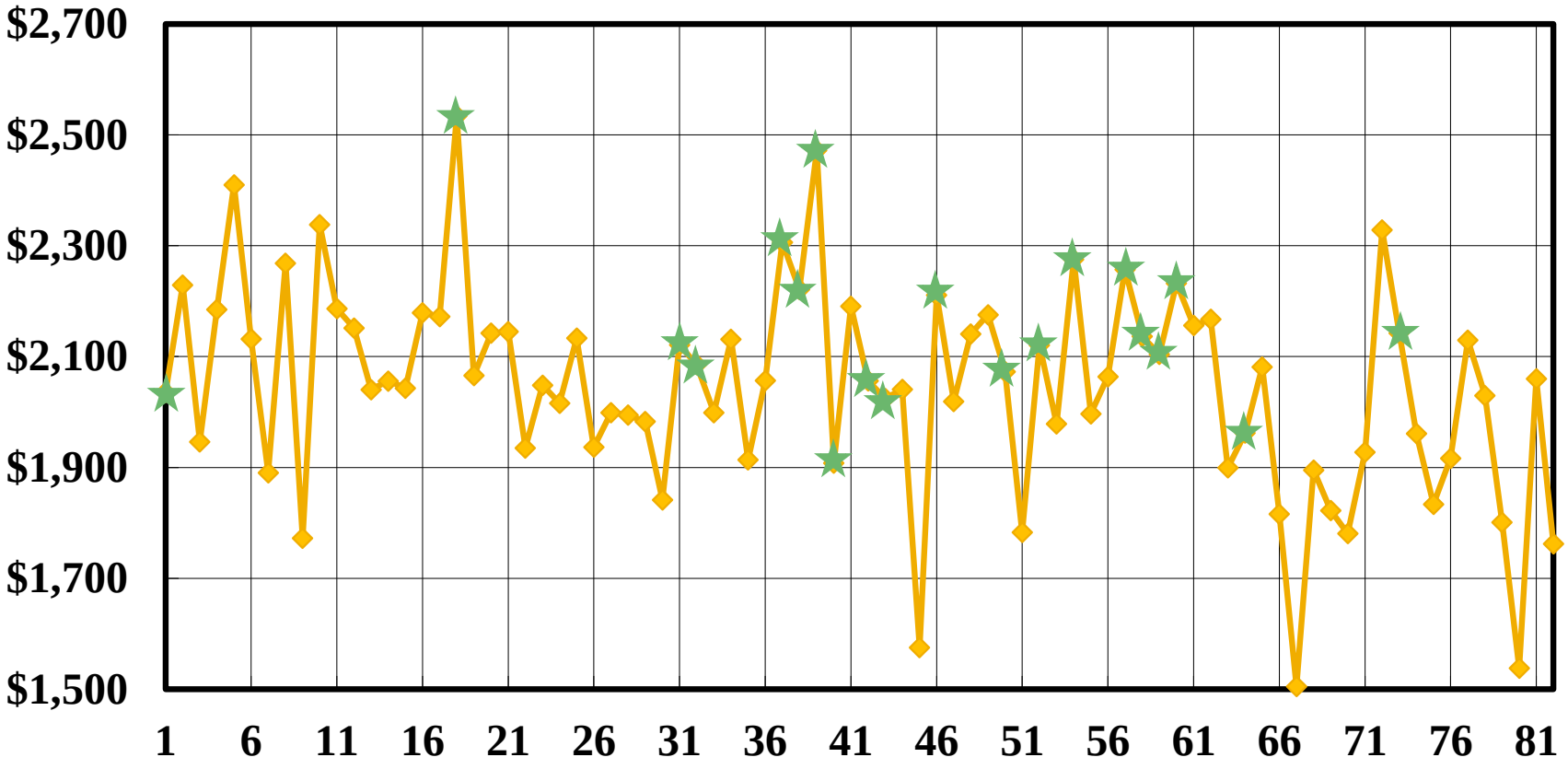
# Cow profitability over selling fall calves

## MU Thompson Research Center



# 2014 Carcass Values

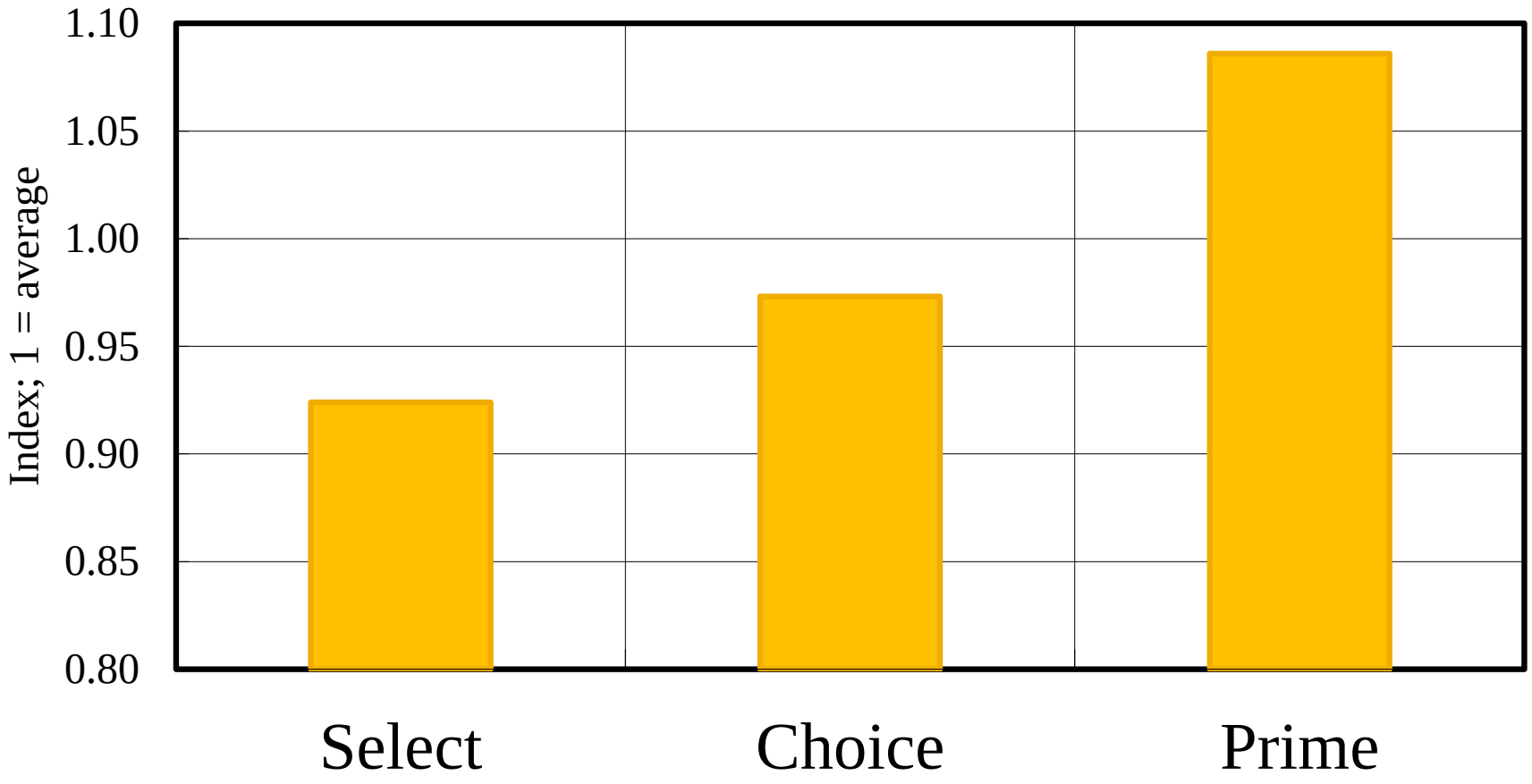
## MU Thompson Research Center



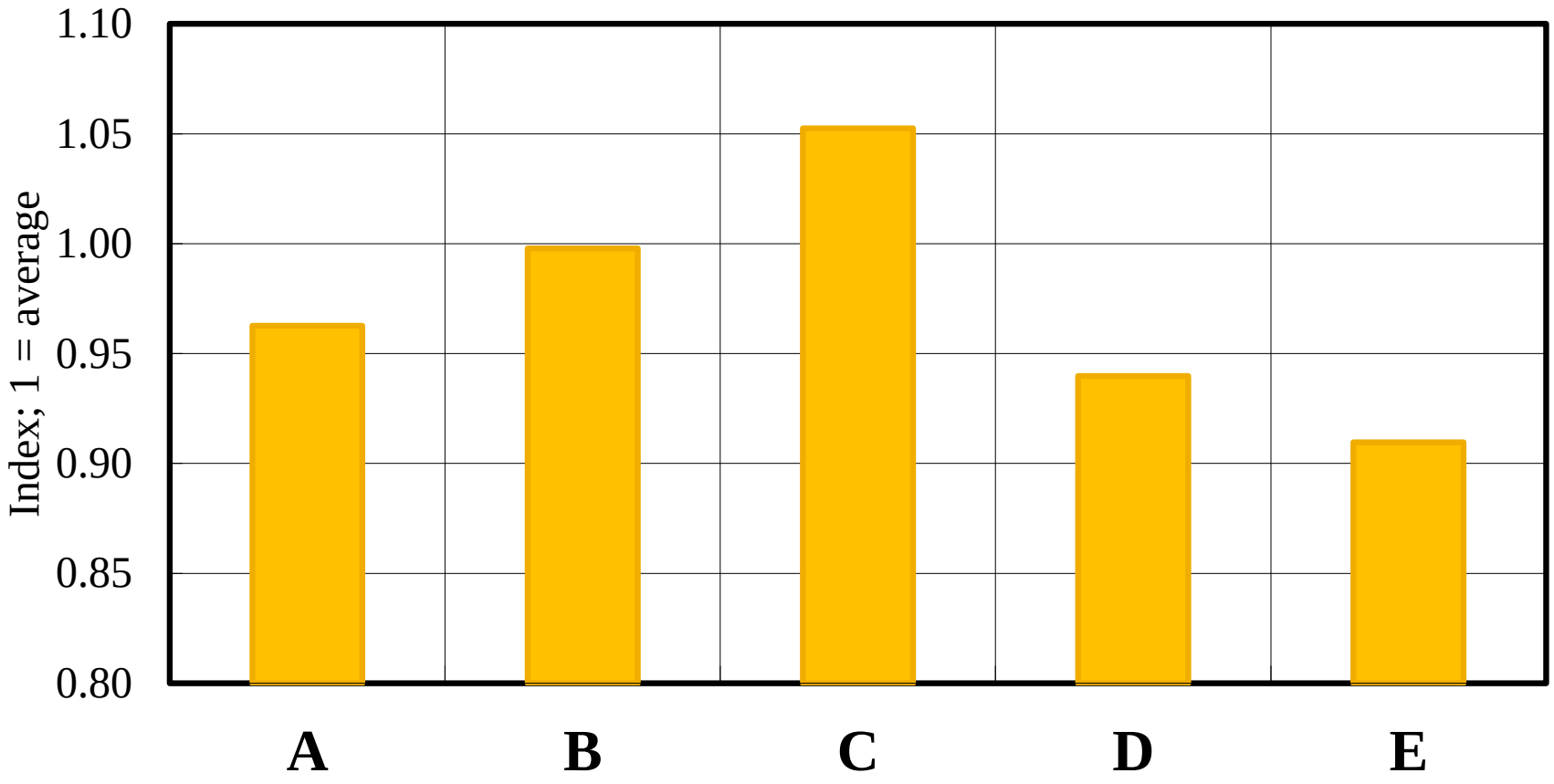

★ Denotes prime carcass

# Does quality affect profitability?

## MU Thompson Research Center



# How about sire?
## MU Thompson Research Center



# The question then becomes……

How can we use existing technologies to supply the growing demand for HIGH-QUALITY BEEF?

# Why QB???

- Genetic gains for the Missouri beef industry created by the Show-Me-Select Replacement Heifer Program.
- Development of fixed-time AI protocols.
- Combining FTAI with high accuracy genetics.
- Economic rewards for high-quality beef.
- The need for producers to economically analyze all phases of their production systems.

# Foundation of QB ….

**Premise = QUALITY PAYS**

How we get there……

- Reproductive management
- Targeting genetics
- Economic analysis

# Where do we go from here?

"As prices and costs increase, traits of efficiency and quality will become bigger drivers of profitability than ever before, and the commodity model of U.S. beef production will no longer be viable"

(BEEF Magazine, July 8, 2011)

# Where do we go from here?

- ✓ The long-term sustainability of the U.S. beef industry must be focused…..
- ✓ We cannot and will not compete globally long-term on a commodity basis
- ✓ We need to identify our strengths and develop them
  - ✓ U.S. produces 82-84% of high-quality beef in the global trade

# QB Program Mission Statement

"The QB mission is to improve the profitability of beef cow-calf operations by facilitating the adoption of applied reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S. and contribute to improvements in beef quality to satisfy increasing domestic and global demand for high-quality beef."

# QB Program Objectives

- ✓ Support the adoption of reproductive and genetic technologies that will add value to beef cattle produced and marketed in the U.S.
- ✓ Provide access to marketing grids that reward producers of high-quality cattle
- ✓ Provide beef producers with access to a comprehensive data base that will support improvements in management and marketing of their cattle from conception to harvest

# The "Real" Value of the <u>QB</u> Program

## It's the database and what we learn from it!

*Impacting:*

*Producers, industry partners, & consumers*

# QB Program Collaborators

Accelerated Genetics®

Cooperative Resources International CRI

SELECT SIRES INC.

GRAINS CATTLE FEEDS

IRSIK & DOLL

SINCE 1978

CERTIFIED ANGUS BEEF® BRAND

Partners in customer success

PRATT FEEDERS LLC

BUFFALO ASHLAND HAYS

# Summary

- A good time to be in the cattle business
- Now is the time to think carefully about herd rebuilding
- Technology adoption crucial to compete in world and domestic meat markets
- The cattle industry has been slow to adopt technology unlike many other agricultural sectors
- Those that adopt newer technologies may get an additional risk mitigation strategy

# Summary

- **AI to sires with high accuracies for specific EPD provides the opportunity to increase profitability and marketability of terminal and breeding stock.**

- **AI to sires with high accuracies offers the greatest probability of making improvements to the traits for which selection pressure is applied.**

# For more information….

*Google…*

Show-Me-Select Replacement Heifers

Quality Beef by the Numbers

# The Economic Evaluation Under the QB Program

**Dr. Scott Brown**

Agricultural Markets and Policy

Division of Applied Social Sciences

brownsc@missouri.edu

College of Agriculture, Food and Natural Resources

http://amap.missouri.edu

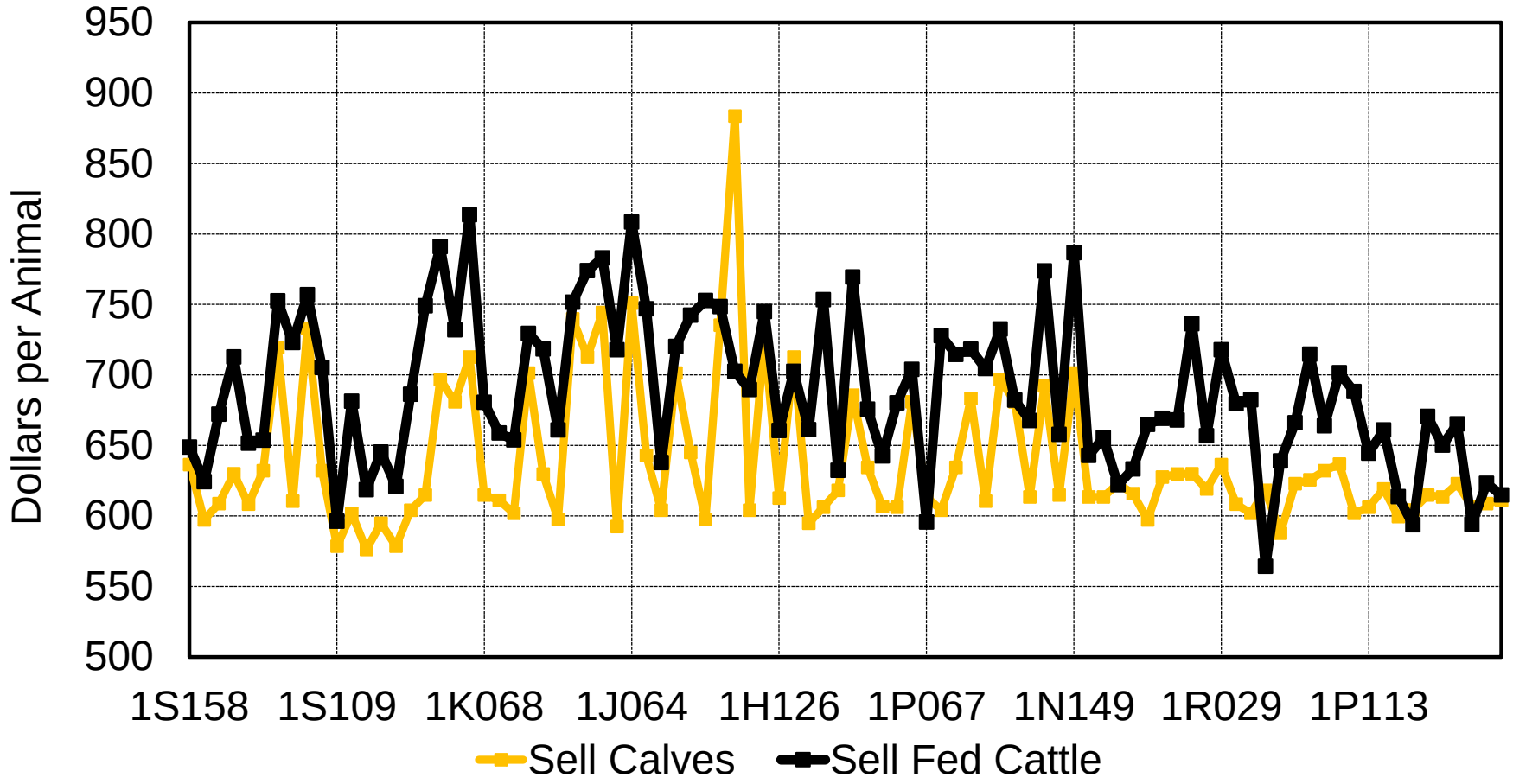
# Thompson Farm Data

- Data on steer calves from 2008 through 2011
- Calf values at weaning using St. Joseph feeder cattle prices
- Carcass data from feeding at Irsik and Doll
- Pen fed cattle – costs spread across cattle based on weight gained

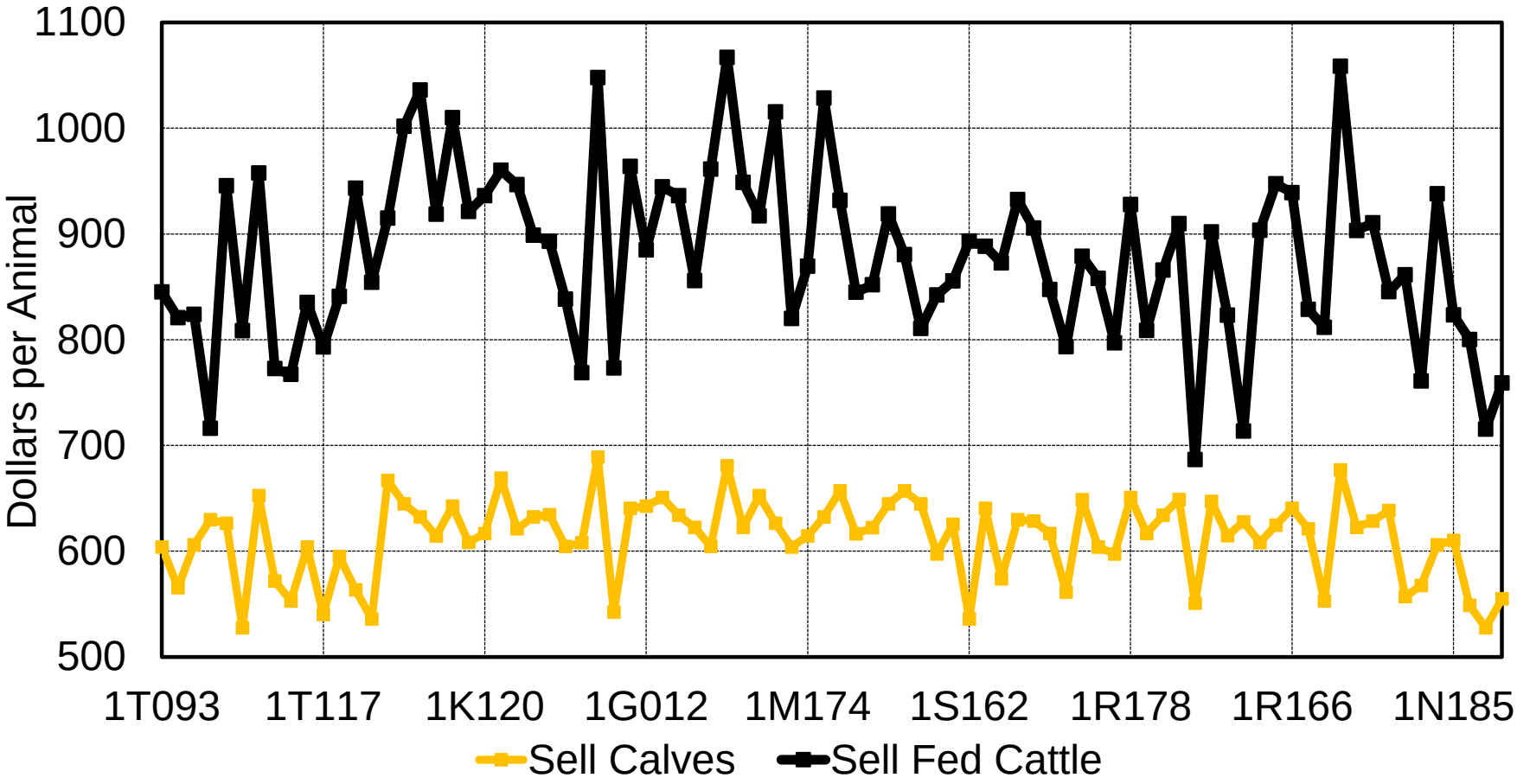
# Good Data Essential to QB

- Without detailed data, the economic comparison becomes very difficult
- The value of QB is not only a ranking among a farm's cows but perhaps more important is where you sit relative to others in QB
- Having this information gives you more flexibility
  - Sell as feeder cattle
  - Retain some portion of ownership through the feedyard

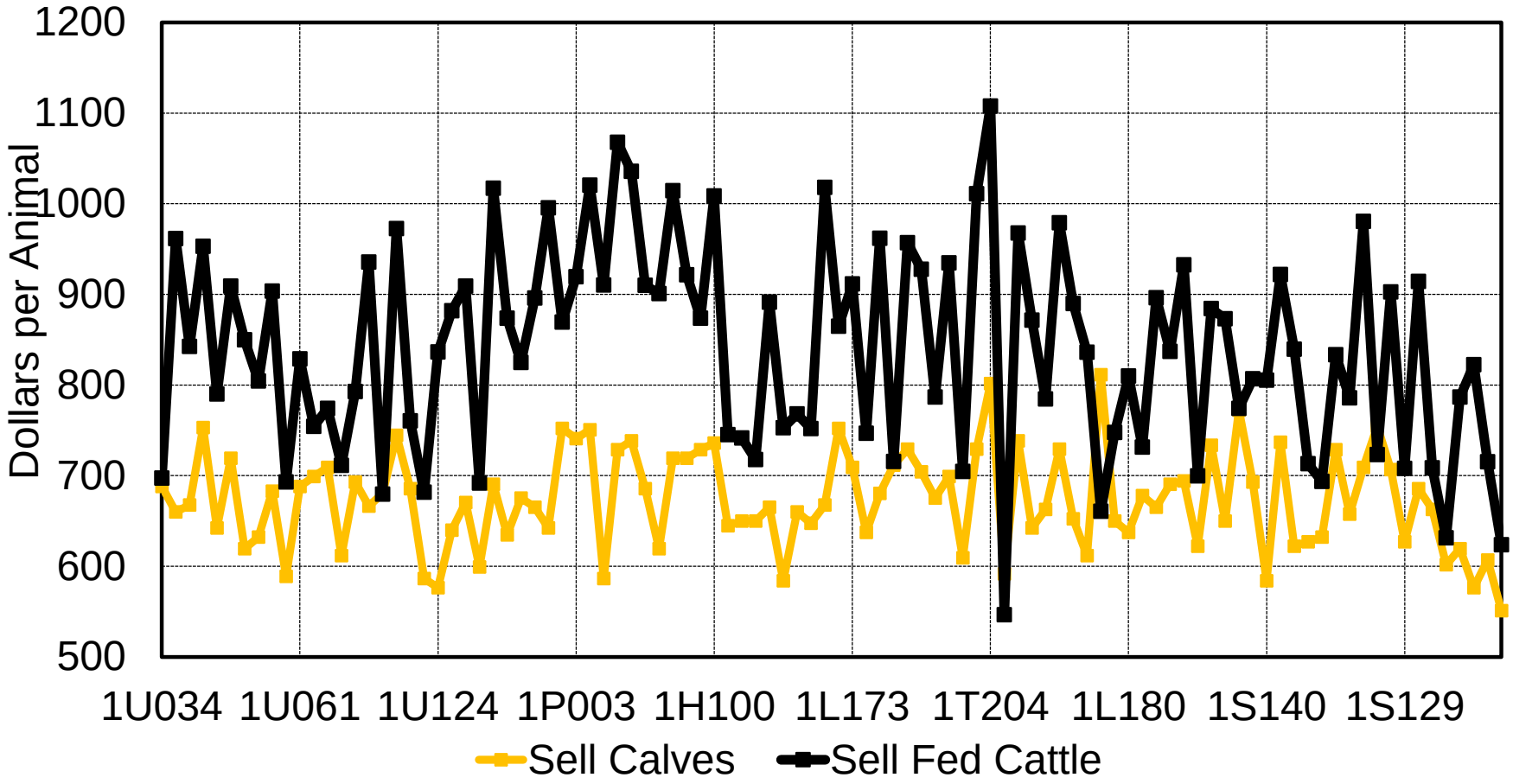
# The 2008 Calf Crop



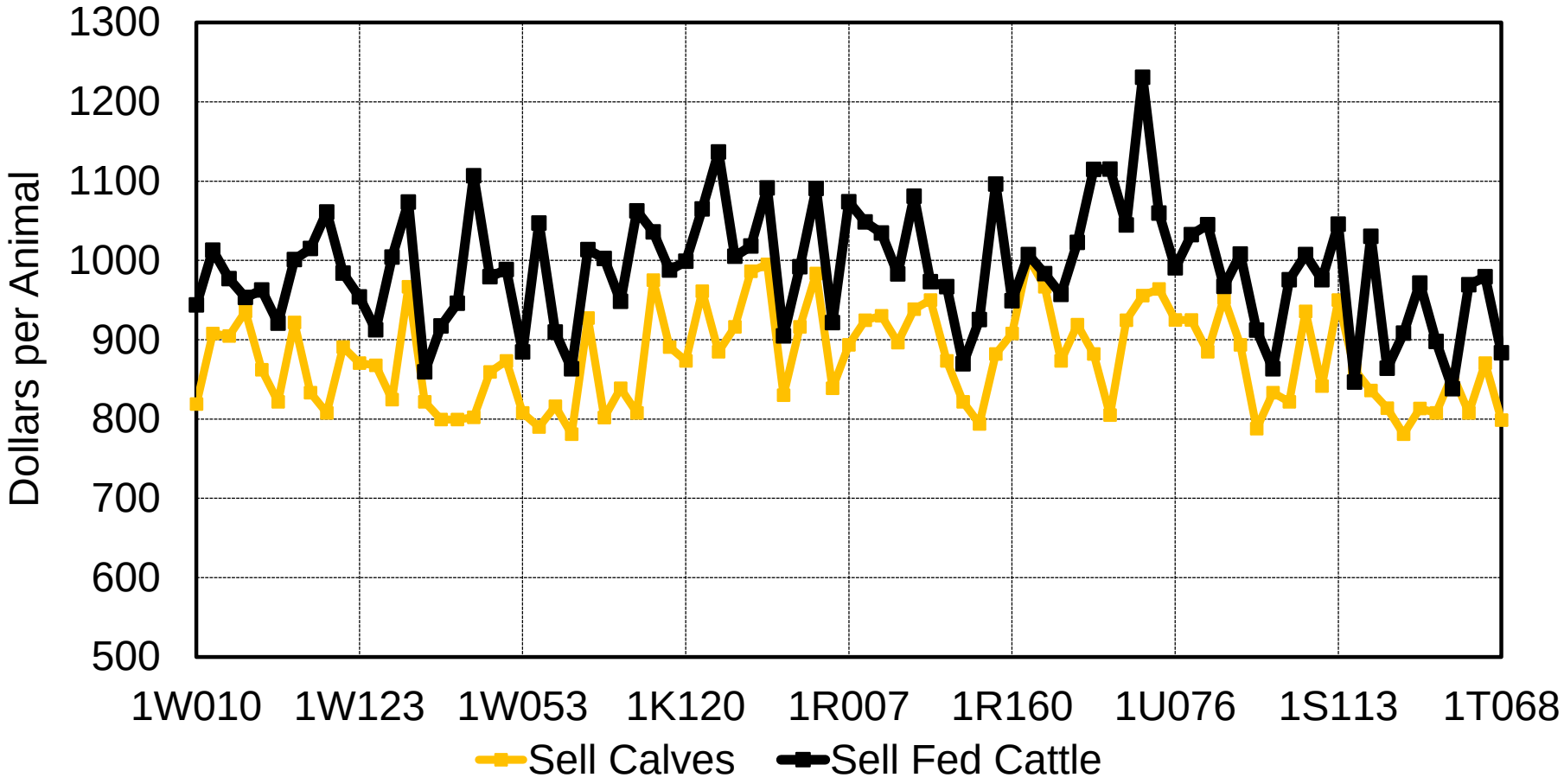
# The 2009 Calf Crop



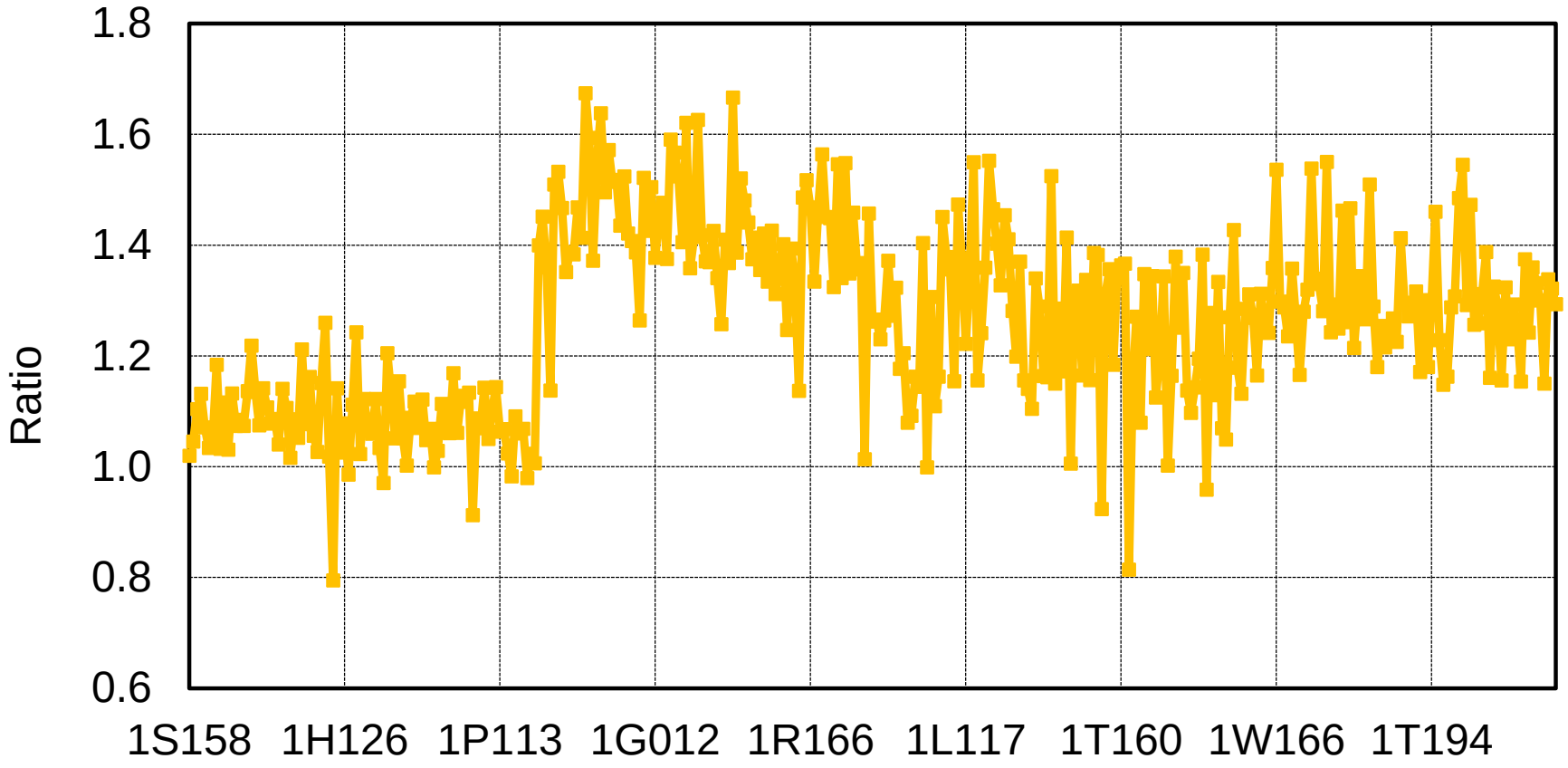
# The 2010 Calf Crop



# The 2011 Calf Crop



# Ratio of Fed Returns Versus Feeder Revenue



# Another Culling Tool

| Cow ID | Fed Score | Feeder Score |
|---|---|---|
| | | |
| 1E132 | 1.15 | 1.09 |
| 1E163 | 0.95 | 0.96 |
| 1F013 | 0.87 | 0.93 |
| 1F013 | 1.06 | 1.06 |
| 1F045 | 0.85 | 0.90 |
| 1F074 | 1.08 | 1.14 |
| 1F074 | 0.86 | 1.12 |
| 1F081 | 0.97 | 0.98 |
| 1F109 | 1.14 | 1.17 |
| 1F114 | 0.91 | 0.95 |
| 1F191 | 0.86 | 0.95 |
| 1G012 | 1.01 | 1.05 |
| 1G030 | 0.93 | 0.92 |
| 1G075 | 1.09 | 1.15 |
| 1G088 | 1.08 | 1.01 |
| 1G088 | 0.83 | 0.92 |
| 1G129 | 1.02 | 1.12 |
| 1G173 | 1.00 | 0.95 |
| 1G173 | 1.00 | 1.07 |
| 1G173 | 1.05 | 1.07 |
| 1H036 | 1.00 | 0.94 |
| 1H036 | 0.79 | 1.21 |
| 1H063 | 0.92 | 0.97 |
| 1H069 | 1.10 | 0.95 |
| 1H069 | 0.97 | 1.02 |
| 1H069 | 0.88 | 0.97 |
| 1H072 | 1.09 | 0.99 |
| 1H087 | 1.04 | 0.93 |
| 1H100 | 1.03 | 1.02 |
| 1H100 | 1.20 | 1.09 |
| 1H100 | 1.00 | 1.05 |
| 1H126 | 0.96 | 0.96 |
| 1H126 | 1.04 | 0.94 |

# Thompson Research Center Example

- Which cow would you cull?

1L106

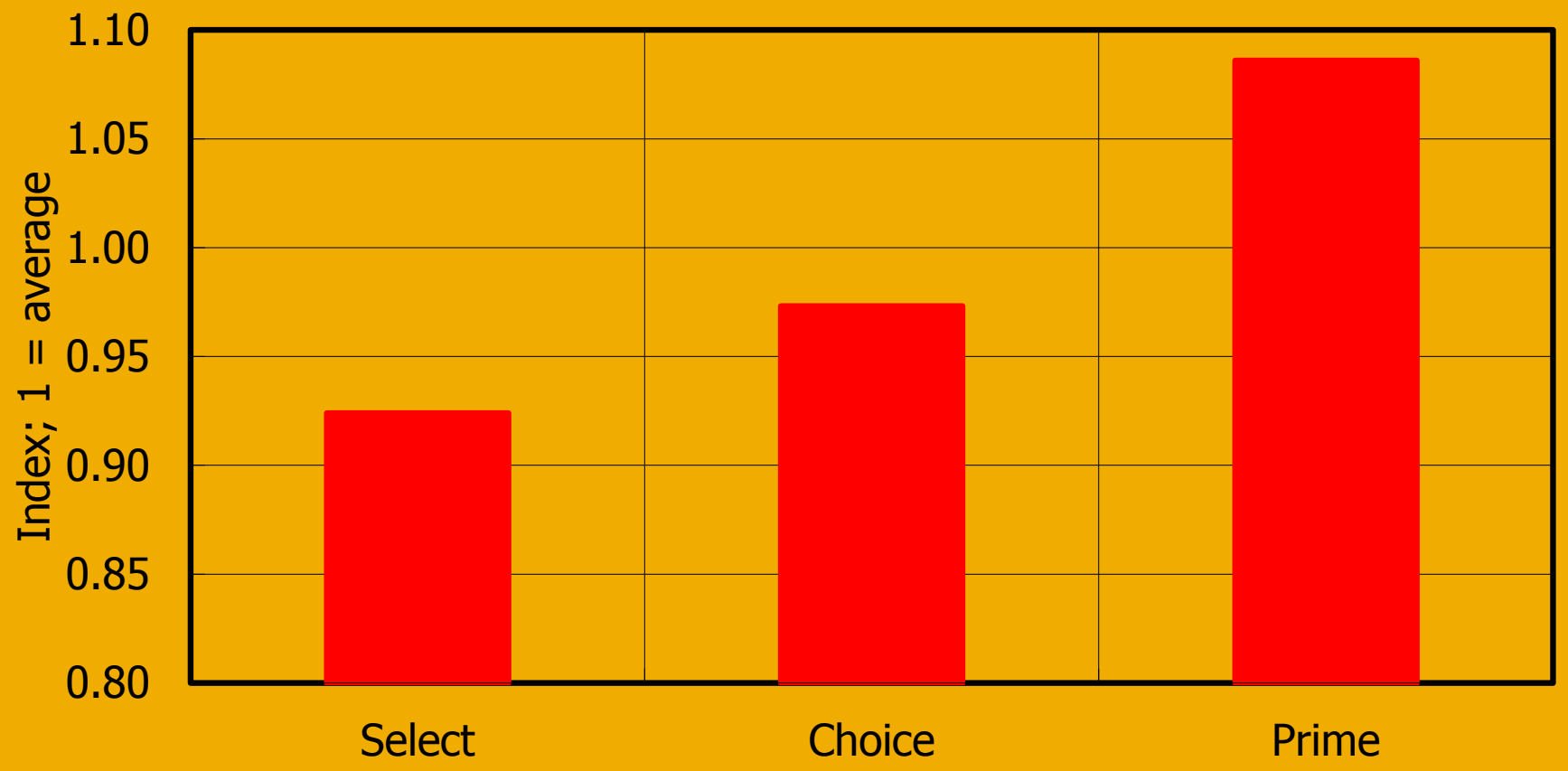
1U111

# Database Possibilities Are Many

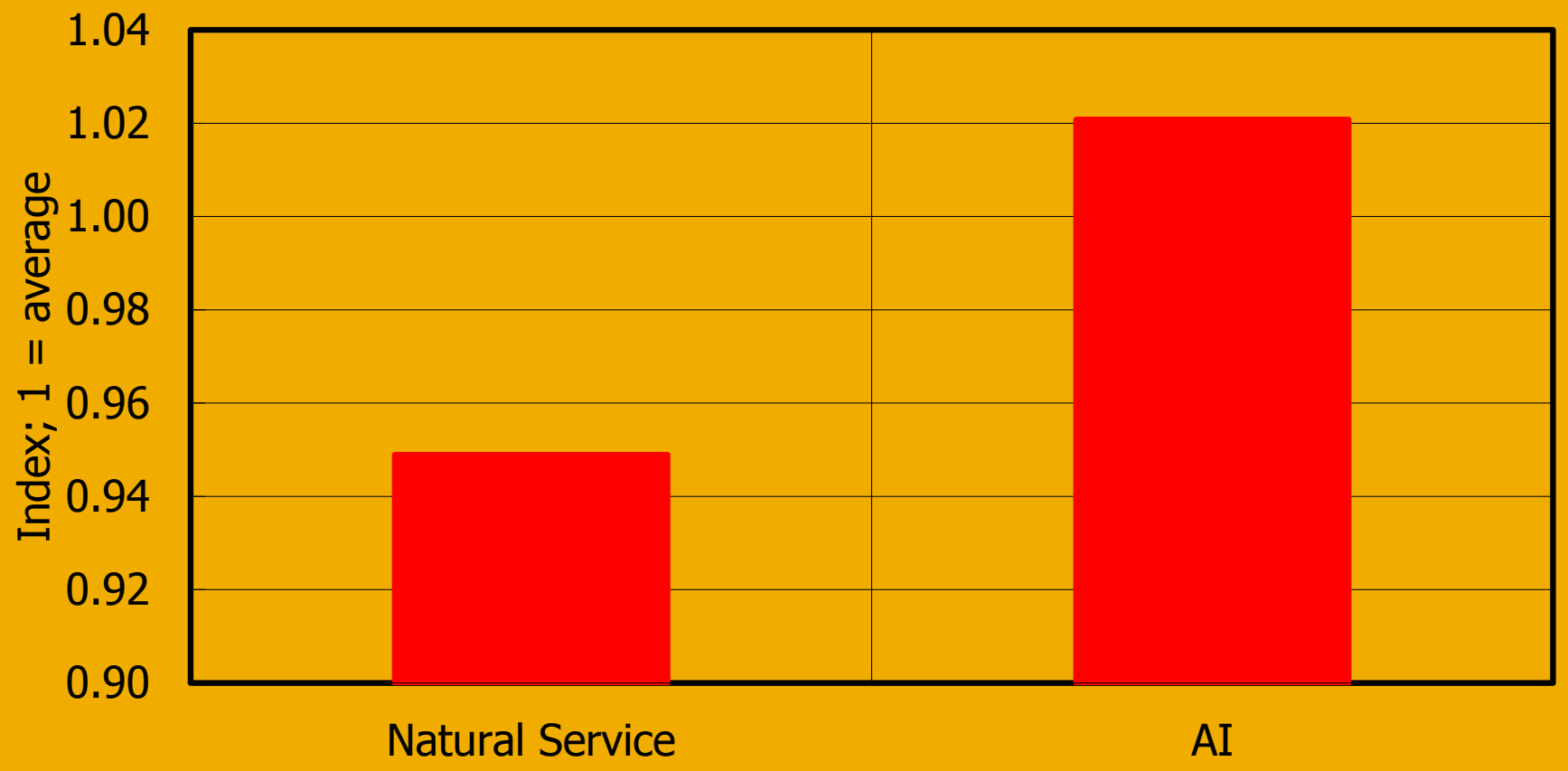
| | |
|---|---|
| **1L106** | **1U111** |
| Three steers | Two steers |
| Economic Value From Steers 112% of average | Economic Value From Steers 90% of average |
| All AI-sired | All AI-sired |
| 1 Prime, 2 CAB | 2 CAB |

Range 64% to 130%

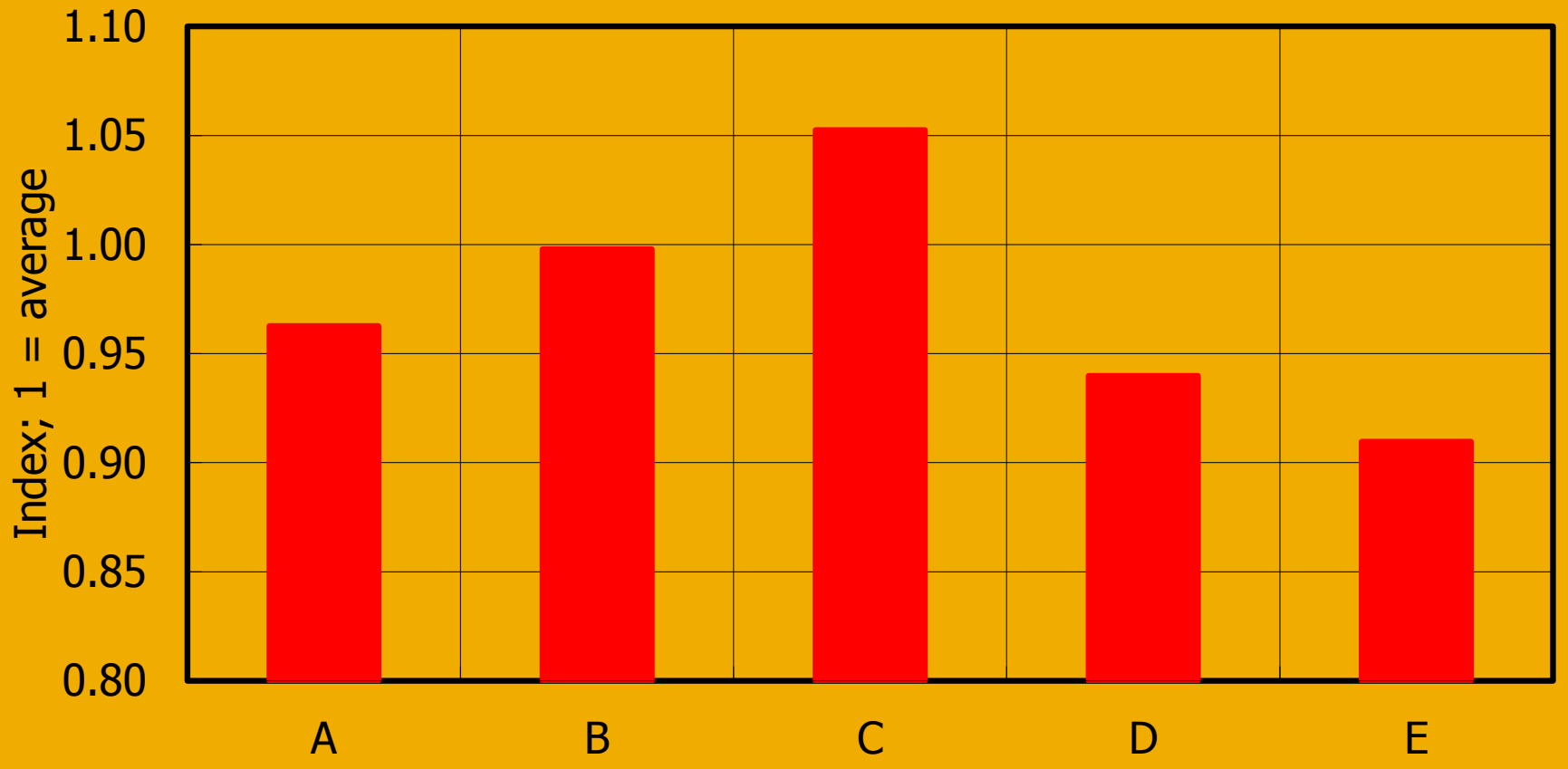
# Does Quality Affect Profitability?



# How About Sire-Type?



# How About Sire?



Proceedings, Applied Reproductive Strategies in Beef Cattle
October 8 – 9, 2014; Stillwater, OK

# CONTROL OF ESTRUS AND OVULATION IN BEEF COWS[1]

D.J. Patterson, J.M. Thomas, J.M. Abel, B.E. Bishop, J.E. Decker, and M.F. Smith
Division of Animal Sciences
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## INTRODUCTION

Estrus synchronization and artificial insemination (AI) remain the most important and widely applicable reproductive biotechnologies available for cattle (Seidel, 1995). Although hormonal treatment of heifers and cows to group estrous cycles has been a commercial reality now for over 30 years, beef producers until now have been slow to adopt this management practice. Perhaps this is because of past failures, which resulted when females that were placed on estrus synchronization treatments failed to reach puberty or to resume normal estrous cycles following calving. In addition, early estrus synchronization programs failed to manage follicular waves, resulting in more days in the synchronized period, which ultimately precluded fixed-time artificial insemination (FTAI) with acceptable pregnancy rates. The development of convenient and economical protocols to synchronize estrus and ovulation to facilitate use of FTAI with resulting high fertility has resulted in increased adoption of these important management practices (Patterson et al., 2003). Research conducted over the past 10 to 15 years has focused on the development of methods that effectively synchronize estrus in postpartum beef cows and replacement beef heifers by decreasing the period of time over which estrus detection is required, thus facilitating the use of FTAI.

Improving traits of major economic importance in beef cattle can be accomplished most rapidly through selection of genetically superior sires and widespread use of artificial insemination. Procedures that facilitate synchronization of estrus in estrous cycling females and induction of an ovulatory estrus in peripubertal heifers and anestrous postpartum cows will increase reproductive rates and expedite genetic progress. Estrus synchronization can be an effective means of increasing the proportion of females that become pregnant early in the breeding period resulting in shorter calving seasons and more uniform calf crops (Dziuk and Bellows, 1983). Females that conceived to a synchronized estrus calved earlier in the calving season and weaned calves that were on average 13 days older and 21 pounds heavier than calves from non-synchronized females (Schafer et al., 1990).

Effective estrus synchronization programs offer the following advantages: 1) cows or heifers are in estrus at a predicted time which facilitates AI, embryo transfer, or other assisted reproductive techniques; 2) the time required for detection of estrus is reduced thus decreasing labor expense associated with estrus detection; 3) AI becomes more practical, enabling producers to utilize

[1]**Acknowledgements.** Research summarized in this manuscript was supported by National Research Initiative Competitive Grant no. 00-35203-9175 and 2005-55203-15750 from the USDA National Institute of Food and Agriculture. The authors gratefully acknowledge Pfizer Animal Health (New York, NY) for providing Lutalyse and EAZI BREED CIDR Cattle inserts; Merial (Athens, GA) for providing Cystorelin; TEVA Animal Health for providing OvaCyst; ABS Global, Accelerated Genetics, Genex Cooperative, Inc., and Select Sires, Inc., for providing semen; and D.S. McAtee and J.J.D. Schreffler at the University of Missouri Thompson Farm for their dedicated support of this research.

genetically superior high accuracy sires; 4) cattle will conceive earlier during the breeding period; and 5) calves will be older and heavier at weaning.

This review focuses on estrus synchronization protocols for beef cows that may be used to facilitate artificial insemination. These procedures include synchronization of estrus in estrous cycling females, and induction of estrus accompanied by ovulation among cows that have not returned to estrus after calving. The following protocols and terms will be referred to throughout this manuscript.

*Protocols for AI performed on the basis of detected estrus:*

*PG*: Prostaglandin $F_{2\alpha}$ (PG; Lutalyse®, Estrumate®, ProstaMate®, InSynch®, estroPLAN®).

*GnRH-PG (Select Synch)*: Gonadotropin-releasing hormone injection (GnRH; Cystorelin®, Factrel®, Fertagyl®, OvaCyst®) followed in 7 days with an injection of PG.

*PG 6-day CIDR*: PG followed in 3 days with an injection of GnRH at CIDR insertion; 6 days later CIDRs are removed coincident with the administration of PG.

*Protocols for fixed-time AI:*

*7-day CO-Synch + CIDR:* GnRH is administered at CIDR insertion on day 0, followed 7 days later with CIDR removal, and PG. Insemination is performed 66 hours after CIDR removal and PG, with GnRH administered at AI.

*5-day CO-Synch + CIDR:* GnRH is administered at CIDR insertion on day 0, followed 5 days later with CIDR removal, and PG. A second injection of PG is administered 8 ± 2 hours after CIDR removal and the first PG injection. Insemination is performed 72 hours after CIDR removal and the first injectionof PG, with GnRH administered at AI.

*Terms:*

*Estrous response*: The number of females that exhibit estrus during a synchronized period.

*Synchronized period*: The period of time during which estrus is expressed after treatment.

*Synchronized conception rate*: The proportion of females that become pregnant of those that exhibit estrus and are inseminated during the synchronized period.

*Synchronized pregnancy rate*: Proportion of females that become pregnant of the total number treated.

To avoid problems when using estrus synchronization, cows should be selected for a program when the following conditions are met: 1) Adequate time has elapsed from calving to the time synchronization treatments are implemented [in most cases a minimum of 40 days postpartum at the beginning of treatment is suggested]; 2) Cows are in average or above-average body condition [scores of at least 5 on a scale of 1 to 9]; and 3) Cows experience minimal calving problems.

## DEVELOPMENT OF METHODS TO SYNCHRONIZE ESTRUS

The development of methods to control the estrous cycle of the cow has occurred in six distinct phases. The physiological basis for estrus synchronization followed the discovery that progesterone inhibited ovulation (Ulberg et al., 1951) and preovulatory follicular maturation

(Nellor and Cole, 1956; Hansel et al., 1961; Lamond, 1964). Regulation of estrous cycles was believed to be associated with control of the corpus luteum, whose life span and secretory activity are regulated by trophic and lytic mechanisms (Thimonier et al., 1975; Patterson et al., 2003). The Progesterone Phase included efforts to prolong the luteal phase of the estrous cycle or to establish an artificial luteal phase by administering exogenous progesterone. Later, progestational agents were combined with estrogens or gonadotropins in the Progesterone–Estrogen Phase. Prostaglandin $F_{2\alpha}$ and its analogs were reported in 1972 to be luteolytic in the bovine (Lauderdale, 1972; Rowson et al., 1972; Liehr et al., 1972; Lauderdale et al., 1974) and ushered in the PG Phase. Treatments that combined progestational agents with PG characterized the Progestogen-PG Phase. All of these protocols addressed control of the luteal phase of the estrous cycle since follicular waves were not recognized at the time.

Precise monitoring of ovarian follicles and corpora lutea over time by transrectal ultrasonography expanded our understanding of the bovine estrous cycle and particularly the change that occurs during a follicular wave (Fortune et al., 1988). Growth of follicles in cattle occurs in distinct wave-like patterns, with new follicular waves occurring approximately every 10 days (6-15 day range). We now know that precise control of estrous cycles requires the manipulation of both follicular waves and luteal lifespan (GnRH-PG Phase).

A single injection of gonadotropin-releasing hormone (GnRH) to cows at random stages of their estrous cycles causes release of luteinizing hormone leading to synchronized ovulation or luteinization of most large dominant follicles (≥ 10 mm; Garverick et al., 1980; Bao and Garverick, 1998; Sartori et al., 2001). Consequently, a new follicular wave is initiated in all cows within 2 to 3 days after GnRH administration. Luteal tissue that forms after GnRH administration is capable of undergoing PG-induced luteolysis 6 or 7 days later (Twagiramungu et al., 1995). The GnRH-PG protocol increased estrus synchronization rate in beef (Twagiramungu et al., 1992a,b) and dairy (Thatcher et al., 1993) cattle. A drawback of this method, however, is that approximately 5 to 20% of the cows are detected in estrus on or before the day of PG injection, thus reducing the proportion of females that are detected in estrus and inseminated during the synchronized period (Kojima et al., 2000; Stevenson et al., 2000; DeJarnette et al., 2001a, b). This information stimulated research in the Progestogen-GnRH-PG Phase.

**Synchronizing estrus and ovulation with the GnRH-PG-GnRH protocol.** Administration of PG alone is commonly utilized to synchronize an ovulatory estrus in estrous cycling cows. However, this method is ineffective in anestrous females and variation among animals in the stage of the follicular wave at the time of PG injection directly contributes to the variation in onset of estrus during the synchronized period (Macmillan and Henderson, 1984; Sirois and Fortune, 1988). Consequently, the GnRH-PG-GnRH protocol was developed to synchronize follicular waves and timing of ovulation. The GnRH-PG-GnRH protocol (Figure 1) for fixed-time AI results in development of a preovulatory follicle that ovulates in response to a second GnRH-induced LH surge 48 hours after PG injection (Ovsynch; Pursely et al., 1995). Ovsynch was validated as a reliable means of synchronizing ovulation for fixed-time AI in lactating dairy cows (Pursley et al., 1995; Burke et al., 1996; Pursley et al., 1997a, b; Schmitt et al., 1996). Time of ovulation with Ovsynch occurs between 24 to 32 hours after the second GnRH injection and is synchronized in 87 to 100% of lactating dairy cows (Pursley et al., 1997a). Pregnancy

rates among cows that were inseminated at a fixed time following Ovsynch ranged from 32 to 45% (Pursley et al., 1997b; 1998). The Ovsynch protocol, however, did not effectively synchronize estrus and ovulation in dairy heifers (35% pregnancy rate compared with 74% in PG controls; Pursley et al., 1997b).

Protocols for FTAI were then tested in postpartum beef cows. Pregnancy rates for Ovsynch treated beef cows were compared with those of cows synchronized and inseminated at a fixed time following treatment with Syncro-Mate-B (Geary et al., 1998a). Calves in both treatment groups were removed from their dams for a period of 48 hr beginning either at the time of implant removal (Syncro-Mate-B) or at the time PG was administered (Ovsynch). Pregnancy rates following FTAI after Ovsynch (54%) were higher than for Syncro-Mate-B (42%) treated cows. One should note that on the day following FTAI, cows were exposed to fertile bulls of the same breed; no attempt was made to determine progeny paternity. Additionally, we do not know the incidence of short cycles among cows that were anestrus prior to treatment and that perhaps returned to estrus prematurely and became pregnant to natural service.

Variations of the Ovsynch protocol (CO-Synch and Select Synch) were tested in postpartum beef cows (Figure 1). It is important to understand that treatment variations of Ovsynch currently being used in postpartum beef cows have not undergone the same validation process that Ovsynch underwent in lactating dairy cows. At this point we do not know whether response in postpartum beef cows to the protocols outlined in Figure 1 is the same or different from lactating dairy cows due to potential differences in follicular wave patterns. Differences in specific response variables may include: a) the relative length of time to ovulation from the second GnRH injection; b) the anticipated range in timing of ovulation; and c) the degree of ovulation synchrony that occurs. Two variations from Ovsynch used most extensively in postpartum beef cows are referred to as CO-Synch and Select Synch (Figure 1). CO-Synch (Geary et al., 1998b) is similar to Ovsynch in that timing and sequence of injections are the same and all cows are inseminated at a fixed time. CO-Synch differs from Ovsynch, however, in that cows are inseminated when the second GnRH injection is administered, compared to the recommended 16 hours after GnRH for Ovsynch treated cows. Select Synch (Geary et al., 2000) differs too, in that cows do not receive the second injection of GnRH and are not inseminated at a fixed time. Cows synchronized with this protocol are inseminated 12 hours after detected estrus. It is currently recommended for Select Synch treated cows that detection of estrus begin as early as 4 days after GnRH injection and continue through 6 days after PG (Kojima et al., 2000). Select Synch, similar to Ovsynch, was less effective than the melengestrol acetate (MGA)-PG protocol in synchronizing estrus in beef heifers (Stevenson et al., 1999).

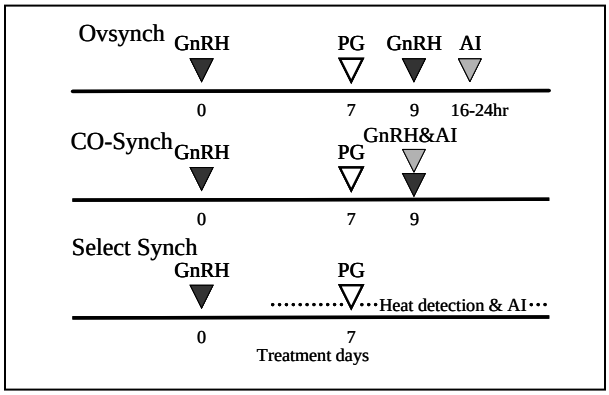


**Figure 1.** Methods currently being used to synchronize estrus and ovulation in postpartum beef cows using the GnRH-PG protocol: Ovsynch, CO-Synch and Select Synch.

## IMPORTANT CONSIDERATIONS RELATED TO CHOOSING A PROGESTIN-BASED PROTOCOL FOR BEEF HEIFERS OR COWS

Use of MGA as part of any estrus synchronization protocol in beef cows constitutes an extra-label use of medicated feed that is prohibited by the Animal Medicinal Drug Use and Clarification Act and regulation 21 CFR 530.11(b). The feeding of MGA is specifically approved for estrus suppression in heifers only (Federal Register, 1997). Removal of MGA from the ration allows heifers to return to estrus and be inseminated or bred in a synchronized time. Although 35 years of feeding MGA to beef cows and beef heifers has demonstrated MGA is safe, effective and economical (Zimbelman, 1963; Zimbelman and Smith, 1966; Zimbelman et al., 1970; Brown et al., 1988; Patterson et al., 1989; Patterson et al., 1995; Imwalle et al., 1998; Deutscher, 2000; Lamb et al., 2000; Patterson et al., 2000; Kojima et al., 2000; Patterson et al., 2002; Wood et al., 2001; Perry et al., 2002; Stegner et al., 2004a, b, c; Wood-Follis et al., 2004; Perry et al., 2004; Bader et al., 2005; Schafer et al., 2007; Sá Filho et al., 2009), the feeding of MGA to adult cows is not an FDA approved label claim and therefore is strictly prohibited by the FDA. It is unfortunate that the MGA label does not include all reproductively mature beef cattle, but it does not. The results reported in the proceedings from this conference, regarding use of the CIDR device in beef cows demonstrates that a viable alternative to MGA is available and approved for use by FDA/CVM. Producers that have used MGA to synchronize cows in the past should transition to CIDR to comply with FDA regulations concerning extra-label use of medicated feeds.

## DEVELOPMENT OF THE 7-DAY CIDR-PG PROTOCOL FOR POSTPARTUM BEEF COWS

Lucy et al., (2001; Table 1) summarized results from initial studies conducted in the U.S. involving controlled internal drug release (CIDR)-based protocols for use in synchronizing estrus in postpartum beef cows. These data were submitted to FDA in support of the original approval for the CIDR in beef heifers and cows. Three treatments were involved in the study and included: 1) untreated control; 2) PG only; and 3) 7-day CIDR-PG. The 7-day CIDR-PG treated cows had CIDRs inserted for 7 days with PG administered on day 6 of CIDR treatment. The 7-day CIDR-PG protocol yielded greater pregnancy rates compared with control or PG treated cows. Treatment with CIDR increased synchronization rates within the first 3 days following PG, resulting in enhanced pregnancy rates. The improved pregnancy rate in anestrous cows treated with the CIDR was noteworthy because anestrous cows in the control or PG treatments never attained pregnancy rates that were similar to those of the 7-day CIDR-PG treated group. The drawback of the protocol was that PG was administered on day 6 after CIDR insertion, which required an additional day of handling the cows.

**Table 1.** Synchronization, conception, and pregnancy rate for postpartum beef cows (modified from Lucy et al, 2001).

| Item | Synchronization rate | | Conception rate | | Pregnancy rate | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Anestrous | | | | | | |
| Control | 16/151 | 11 | 6/16 | 38 | 6/151 | 4 |
| PG | 30/154 | 19 | 17/30 | 57 | 17/154 | 11 |
| CIDR-PG | 64/142 | 45 | 36/63 | 57 | 36/141 | 26 |
| Cyclic | | | | | | |
| Control | 26/134 | 19 | 15/26 | 58 | 15/134 | 11 |
| PG | 63/129 | 49 | 44/63 | 70 | 44/129 | 34 |
| CIDR-PG | 102/141 | 72 | 64/101 | 63 | 64/140 | 46 |
| Total | | | | | | |
| Control | 42/285 | 15 | 21/42 | 50 | 21/285 | 7 |
| PG | 93/283 | 33 | 61/93 | 66 | 61/283 | 22 |
| CIDR-PG | 166/283 | 59 | 100/164 | 61 | 100/283 | 35 |

## DEVELOPMENT OF THE 7-DAY CO-SYNCH + CIDR PROTOCOL

**The multi-state CIDR trial.** Lamb et al. (2001) and Stevenson et al. (2003) reported that pregnancy rates resulting from AI increased from 48 to 59% with the addition of a CIDR device to the CO-Synch protocol; indicating that supplemental progesterone offered the potential to improve pregnancy rates that resulted after fixed-time AI. Larson et al. (2006; Figure 2) designed a study to determine whether a fixed-time AI protocol could yield pregnancy rates similar to a protocol that required detection of estrus, and whether inclusion of a CIDR to a GnRH-PG based protocol would increase pregnancy rates resulting from AI. The study was conducted with 14 herds in 7 states, and included five experimental treatments shown in Figure 2. Cows assigned to the CIDR-PG, Select Synch & TAI, and Select Synch + CIDR and TAI treatments were observed for signs of behavioral estrus for 3 days up to 72 hours after PG. Cows in each treatment that failed to exhibit estrus by this time were inseminated at 84 hours after PG. Pregnancy rates resulting from AI during the synchronized period are listed in Table 2.

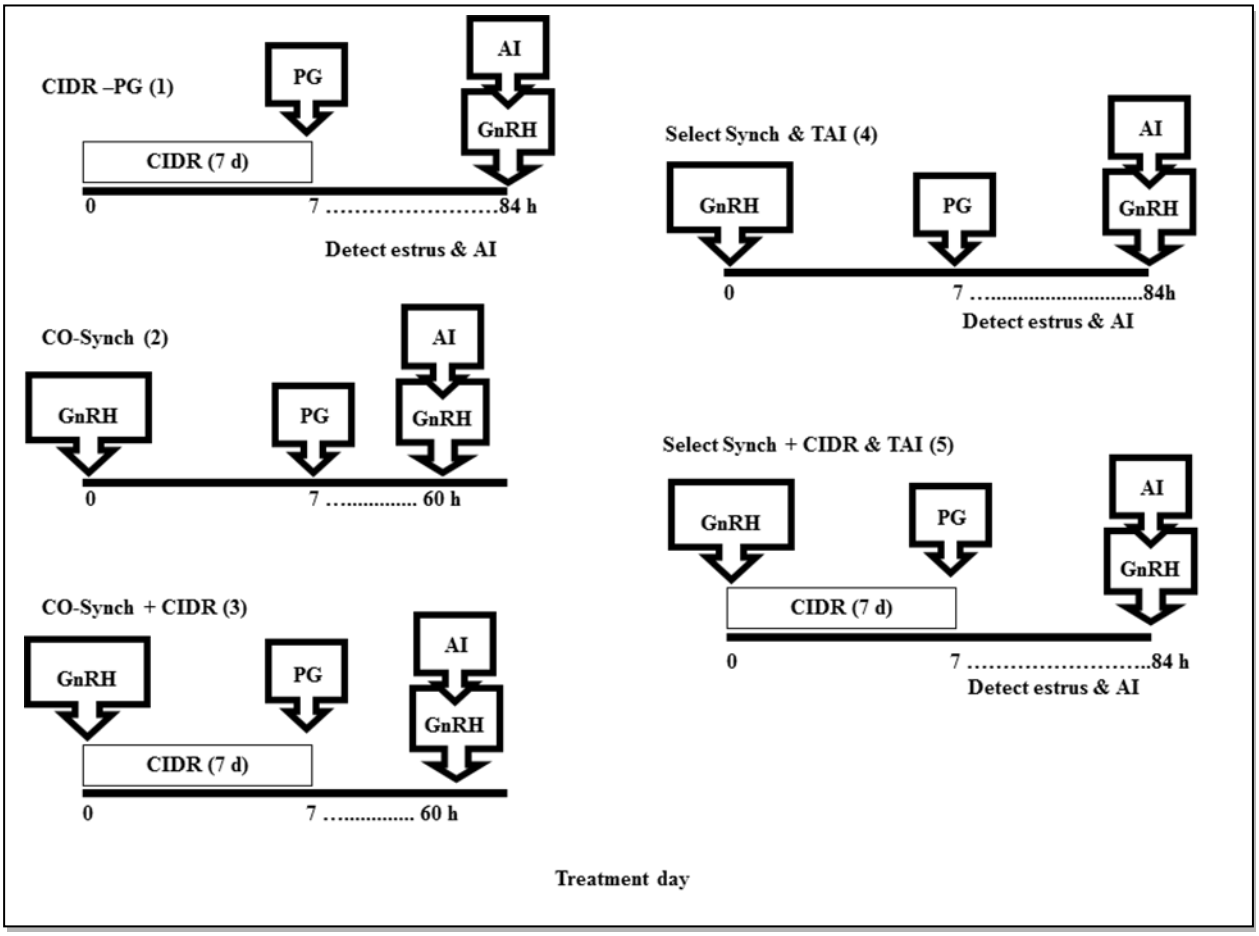


**Figure 2.** Treatment schedules for cows in the multi-state CIDR trial (Larson et al., 2006).

**Table 2.** Pregnancy rates following AI among beef cows in the multi-state CIDR trial. [1]

| | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | |
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| Total | 266/506[x] | 53 | 238/548[y] | 43 | 290/539[x] | 54 | 269/507[x] | 53 | 289/498[x] | 58 |

[1]Refer to Figure 2 for a description of the 5 treatment protocols.
[xy]Percentages without a common superscript letter differ, $P < 0.05$.
(Larson et al, 2006).

Results listed in Table 2 support previous studies that reported an improvement in fixed-time AI pregnancy rates in postpartum beef cows with the addition of a CIDR to the CO-Synch protocol. These differences may result from the potential added benefit of induced cyclicity among anestrous cows that occurred following CIDR removal. Addition of the CIDR to the CO-Synch protocol prevents premature expression of estrus that occurs between GnRH and PG among cows that do not receive a CIDR. In the absence of a CIDR, it is estimated that 5 to 20% of the total number of cows treated will exhibit estrus prior to and immediately after PG injection

(Kojima et al., 2000; Stevenson et al., 2000; DeJarnette et al., 2001a, b). Therefore, addition of the CIDR to the CO-Synch protocol prevents the premature expression of estrus prior to or following PG.

Larson et al. (2006) reported that pregnancy rates resulting from clean-up AI in the 3 treatments that involved estrous detection ranged from 26 to 39%, which resulted in a 9 to 11% increase in pregnancy rates. These results indicate that when using these protocols, a clean-up time AI is required to achieve pregnancy rates that are similar to those resulting from the CO-Synch + CIDR fixed-time AI protocol that requires no estrous detection. The authors concluded that the Select Synch + CIDR and TAI protocol consistently produced the highest pregnancy rates across the various locations; however the CO-Synch + CIDR protocol was effective in facilitating fixed-time AI without detecting estrus. The studies reported by Lamb et al. (2001) and Larson et al. (2006) indicate that pregnancy rates resulting from fixed-time AI may be expected to differ on the basis of parity, days postpartum, body condition and geographic location.

**Does timing of insemination affect pregnancy rates resulting from fixed-time AI following administration of the CO-Synch + CIDR protocol?** Several studies involving the CO-Synch + CIDR protocol evaluated the effect of timing of AI on subsequent pregnancy rates resulting from FTAI with insemination times varying from 48 to 72 h after PG (Bremer et al., 2004; Dobbins et al., 2006). Timing of insemination following the CO-Synch + CIDR protocol was based on recommendations from the pharmaceutical and AI industries (54 to 66 h) and other reports where the timing of AI included 48, 54, 56, 60, 64, 66, and 72 h post PG (Lamb et al., 2001; Bremer et al., 2004; Dobbins et al., 2006; Larson et al., 2006; Schafer et al., 2007). For this reason, Busch et al. (2008) compared FTAI pregnancy rates among lactating beef cows synchronized with the CO-Synch + CIDR protocol that were inseminated at 54 or 66 h after PG, and characterized the estrous response of cows in each treatment prior to FTAI (Figure 3). In this study, the interval from PG to FTAI (mean ± SD) was 54.2 ± 0.5h and 66.2 ± 0.4h for cows in the 54 and 66 h treatments, respectively. There was no effect of year, location, technician, sire, or pre-treatment cyclicity status (Table 3) before initiation of treatment on pregnancy rates resulting from FTAI. However, there was a significant effect of treatment (timing of insemination) on pregnancy rates resulting from FTAI among all cows (Table 4). Based on the odds ratio, cows inseminated at 66 h following PG administration were 1.32 times more likely to conceive to the FTAI than cows inseminated at 54 h following PG administration. Final pregnancy rate at the end of the 60 d breeding season did not differ between treatments (Table 4).

Busch et al. (2008) reported that estrous response following PG and prior to FTAI was greater among cows inseminated at 66 h (50%) than cows inseminated at 54 h (26%). However, there was no difference in estrous response within treatment between cyclic and anestrous cows and no overall difference between cyclic and anestrous cows. Mean interval from PG to estrus was shorter for FTAI at 54 h (mean ± SE, 46.7 ± 1.1 h) compared to FTAI at 66 h (53.8 ± 1.0 h); however, these differences occurred as a result of HeatWatch transmitters being removed at AI. Cows that exhibited estrus prior to FTAI had significantly higher pregnancy rates (76%) than cows that did not exhibit estrus before AI (56%; Table 5). Also, cows that exhibited estrus before FTAI at 66 h had a higher pregnancy rate (81%) than cows that exhibited estrus before FTAI at 54 h (65%).

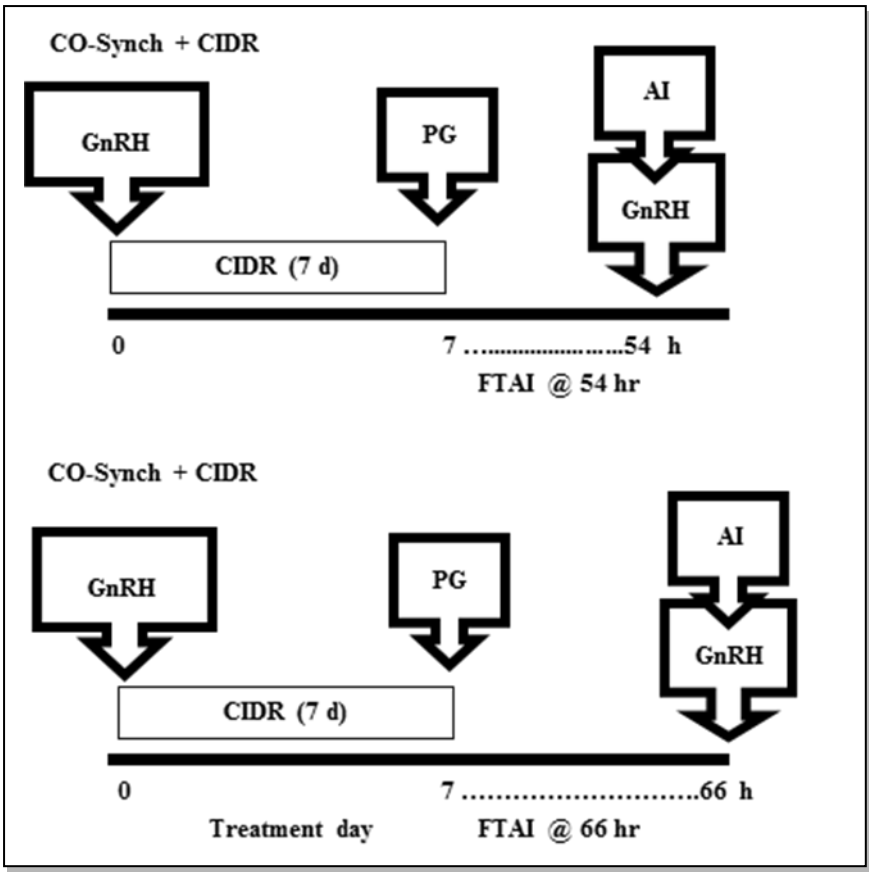


**Figure 3.** Treatment schedule for cows assigned to the CO-Synch + CIDR protocol with FTAI at 54 or 66 h. From Busch et al. (2008).

**Table 3.** Pregnancy rates after fixed-time artificial insemination based on estrous cyclicity before initiation of treatments.[1] From Busch et al. (2008).

| | | FTAI at 54 h | | | | FTAI at 66 h | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Location | Cyclic | | Anestrus | | Cyclic | | Anestrus | |
| | Location | Proportion | % | Proportion | % | Proportion | % | Proportion | % |
| Year 1 | 1 | 50/79 | 63 | 16/29 | 55 | 49/79 | 62 | 17/31 | 55 |
| | 2 | 52/88 | 59 | 7/15 | 47 | 67/93 | 72 | 5/10 | 50 |
| | Combined | 102/167 | 61 | 23/44 | 52 | 116/172 | 67 | 22/41 | 54 |
| Year 2 | 1 | 28/42 | 67 | 39/56 | 70 | 35/51 | 69 | 36/50 | 72 |
| | 2 | 48/82 | 58 | 17/33 | 52 | 64/90 | 71 | 13/22 | 59 |
| | Combined | 76/124 | 61 | 56/89 | 63 | 99/141 | 70 | 49/72 | 68 |
| | TOTAL | 178/291 | 61 | 79/133 | 59 | 215/313 | 69 | 71/113 | 63 |

[1]See Figure 3 for a description of the protocols.

The onset of estrus prior to FTAI in beef cows was shown to improve pregnancy rates when compared to cows that did not exhibit estrus (Perry et al., 2005). Busch et al. (2008) reported that cows that exhibited estrus following administration of the CO-Synch protocol had greater serum estradiol concentrations during the 2 days before insemination compared to cows that were induced to ovulate. Busch et al. (2008) concluded that cows that exhibited estrus may have attained concentrations of estradiol necessary to effectively prepare follicular cells for luteinization, and (or) induced an adequate number of uterine progesterone receptors (Zelinski et al., 1980); thus providing an adequate uterine environment for pregnancy establishment and maintenance. These data indicate that higher estrous response rates prior to FTAI in beef cows should result in greater pregnancy rates resulting from FTAI, provided that AI is performed within an acceptable time period following the peak estrous period. It is important to note that there was no difference within treatment in pregnancy rates resulting from FTAI between cows that were classified as cyclic or anestrus before treatment initiation. These results indicate that the CO-Synch + CIDR protocol effectively induces cyclicity in anestrous cows as measured by estrus, ovulation, and pregnancy outcome.

A key observation from the study by Busch et al. (2008) lies in the fact that pregnancy rates resulting from fixed-time AI at 66 h following administration of the CO-Synch + CIDR protocol were consistent across locations and years. These results too, as they relate to pregnancy rates following fixed-time AI, compare favorably with the study by Schafer et al. (2007) and from field trials in Missouri reported by Patterson et al. (2007). Interestingly, too, these results are consistently higher than those reported in the literature (Lamb et al., 2001; Bremer et al., 2004; Dobbins et al., 2006; Larson et al., 2006) when cows were inseminated at 48, 56, 60, 64 or 72 h following treatment administration, all of which point to the importance of timing of insemination and the associated impact on pregnancy outcome.

**Table 4.** Pregnancy rates of cows in response to fixed-time AI and at the end of the breeding season.[1] From Busch et al. (2008).

| Year | Location | Pregnancy rate to fixed-time AI[1] | | Pregnancy rate at end of breeding season[2] | |
|---|---|---|---|---|---|
| | | Proportion | % | Proportion | % |
| Year 1 | Location 1 | | | | |
| | FTAI at 54 h | 66/108 | 61 | 96/106 | 91 |
| | FTAI at 66 h | 66/110 | 60 | 99/110 | 90 |
| | Combined | 132/218 | 61 | 195/216 | 90 |
| | Location 2 | | | | |
| | FTAI at 54 h | 59/103 | 57 | 87/103 | 84 |
| | FTAI at 66 h | 72/103 | 70 | 100/102 | 98 |
| | Combined | 131/206 | 64 | 187/205 | 91 |
| | Combined | | | | |
| | FTAI at 54 h | 125/211 | 59 | 183/209 | 88 |
| | FTAI at 66 h | 138/213 | 65 | 199/212 | 94 |
| Year 2 | Location 1 | | | | |
| | FTAI at 54 h | 67/98 | 68 | 92/98 | 94 |
| | FTAI at 66 h | 71/101 | 70 | 85/100 | 85 |
| | Combined | 138/199 | 69 | 177/198 | 89 |
| | Location 2 | | | | |
| | FTAI at 54 h | 65/115 | 57 | 110/115 | 96 |
| | FTAI at 66 h | 77/112 | 69 | 105/112 | 94 |
| | Combined | 142/227 | 63 | 215/227 | 95 |
| | Combined | | | | |
| | FTAI at 54 h | 132/213 | 62 | 202/213 | 95 |
| | FTAI at 66 h | 148/213 | 69 | 190/212 | 90 |
| TOTAL | FTAI at 54 h | 257/424 | 61[x] | 385/422 | 91 |
| TOTAL | FTAI at 66 h | 286/426 | 67[y] | 389/424 | 92 |

[1]See Figure 3 for a description of the protocols.
[2] Pregnancy rate to fixed-time AI determined by ultrasound 56 to 78 d after AI.
[3] Pregnancy rate at the end of the breeding season determined 60 to 110 d after the end of a 60 d breeding season.
[x,y]Means within a column with different superscripts are different, $P = 0.05$.

**Table 5.** Pregnancy rate based on estrous response (Location 2; Busch et al., 2008).

| | 54 h | | 66 h | | Combined | |
|---|---|---|---|---|---|---|
| Estrous response | Proportion | % | Proportion | % | Proportion | % |
| Exhibited estrus | 37/57 | 65%[x] | 86/106 | 81%[a,y] | 123/163 | 76%[a] |
| DID NOT exhibit estrus | 87/161 | 54% | 63/109 | 58%[b] | 150/270 | 56%[b] |

[1]See Figure 3 for a description of the protocols.
[a,b] Percentage within a column with different superscripts are different, $P < 0.01$.
[x,y] Percentage within a row with different superscripts are different, $P = 0.03$.

## DEVELOPMENT OF THE 5-DAY CO-SYNCH + CIDR PROTOCOL

Labor required to detect estrus has limited use of AI in U.S. beef herds (NAHMS, 1998). Consequently, estrus synchronization protocols must not only be effective, but practical and economical to implement. Recently, estrus synchronization protocols were developed that eliminate the need to detect estrus, allowing AI to be performed at predetermined fixed times without reducing AI pregnancy rates (Geary et al., 1998a; Perry et al., 2002; Stegner et al., 2004b; Bader et al., 2005; Larson et al., 2006; Schafer et al., 2007; Busch et al., 2008; Bridges et al, 2008).

The CO-Synch protocol uses GnRH and PG to synchronize estrus and ovulation prior to FTAI (Geary et al., 1998a; Perry et al., 2002; Lamb et al., 2001; Larson et al., 2006). The 7-d interval between GnRH and PG administration provides the necessary time for a new follicular wave to be recruited, along with selection and maturation of the dominant follicle to a point where successful ovulation of a healthy oocyte may be achieved (Thatcher et al., 1989; Pursley et al., 1995). The 7-day interval also allows time for accessory CL to become responsive to the luteolytic action of a single PG injection.

The CO-Synch protocol was shown to have marginal success in synchronizing estrus before FTAI due to 5 to 15% of estrous cycling cows expressing estrus prior to the time PG was administered (Twagiramungu et al., 1995; Kojima et al., 2000). Addition of the CIDR to the CO-Synch protocol prevents cows from exhibiting estrus prior to the time PG is administered and resulted in enhanced fertility among anestrous cows (Lamb et al., 2001; Larson et al., 2006). Pregnancy rates resulting from FTAI were improved when progestins were used to presynchronize estrus (Perry et al., 2002; Stegner et al., 2004b; Bader et al., 2005; Schafer et al., 2007) prior to the administration of GnRH and PG or were included as part of the CO-Synch protocol (Lamb et al., 2001; Larson et al., 2006; Schafer et al., 2007; Busch et al., 2008).

Bridges et al. (2008) hypothesized that a modification to the 7-day CO-Synch + CIDR protocol would conceptually increase secretion of estradiol by the ovulatory follicle and decrease the incidence of induced ovulation of follicles with reduced estrogenic activity. Bridges et al. (2008)

proposed that shortening the duration of CIDR treatment with a 5-day protocol would result in improvements in FTAI pregnancy rates. This hypothesis was based on the premise that day 4 dominant follicles have higher intrafollicular concentrations of estradiol-17β ($E_2$) and a greater ability to produce $E_2$ compared to older age follicles (Valdez et al., 2005). Bridges et al. (2009) reported that maximum preovulatory concentrations of estradiol tended to be greater in 5-day compared to 7-day CIDR-treated cows that failed to respond to GnRH at CIDR insertion, and that postovulatory circulating concentrations of progesterone were greater among 5-day compared to the 7-day treated cows. Increased follicular concentrations of $E_2$ and elevated postovulatory concentrations of progesterone are believed to reflect greater physiological maturity of the dominant follicle and to result in higher AI pregnancy rates (Lopez et al., 2005; Perry et. al., 2005). Therefore, Bridges et al. (2008) proposed that if CIDR removal and AI are more accurately timed with the 5-day protocol to coincide with follicular development, higher AI pregnancy rates may be achieved.

Bridges et al. (2008) compared the 5-day CO-Synch + CIDR protocol with fixed-time AI 72 hours after CIDR removal and PG with a 7-day CO-Synch + CIDR protocol with fixed-time AI performed 60 hours after CIDR removal and PG (Figure 4). Cows in both treatment groups were administered a second injection of PG 12 hours after CIDR removal and the first PG injection.

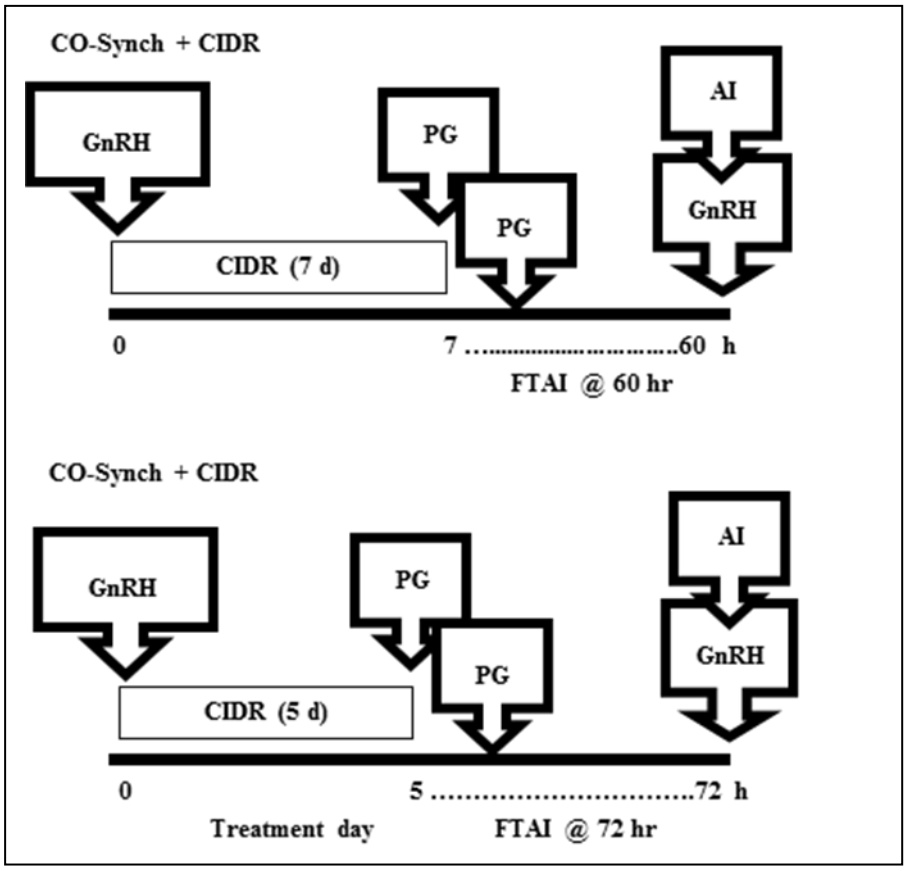


**Figure 4.** Cows in the 7-day CO-Synch + CIDR group received GnRH and CIDR inserts on day 0, PG at CIDR removal and again 12 hr later. FTAI was performed at 60 hr after CIDR removal for cows assigned to the 7-day treatment. Cows in the 5-day CO-Synch + CIDR group received GnRH and a CIDR insert on day 0, PG at CIDR removal and again 12 hr later. FTAI was performed at 60 hr after CIDR removal for cows assigned to the 7-day treatment. From Bridges et al. (2008).

**Table 6.** Pregnancy rates of cows after fixed-time AI in the study by Bridges et al. (2008)[1].

| | Experiment 1 | | Experiment 2 | | Combined | |
|---|---|---|---|---|---|---|
| | 5-day | 7-day | 5-day | 7-day | 5-day | 7-day |
| No. cows | 105 | 111 | 199 | 201 | 304 | 312 |
| FTAI pregnancy rate | 80%[x] | 67%[y] | 65%[x] | 56%[y] | 70%[x] | 60%[y] |

[1]See Figure 4 for a description of the protocols.
[x,y] Percentages within a row with different superscripts are different, $P < 0.05$.

Pregnancy rates resulting from FTAI for cows assigned to each of the two treatments (Figure 4) are listed in Table 6, and were higher among cows assigned to the 5-day protocol. It is important to point out that cows in both treatments were administered two injections of PG, one at CIDR removal and again 12 hours later. Two injections of PG are required with the 5-day protocol to effectively regress accessory corpora lutea that form as a result of GnRH-induced ovulations at the initiation of treatment (Bridges et al., 2008; Kasimanickam et al., 2008). Kasimanickam et al. (2008) reported that the increase in pregnancy rate associated with a second PG treatment was approximately 15% higher compared with pregnancy rates of cows that received only a single PG injection following administration of the 5-day CO-Synch + CIDR protocol. It is important to point out however, that two injections of PG following CIDR removal are not required for cows assigned to a 7-day protocol. Additionally, cows assigned to the 5-day protocol were inseminated 72 hours after the first injection of PG, whereas cows assigned to the 7-day protocol were inseminated 60 hours after the first PG injection. Bridges et al. (2008) concluded that reducing the interval from GnRH and CIDR insertion from 7 to 5 days, administering two injections of PG at CIDR removal and again 12 hours later, and extending the interval from CIDR removal to FTAI to 72 hours was an effective estrus synchronization protocol for use in facilitating FTAI in postpartum beef cows.

Bridges et al. (2012) reported results from an experiment to determine whether two injections of PG administered at CIDR removal would be an effective alternative to administering two injections at separate time intervals (8 hours apart) for cows assigned to a 5-day CO-Synch + CIDR protocol. Cows in 13 herds and 8 states were involved in the study which compared pregnancy rates among cows assigned to one of three treatment groups: one 25 mg injection of PG administered at CIDR removal and a second 25 mg injection of PG administered 8 hours later; two 25 mg injections of PG administered into two injection sites coincident with CIDR removal; and a single 25 mg injection of PG administered at CIDR removal. Pregnancy rates resulting from FTAI were highest (55%) for cows administered one 25 mg injection of PG at CIDR removal and a second 25 mg injection of PG administered 8 hours later. Pregnancy rates for cows that received two 25 mg injections of PG administered into two injection sites coincident with CIDR removal were intermediate (51%) and not different from the two other treatment groups (single injection, 48%). Based on these data the recommendation for use of this protocol to facilitate fixed-time AI in beef cows is to administer two doses of PG 8 h apart, the first coincident with the time of CIDR removal and the second 8 h later.

## COMPARISON OF THE 7-DAY AND 5-DAY CO-SYNCH + CIDR PROTOCOLS IN FACILITATING FIXED-TIME AI IN POSTPARTUM BEEF COWS

Wilson et al. (2010) conducted two experiments to: 1) Characterize and compare the 7-day and 5-day Select Synch + CIDR protocols on the basis of follicular dynamics and timing and synchrony of estrus following treatment administration (Figure 5); and 2) Compare pregnancy rates resulting from FTAI following administration of the 7-day and 5-day CO-Synch + CIDR protocols with insemination performed 66 and 72 h following treatment, respectively (Figure 7).

In the *first experiment*, Wilson et al. (2010) reported that response to GnRH, dominant follicle size at GnRH, interval to estrus, variance for interval to estrus, or estrous response did not differ between the 5-day and 7-day Select Synch + CIDR treatments (Table 7). Figure 6 illustrates the distribution of estrus for the two treatments. There was, however, an effect of pre-treatment estrous cyclicity status on estrous response, with 75/82 (92%) of the estrous cycling cows exhibiting estrus and 21/35 (60%) of the anestrous cows exhibiting estrus during the synchronized period. There was no effect of technician or treatment on synchronized conception or pregnancy rates resulting from AI, respectively (Table 8). Pregnancy rates resulting from AI were affected by estrous cyclicity status of cows prior to treatment initiation, with 57/82 (69.5%) of the estrous cycling cows and 12/35 (34.2%) of the anestrous cows conceiving to AI.

**Table 7.** Estrous response, interval to estrus, response to GnRH, and mean follicle size at GnRH.

| Treatment[1] | Estrous[2] response Proportion (%) | | Interval[3] to estrus (h) | Variance for interval to estrus | Response[4] to GnRH Proportion (%) | Dominant follicle size at GnRH (mm) |
|---|---|---|---|---|---|---|
| 5-day Select Synch + CIDR | 46/58 | 79 | 71.2 ± 2.6 | 316 | 41/58<br>71 | 11.9 ± 0.4 |
| 7-day Select Synch + CIDR | 50/59 | 85 | 64.8 ± 2.6 | 348 | 42/59<br>71 | 11.9 ± 0.4 |

[1] See Figure 5 for a description of the treatment protocols. From Wilson et al. (2010).
[2]Estrous response = number of cows that exhibited estrus during the synchronized period (0 to 144 h after PG administration).
[3]Interval to estrus = number of hours from administration of PG to onset of estrus (mean ± SE).
[4]Cows were considered to have responded to GnRH if the dominant follicle observed by ultrasonography on day 0 or 1 was no longer visible on day 2 or 3 for the respective treatments (mean ± SE).

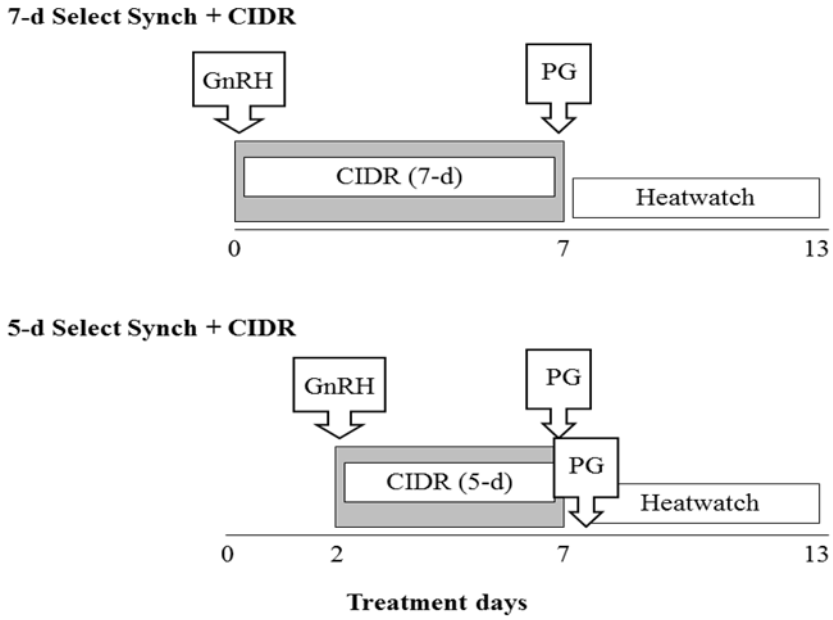


**Figure 5.** Cows in the 7-day Select-Synch + CIDR treatment received GnRH and CIDR inserts on day 0. Prostaglandin $F_{2\alpha}$ was administered and CIDR inserts were removed on day 7. Estrus detection and AI were performed within a 144 h synchronized period after PG was administered. Cows in the 5-day Select-Synch + CIDR treatment received GnRH and a CIDR insert on day 0. Prostaglandin $F_{2\alpha}$ was administered and CIDR inserts were removed on day 5. A second injection of PG was administered 12 h after the first PG injection. Estrus detection and AI were performed within a 144 h synchronized period after PG. From Wilson et al. (2010).

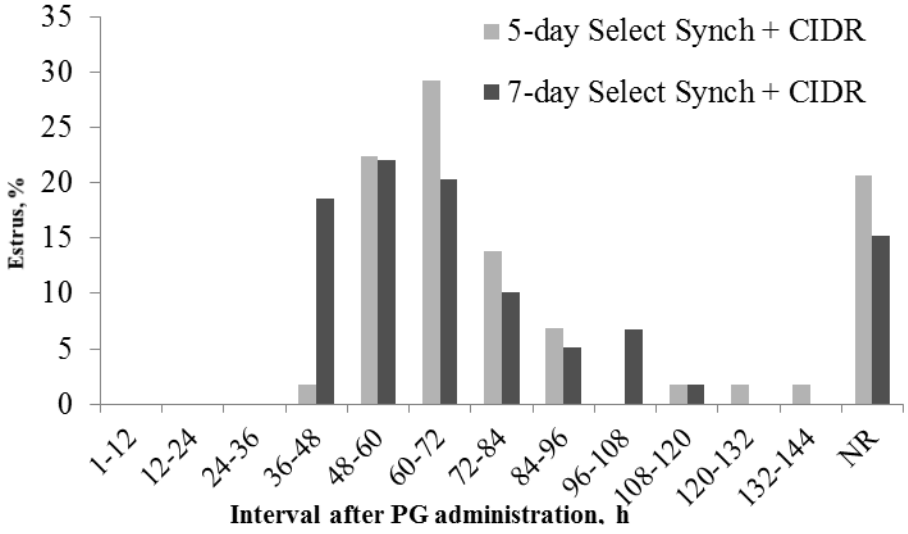


**Figure 6.** Percentage of cows in the 5-day and 7-day Select Synch + CIDR treatments that exhibited estrus after PG: 5-day Select Synch + CIDR (gray bar) and 7-day Select Synch + CIDR (black bar). NR = no estrous response. See Figure 5 for a description of the treatment protocols. From Wilson et al. (2010).

**Table 8.** Synchronized AI conception rates, synchronized AI pregnancy rates, and final pregnancy rates.

| Treatment[1] | Synchronized AI conception rate[2] Proportion | (%) | Synchronized AI pregnancy rate[3] Proportion | (%) | Final pregnancy rate[4] Proportion | (%) |
|---|---|---|---|---|---|---|
| 5-day Select Synch + CIDR | 33/46 | 72 | 33/58 | 57 | 52/58 | 90 |
| 7-day Select Synch + CIDR | 36/50 | 72 | 36/59 | 61 | 51/59 | 86 |

[1] See Figure 5 for a description of the treatment protocols. From Wilson et al. (2010).
[2]Synchronized AI conception rate = number of cows that conceived of those exhibiting estrus and inseminated during the synchronized period (0 to 144 h after PG administration).
[3]Synchronized pregnancy rate = number of cows that conceived of the total number treated during the synchronized period (0 to 144 h after PG administration).
[4]Final pregnancy rate = number of cows that conceived by the end of the 60 day breeding season.

Wilson et al. (2010) designed a *second experiment* (Figure 7) to compare pregnancy rates resulting from FTAI following administration of the 7-d and 5-d CO-Synch + CIDR protocols with insemination performed 66 and 72 h following treatment, respectively. There were no differences in pregnancy rates resulting from fixed-time AI between the 7-d and 5-d treatment groups, with 67% of the cows in each treatment conceiving to FTAI (Table 9). The interval from PG to FTAI was 66.4 ± 1.2 h and 72.6 ± 0.6h for the 7-day and 5-day treatment groups, respectively. Estrous cyclicity status prior to treatment initiation had no effect on pregnancy rates resulting from FTAI for cows assigned to the two treatments (Table 10).

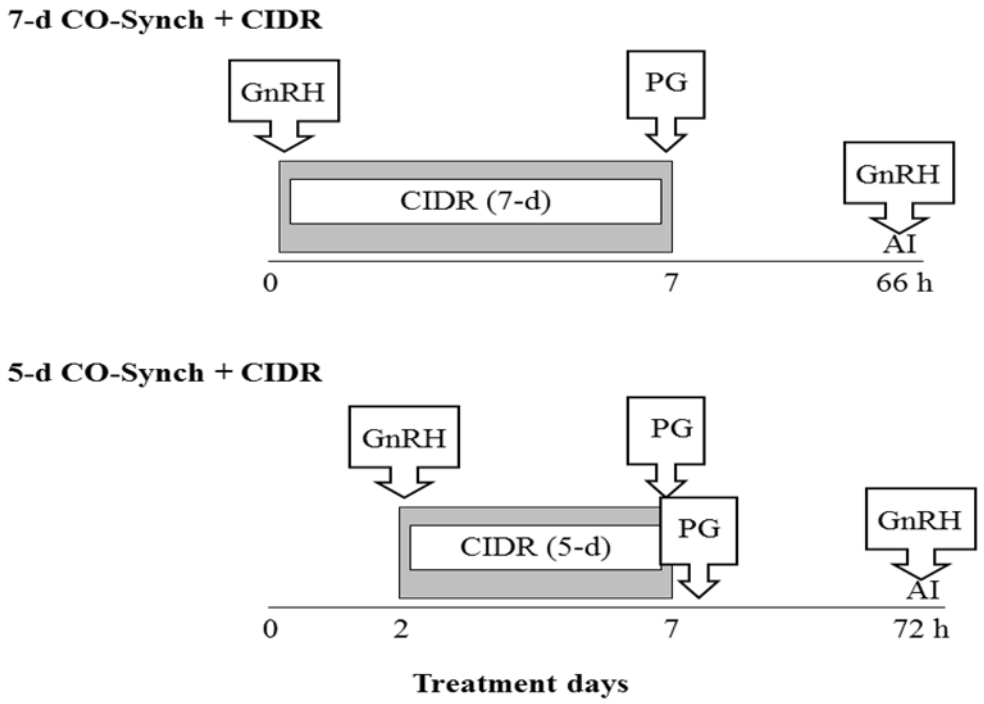


**Figure 7.** Cows in the 7-day CO-Synch + CIDR treatment received GnRH and CIDR inserts on day 0. Prostaglandin $F_{2\alpha}$ was administered and CIDR inserts were removed on day 7. All 7-day treated cows were fixed-time inseminated 66 h following treatment with GnRH administered at AI. Cows in the 5-day CO-Synch + CIDR treatment received GnRH and a CIDR insert on day 0. Prostaglandin $F_{2\alpha}$ was administered and CIDR inserts were removed on day 5. A second injection of PG was administered 12 h after the first PG injection. All 5-day treated cows were fixed-time inseminated 72 h following treatment with GnRH administered at AI. From Wilson et al. (2010).

**Table 9.** Pregnancy rates after fixed-time AI and at the end of the breeding season.

| | Pregnancy rate to fixed-time AI | | Pregnancy rate at the end of the breeding season | |
|---|---|---|---|---|
| Location and treatment[1] | Proportion | % | Proportion | % |
| Location 1 | | | | |
| 5d | 36/60 | 60 | 57/60 | 95 |
| 7d | 38/58 | 66 | 57/58 | 98 |
| Location 2 | | | | |
| 5d | 72/100 | 72 | 99/100 | 99 |
| 7d | 73/102 | 72 | 97/102 | 95 |
| Location 3 | | | | |
| 5d | 32/50 | 64 | 45/50 | 90 |
| 7d | 29/49 | 59 | 46/49 | 94 |
| Overall | | | | |
| 5d | 140/210 | 67 | 201/210 | 96 |
| 7d | 140/209 | 67 | 200/209 | 96 |

[1] See Figure 7 for a description of the treatment protocols. From Wilson et al. (2010).

**Table 10.** Pregnancy rates after fixed-time AI based on estrous cyclicity before initiation of treatments.

| | 5-d CO-Synch + CIDR[1] | | | | 7-d CO-Synch + CIDR[1] | | | |
|---|---|---|---|---|---|---|---|---|
| | Estrous cycling | | Anestrus | | Estrous cycling | | Anestrus | |
| Location | Proportion | % | Proportion | % | Proportion | % | Proportion | % |
| 1 | 34/55 | 62 | 2/5 | 40 | 35/53 | 66 | 3/5 | 60 |
| 2 | 31/38 | 82 | 41/62 | 66 | 27/41 | 66 | 46/61 | 75 |
| 3 | 20/29 | 69 | 12/21 | 57 | 20/34 | 59 | 9/15 | 60 |
| Combined | 85/122 | 70 | 55/88 | 63 | 82/128 | 64 | 58/81 | 72 |

[1] See Figure 7 for a description of the treatment protocols. From Wilson et al. (2010).

The 5-day and 7-day CO-Synch + CIDR protocols are similar except for differences in the interval from GnRH to PG administration and the length of CIDR treatment (5 versus 7 days, respectively), and that two injections of PG are required with the 5-day protocol. Additionally, FTAI in Wilson's study was performed at 72 h from the first injection of PG for the 5-day treated cows versus 66 h for the 7-day treated cows. Two injections of PG are required with the 5-day protocol to effectively regress accessory corpora lutea that form as a result of GnRH-induced ovulations at the initiation of treatment (Bridges et al., 2008; Kasimanickam et al., 2008). Kasimanickam et al. (2008) demonstrated that cows assigned to the 5-day protocol that received only one injection of PG had significantly lower pregnancy rates resulting from FTAI compared to cows assigned to the 5-day protocol that received two injections of PG 12 h apart. As previously discussed, Bridges et al. (2008) hypothesized that shortening the duration of CIDR treatment from 7- to 5-day would better time CIDR removal coincident with optimal follicular development, and that lengthening the period of proestrus (the time between PG and AI) would result in higher pregnancy rates following FTAI.

Bridges et al. (2008) reported that pregnancy rates following FTAI were higher for cows assigned to the 5-day protocol compared to cows that were assigned to a 7-day protocol. However, the results reported by Wilson et al. (2010) indicate that there were no differences in pregnancy rates resulting from FTAI between 5-day and 7-day treated cows. It is important to contrast these results with those reported by Bridges et al. (2008) for cows assigned to the 7-day protocol. Cows assigned to the 7-day protocol in Wilson's experiment received a single injection of PG and were inseminated 66 h after PG; whereas, 7-day treated cows in Bridges' study received two injections of PG with AI performed 60 h after the first PG injection.

A possible explanation for differences in results between the second experiment reported by Wilson et al. (2010) compared to results reported by Bridges et al. (2008) may be related to the differences in timing of AI for the 7-day treated cows in each study. In comparing results from Experiments 1 and 2 in the studies reported by Wilson et al. (2010) it is important to point out that timing of insemination for the respective protocols in *Experiment 2* paralleled the timing of peak estrus from *Experiment 1*. For cows assigned to the 5-day protocol (Wilson et al., 2010), the mean time of AI (72.6 h) in Experiment 2, paralleled the mean interval to estrus (71.2 h) from Experiment 1. Likewise for the 7-day treated cows (Wilson et al., 2010), the mean time of AI (66.5 h) in Experiment 2 paralleled the mean interval to estrus (64.8 h) reported in Experiment 1. Arguably, lengthening the proestrus period to 66 h for cows assigned to the 7-day

protocol may explain the similarity in FTAI pregnancy rates between treatment groups, versus those previously reported by Bridges et al. (2008), in which cows were inseminated at 60 h.

These data (Wilson et al., 2010) suggest that pregnancy rates resulting from FTAI are perhaps more a function of properly timed AI in relation to proestrus, rather than timing CIDR removal and follicular development. Timing of AI is important relative to pregnancy outcome following FTAI. Busch et al. (2008) confirmed that FTAI pregnancy rates were higher when AI was performed at 66 h versus 54 h after administration of the 7-day CO-Synch + CIDR protocol. The 66 h interval would appear to be the near optimal timing of AI based on the results from Wilson et al. (2010); however, no direct comparison of pregnancy rates resulting from AI performed at 60 h versus 66 h has been made. In addition, AI is recommended to be performed 72 h following administration of the 5-day protocol (Bridges et al., 2008), which also coincides with what would be considered to be near the optimal timing of AI from the results reported by Wilson et al. (2010). As previously stated, when pregnancy rates following FTAI for the 5-day and 7-day CO-Synch + CIDR protocols were compared, no differences were found between treatments when cows were inseminated at 72 and 66 h, respectively. These data seem to confirm the premise that length of the proestrus period is an important consideration relative to pregnancy outcome following administration of both the 5-day and 7-day protocols.

Finally, Wilson et al. (2010) and Whittier et al. (2013) compared the 5- and 7-day CO-Synch + CIDR protocols on the basis of pregnancy outcome and practical application in the field. The results from these studies demonstrate that the two treatments performed comparably on the basis of pregnancy rates resulting from FTAI, although the study reported by Whittier et al. showed a 3% improvement in pregnancy rate resulting from FTAI among cows assigned to the 5-d protocol. Given this observation, the 5-day protocol provides an effective alternative to the 7-day protocol for use in facilitating FTAI, however beef producers must consider the increased labor and treatment costs associated with the 5-day CO-Synch + CIDR protocol.

## DEVELOPMENT OF THE PG 6-DAY CIDR PROTOCOL

Perry et al. (2012) designed an experiment (Figure 8) to determine whether controlling follicular development to optimize follicle size and estradiol exposure would be effective in maximizing pregnancy success. The objectives of the studies (Perry et al., 2012) were to determine: 1) if inducing luteal regression 3 days prior to an injection of GnRH improved control of follicular turnover, and 2) if inducing luteal regression 3 days before a modified CIDR protocol improved pregnancy success compared to the 5-day CIDR protocol. Results reported from the study (Perry et al., 2012) indicate that induction of luteal regression 3 days before initiation of a modified CIDR protocol increased pregnancy rates compared to the 5-day CIDR protocol. Additionally, induction of luteal regression 3 days prior to the injection of GnRH at the initiation of the PG-CIDR protocol resulted in increased incidence of ovulation following the injection of GnRH. These authors (Perry et al., 2012) suggest that better control of follicular development at the initiation of the CIDR protocol may result in greater pregnancy success. Pregnancy rates resulting from fixed-time AI for the PG 6-day CIDR treated group were higher (160/248, 65%) than the 5-day CO-Synch + CIDR treated group (136/249, 55%). Both protocols require that cows be handled 4 times to effectively administer the complete treatment schedule.

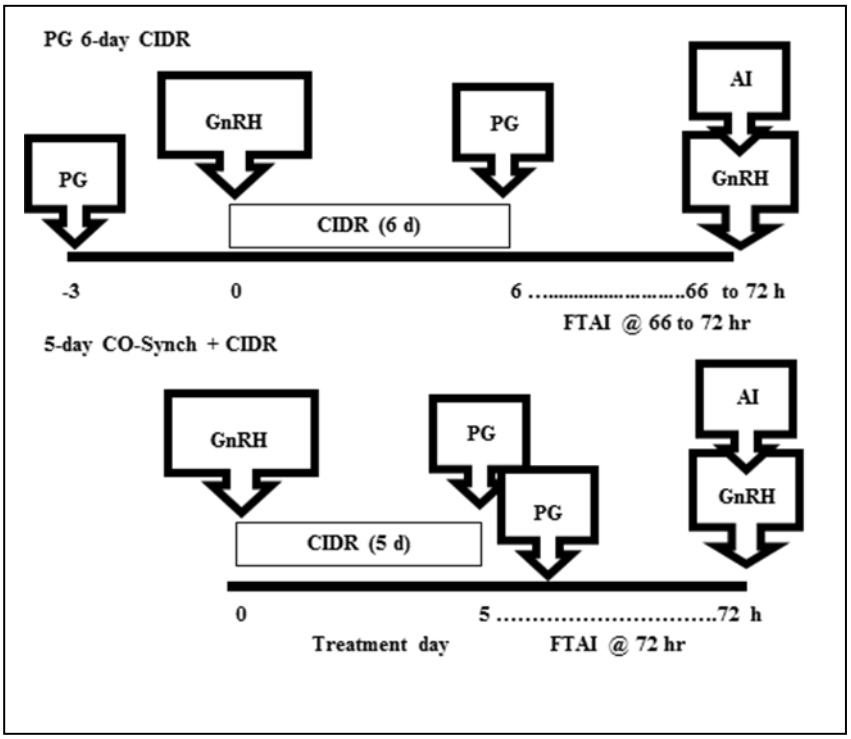


**Figure 8.** Comparison of the PG 6-day CIDR protocol with the 5-day CO-Synch + CIDR protocol (Perry et al., 2012).

## EVALUATING THE 14-DAY CIDR-PG PROTOCOL IN POSTPARTUM BEEF COWS

Long-term progestin (14-d) administration has been used effectively to synchronize estrus and ovulation in beef heifers and cows (Schafer et al., 2007; Leitman et al., 2009; Mallory et al., 2011; Nash et al., 2012; Nash et al., 2013). Long-term CIDR administration for 14-d suppresses estrus, inhibits ovulation, induces the development of a persistent dominant follicle that can ovulate after CIDR removal, and induces estrous cyclicity in pre- or peripubertal beef heifers and anestrous postpartum beef cows (Ahmad et al., 1995; Revah and Butler, 1996; Roche et al., 1999; Perry et al., 2004; Leitman et al., 2008). Ovulation of a dominant follicle after CIDR removal creates a synchronized estrous cycle that pre-synchronizes cows prior to FTAI (Nash et al., 2013). In these cases, PG was administered 16 d after CIDR removal with GnRH administered at FTAI. The 14-d CIDR-PG protocol was developed as an alternative to the 14-d melengestrol acetate (MGA)-PG protocol for use in beef heifers (Brown et al., 1988). Deutscher et al. (2000) and Lamb et al. (2000) reported that extending the interval by 2 d from MGA withdrawal to PG improved total estrous response, synchrony of estrus after PG, and resulting pregnancy rates after the synchronized estrous period. Speculation regarding these improvements may pertain to differences in preovulatory follicle size at the time of PG-induced luteolysis, which perhaps stems from differences in follicular dynamics in relation to stage of a follicular wave at the time PG is administered. Nash et al. (2012) reported that pregnancy rates resulting from FTAI were similar for cows assigned to a 14-day CIDR-PG protocol compared to the 7-day CO-Synch + CIDR protocol, however estrous response after PG and prior to FTAI was reduced in cows assigned to the long-term (23%; 14-d CIDR-PG) compared to the short-term protocol (49%; 7-d CO-Synch + CIDR; Nash et al., 2012).

Martin et al. (2014) conducted an experiment (Figure 9) to determine whether extending the interval from CIDR removal to PG among cows assigned to a 14-d CIDR-PG protocol would increase estrous response after PG and potentiate improvements in pregnancy rates after FTAI. The results from this study (Martin et al., 2014) provide evidence that a 14-19 d CIDR-PG schedule may be a more appropriate schedule for mature aged cows ≥ 4 yr versus younger aged females (2- and 3-year-olds). Results from this study support the proposed hypothesis that extending the interval from CIDR removal to PG would increase estrous response after PG and potentiate improvements in pregnancy rates after FTAI.

Beef producers may be reluctant to use long-term CIDR-based protocols in cows, as these protocols are more challenging to implement in herds with extended calving periods. Furthermore, long-term CIDR-based protocols require that cows are handled one extra time compared to short-term schedules (7-d CO-Synch + CIDR). Long-term protocols provide a unique opportunity however, to combine animal health and reproduction in a single management step, by administering pre-breeding vaccinations at the time of CIDR insertion. The results reported by Martin et al. (2014) agree with previous studies (Nash et al., 2012; Nash et al., 2013) indicating that long-term CIDR-based protocols provide an alternative method of synchronizing estrus prior to FTAI in postpartum beef cows, while at the same time provide labor-reducing management options pertaining to animal health-related considerations.

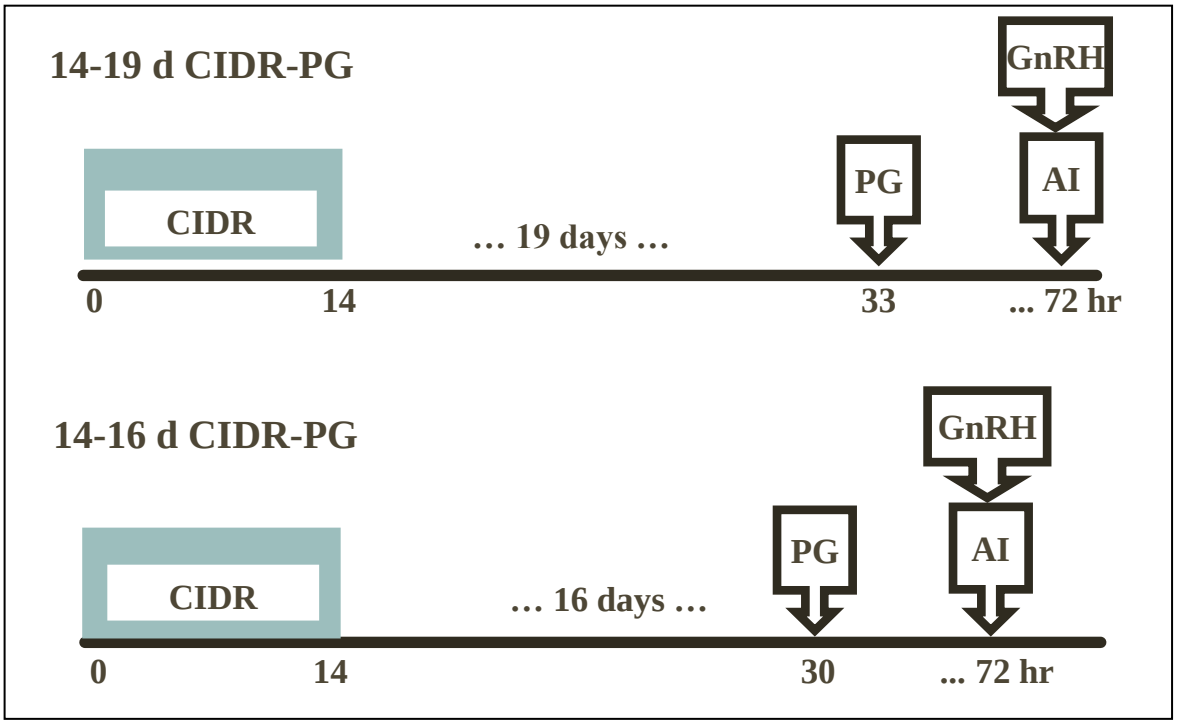


**Figure 9.** Comparison of a 16- versus a 19-day interval between controlled internal drug release removal and prostaglandin $F_{2\alpha}$ following a 14-day controlled internal drug release treatment and fixed-time artificial insemination in postpartum beef cows (Martin et al., 2014).

## SPLIT-TIME AI: DELAYED INSEMINATION OF NON-ESTROUS BEEF COWS IN FTAI

The elimination of estrus detection from FTAI protocols greatly decreases the labor and inconvenience of carrying out an AI program. Increasing numbers of beef cows are being inseminated by appointment as a result of fixed-time AI. However, previous studies report varying pregnancy rates to FTAI based on estrus expression prior to FTAI, with females that expressed estrus performing significantly better than females that failed to express estrus prior to FTAI (Perry et al., 2005; Busch et al., 2007; Busch et al., 2008; Wilson et al., 2010; Mallory et al., 2011).

This is particularly problematic when using sex-sorted semen, as conception to sex-sorted semen is currently maximized when cows are inseminated following an observed estrus (Seidel, 2007). Appointment breeding without estrus detection is currently not recommended with sex-sorted semen (Seidel, 2011). Sex-sorted semen presents unique challenges for use in FTAI both in terms of sperm cell quantity and quality. Fewer sperm cells are placed in an AI dose of sex-sorted semen (typically 2 x $10^6$ cells per dose as compared to 20 x $10^6$ cells per dose in conventional semen), and lower sperm cell number per dose has been demonstrated to negatively impact fertility (Den Daas et al., 1998; DeJarnette et al., 2008). Sex-sorted semen is also characterized by decreased sperm quality. Hollinshead et al. (2003) found that the sex-sorting process induces a higher proportion of capacitated sperm cells, and this and other stresses of the cell sorting process may limit the fertile lifespan of sperm cells which have been sex-sorted. Therefore, insemination closer to the time of ovulation is generally advantageous.

Thomas et al. (2014) found that delaying insemination of non-estrous cows until 20 h after GnRH administration, a strategy termed "split-time AI," improved pregnancy rates when using sex-sorted semen in conjunction with timed AI. Estrus was synchronized for 656 suckled beef cows with the 7-day CO-Synch + CIDR protocol (Figure 10; 100 μg GnRH + CIDR [1.38 gm progesterone] on d 0; 25 mg $PGF_{2\alpha}$ at CIDR removal on d 7; and 100 μg GnRH on d 10, 66 h after CIDR removal). Estrus detection aids (Estrotect) were applied at $PGF_{2\alpha}$ and CIDR removal on d 7, and estrous expression was recorded at GnRH on d 10. Cows were assigned to one of three treatments: (1) FTAI (concurrent with GnRH, 66 h after CIDR removal) with conventional semen regardless of estrous expression; (2) FTAI with sex-sorted semen regardless of estrous expression; or (3) FTAI with sex-sorted semen for cows having expressed estrus, and delayed AI 20 h after final GnRH for cows failing to express estrus.

Pregnancy rates based on treatment and estrous expression are presented in Table 11. A treatment x estrous expression interaction was found ($P < 0.0001$). Higher pregnancy rates ($P < 0.0001$) were achieved with conventional semen (Treatment 1, 77%) than with sex-sorted semen (Treatments 2 and 3, 51% and 42%, respectively) among cows that expressed estrus. However, among cows that failed to express estrus, delayed insemination with sex-sorted semen yielded higher ($P < 0.0001$) pregnancy rates than with sex-sorted semen at the standard time (Treatments 2 and 3, 3% versus 36%, respectively). Furthermore, among cows that failed to express estrus, FTAI pregnancy rates when using sex-sorted semen at the delayed time (36%) were comparable ($P = 0.9$) to those achieved using conventional semen at the standard time (Treatment 1; 37%). These results indicate that delaying AI of non-estrous cows by 20 h from the standard FTAI improves pregnancy rates when sex-sorted semen is used with FTAI.

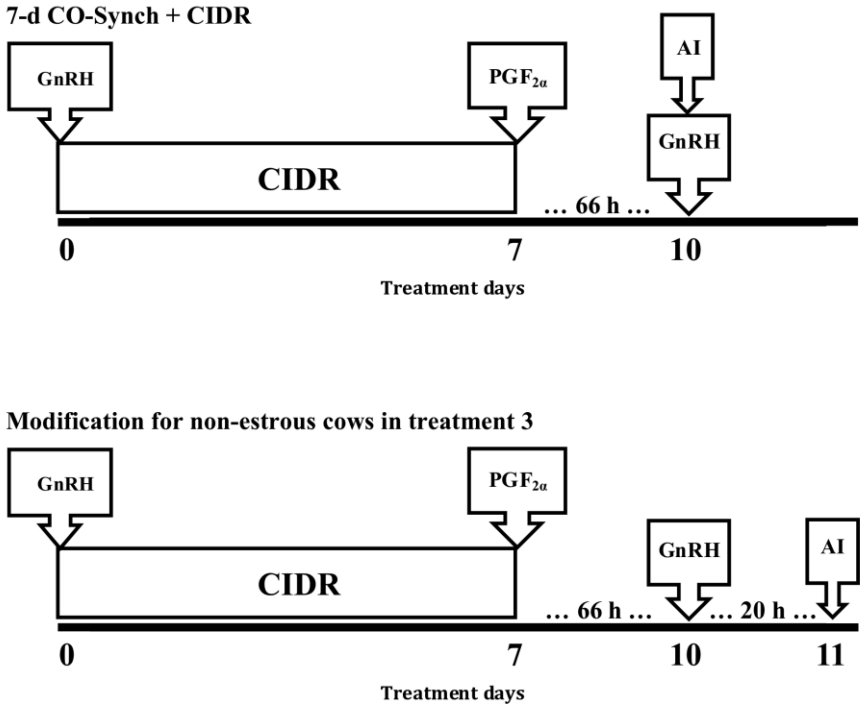


**Figure 10.** 7-d CO-Synch + CIDR with modification for delayed insemination

**Table 11**. Pregnancy rate to AI with sex-sorted semen based on estrous response and treatment[1].

| | Pregnancy rate to AI[3] | | | | | |
|---|---|---|---|---|---|---|
| | Treatment 1 | | Treatment 2 | | Treatment 3 | |
| Estrous response[2] | Proportion | % | Proportion | % | Proportion | % |
| Estrous | 81/105 | 77%[a] | 53/104 | 51%[b] | 47/111 | 42%[bc] |
| Non-estrous | 42/113 | 37%[d] | 3/113 | 3%[e] | 40/110 | 36%[cd] |
| Combined | 123/218 | 56% | 56/217 | 26% | 87/221 | 39% |

[a-d] Pregnancy rates with different superscripts within rows or columns are different, $P < 0.0001$.
[1]Cows received a controlled internal drug-release (CIDR) insert (1.38 g progesterone) and were administered GnRH (100 µg, i.m.) on d 0. On d 7, the CIDR insert was removed and $PGF_{2\alpha}$ (25 mg, i.m.) was administered. At 66 h after CIDR insert removal and $PGF_{2\alpha}$ , the cows received GnRH (100 µg, i.m.). Cows were assigned to one of three treatments: (1) FTAI (concurrent with GnRH, 66 h after CIDR removal) with conventional semen regardless of estrous expression; (2) FTAI with sex-sorted semen regardless of estrous expression; or (3) FTAI with sex-sorted semen for cows having expressed estrus, and delayed AI 20 h after final GnRH for cows failing to express estrus.
[2]Estrous response by 66 h after $PGF_{2\alpha}$ administration, as determined by activation of an estrus detection aid (Estrotect).
[3]Pregnancy rate to AI determined by ultrasound 60 d after AI.

Thomas et al. (2014) also evaluated this approach when using conventional, non-sex-sorted semen. Estrus was synchronized for 951 mature, suckled cows across 9 locations using the 7-d CO-Synch + CIDR protocol (100 µg GnRH + CIDR [1.38 gm progesterone] on d 0; 25 mg PGF2α at CIDR removal on d 7; and 100 µg GnRH on d 10, 66 h after CIDR removal). Estrus detection aids (Estrotect) were applied at $PGF_{2\alpha}$ and CIDR removal on d 7, and estrous expression was recorded at GnRH on d 10. Cows within each location were assigned to one of two treatments based on age, days postpartum (DPP), and body condition score (BCS): (1) FTAI (concurrent with GnRH, 66 h after $PGF_{2\alpha}$) regardless of estrous expression or (2) FTAI for cows expressing estrus, and delayed AI (20 h after GnRH) for cows failing to express estrus. Pregnancy rates based on treatment and estrous expression are presented in Table 12. No significant effect of treatment was found on AI pregnancy rate (P = .76).

**Table 12.** Pregnancy rate to AI with conventional semen based estrous response and treatment[1].

| | Pregnancy rate to AI[3] | | | |
|---|---|---|---|---|
| | Treatment 1 | | Treatment 2 | |
| Estrous response[2] | Proportion | % | Proportion | % |
| Estrous | 220/339 | 65[a] | 214/338 | 63[a] |
| Non-estrous | 60/133 | 45[b] | 70/141 | 50[b] |
| Total | 280/472 | 59 | 284/479 | 59 |

[a-b]Pregnancy rates with different superscripts within rows or columns are different, $P < 0.001$.

[1]Cows received a controlled internal drug-release (CIDR) insert (1.38 g progesterone) and were administered GnRH (100 µg, i.m.) on d 0. On d 7, the CIDR insert was removed and prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$; 25 mg, i.m.) was administered. At 66 h after CIDR insert removal and $PGF_{2\alpha}$ , cows received GnRH (100 µg, i.m.) and were assigned to one of two treatments: (1) FTAI (concurrent with GnRH, 66 h after CIDR removal) with conventional semen regardless of estrous expression or (2) FTAI with conventional semen for cows having expressed estrus, and delayed AI 20 h after final GnRH for cows failing to express estrus.

[2]Estrous response by 66 h after $PGF_{2\alpha}$ administration, as determined by activation of an estrus detection aid (Estrotect, Rockway Inc, Spring Valley, WI).

[3]Pregnancy rate to AI determined by ultrasound 60 to 90 d after AI.

Insemination at the optimal time relative to estrus may be more or less critical based on individual bull fertility (Macmillan and Watson, 1975). It was hypothesized that delaying insemination of non-estrous females until 20 h after GnRH administration would better align the lifespan of viable, capacitated sperm with the timing of ovulation, potentially allowing for higher FTAI pregnancy rates. This effect may occur in certain situations with respect to optimizing the timing of sperm fertility, such as when using sex-sorted semen. However, the results of the current study suggest that development of a favorable female environment may be the more critical factor in increasing the pregnancy rates of non-estrous females receiving delayed insemination.

Estrus expression prior to AI is associated with improved fertility for a number of reasons. Initiation of estrus in cattle is preceded by a rise in serum concentrations of estradiol (Allrich, 1994), and preovulatory estradiol coordinates several physiological processes that contribute to the establishment and maintenance of pregnancy, including effects on follicular cells, the oocyte, gamete transport, and preparation of the uterine environment (Pohler et al., 2012). Lower estradiol concentrations among non-estrous females may also affect pregnancy rates by

impairing sperm transport in the female reproductive tract. Perry et al. (2005) suggested that preovulatory concentrations of estradiol during standing estrus may modulate uterine pH to affect sperm transport. Delaying insemination of non-estrous cows by 20 h allowed time for initiation of estrus among a larger percentage of these cows, and the resulting increase in pregnancy rates of the estrous cows may be attributed to a more favorable uterine and oviductal environment. When receiving delayed insemination 20 h after GnRH administration, cows that expressed estrus during the 20 h delay period achieved significantly higher pregnancy rates than those cows that still had not expressed estrus by the time of delayed insemination (67% versus 40%).

The lack of a treatment advantage among cows when using conventional semen may also be related to the high estrous response rate by 66 h after $PGF_{2\alpha}$. Across locations, 72% of cows had expressed estrus by 66 h after $PGF_{2\alpha}$. In contrast, when delayed insemination was effective in improving pregnancy rates of non-estrous cows to sex-sorted semen, only 49% of cows had expressed estrus by 66 h after $PGF_{2\alpha}$. A higher estrous response rate by 66 h after $PGF_{2\alpha}$ results in fewer non-estrous females and may minimize any advantage to delaying insemination. Therefore, mature cows may benefit from split-time AI over fixed-time AI in certain situations when using conventional semen, such as following low estrous response rates by the time of fixed-time AI. Further studies are currently evaluating alternative strategies when administering GnRH to cows and heifers in conjunction with split-time AI using conventional semen.

## MANAGEMENT CONSIDERATIONS RELATED TO ESTRUS SYNCHRONIZATION AND FTAI

**Managing anestrus.** As previously discussed, one of the main challenges herd owners face at the beginning of any breeding period, is the number of cows that have resumed estrous cyclicity following calving and before the breeding season begins. A primary advantage in administering a CIDR-based protocol in postpartum beef cows lies in the fact that these protocols not only facilitate estrous synchronization and AI in cyclic cows, but offer the added benefit of induced estrous cyclicity in anestrous cows following treatment administration.

Figure 11 illustrates results from four published studies conducted by our laboratory comparing pregnancy rates after fixed-time AI. In each of these studies, postpartum beef cows were blood sampled twice before placement on an estrus synchronization protocol to determine pretreatment estrous cyclicity status. Results were then compared on the basis of efficacy of the protocols in facilitating FTAI, and evaluating how cows that were anestrus prior to treatment administration compared to cyclic cows on the basis of pregnancy outcome after FTAI. The combined results from these four studies clearly demonstrate the significant benefit associated with treatment with a progestin prior to FTAI, as there was only a 1 percentage point difference in pregnancy rates among cows that were cyclic or anestrus prior to treatment administration.

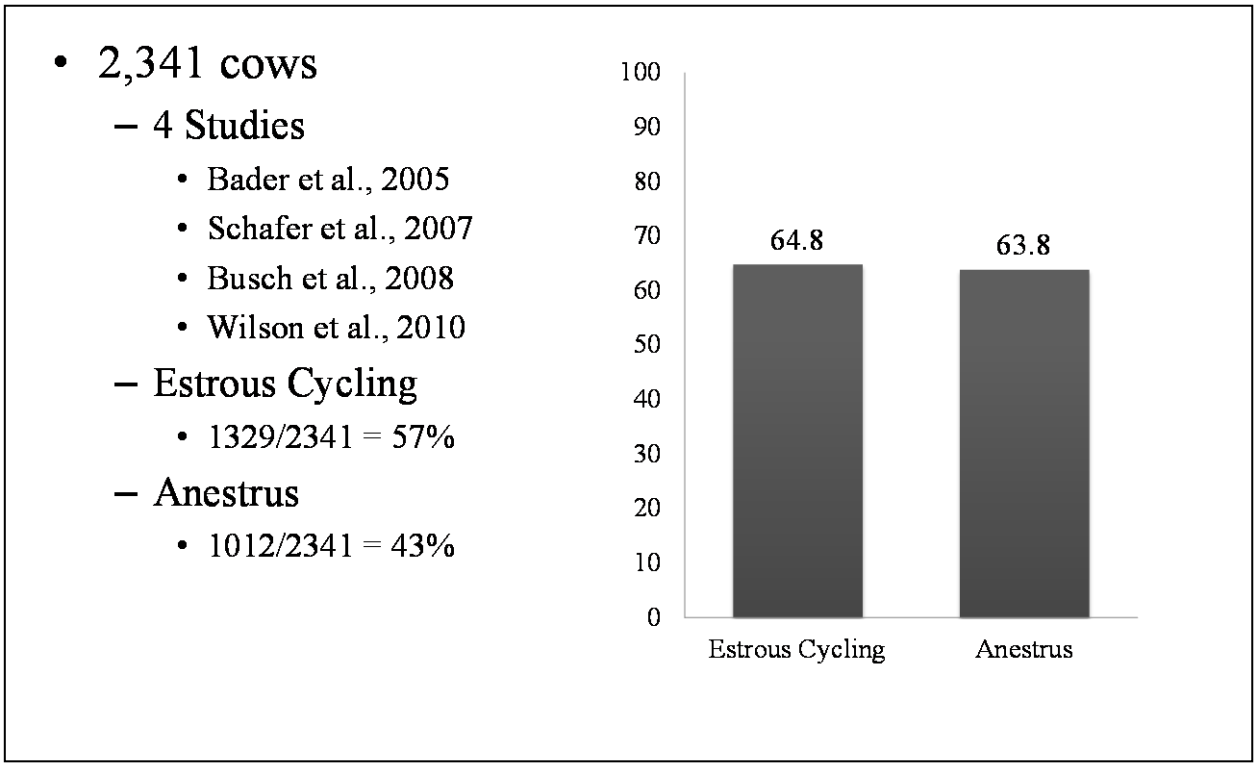


**Figure 11.** Pregnancy rates (% pregnant) after fixed-time AI in postpartum beef cows based on pretreatment estrous cyclicity status.

**What to expect at calving.** Our data support the use of estrus synchronization not only as a means of facilitating more rapid genetic improvement of beef herds, but perhaps, more importantly, as a powerful reproductive management tool. Profitability may be increased by reducing the extent to which labor is required during the calving period, and increasing the pounds of calf weaned that result from a more concentrated calving distribution and a resulting increase in the age of calves at weaning. Cumulative calving distribution patterns indicate that in many cases over 85% of pregnant cows among synchronized herds will calve within the first 30 days of the calving period (Perry et al., 2002 ; Stegner et al., 2004a,b,c; Bader et al., 2005; Schafer et al., 2007; Busch et al., 2008; Wilson et al., 2010).

Calving dates for cows that conceived on the same day to fixed-time AI were recorded to address concerns that pertain to the subsequent calving period (Bader et al., 2005). Calf birth dates were recorded for cows that conceived to fixed-time AI at each location involved in the study by Bader et al. (2005). The resulting calving distribution for cows that conceived to the respective sires at each of the locations in the two treatments is illustrated in Figure 12. Calving distribution patterns differed among individual sires (Table 13; $P < 0.05$). Calving distribution among cows that conceived to fixed-time AI for Location 1 (sires A and B) was 21 and 16 days, respectively. Distributions for Location 2 (sires C and D) were 16 and 20 days, respectively. The calving distribution among cows at location 3 (sire E), was 18 days. Sire B at Location 1 and sire E at Location 3 was the same sire. Cows that conceived on the same day gave birth to calves over a 16 to 21 day period, dependent upon the respective sire. These distributions indicate that

successful use of FTAI will not result in an overwhelming number of cows calving on the same day(s). This furthermore suggests that current management practices will not need to be greatly altered to accommodate the early portion of the calving season.

**Table 13**. Comparison of gestation lengths (Mean ± SE) among AI sires and locations.

| Location | Sire | Gestation length, days | Range, days |
|---|---|---|---|
| 1 | A | 283.5 ± 0.5 | 272 - 292 |
| | B[a] | 282.1 ± 0.5 | 275 - 290 |
| 2 | C | 282.9± 0.8 | 274 - 289 |
| | D | 284.1 ± 0.6 | 275 - 294 |
| 3 | E[a] | 282.0 ± 0.5 | 274 - 291 |

[a]Sire B at location 1 and sire E at location 3 are the same sire.
From Bader et al. (2005).

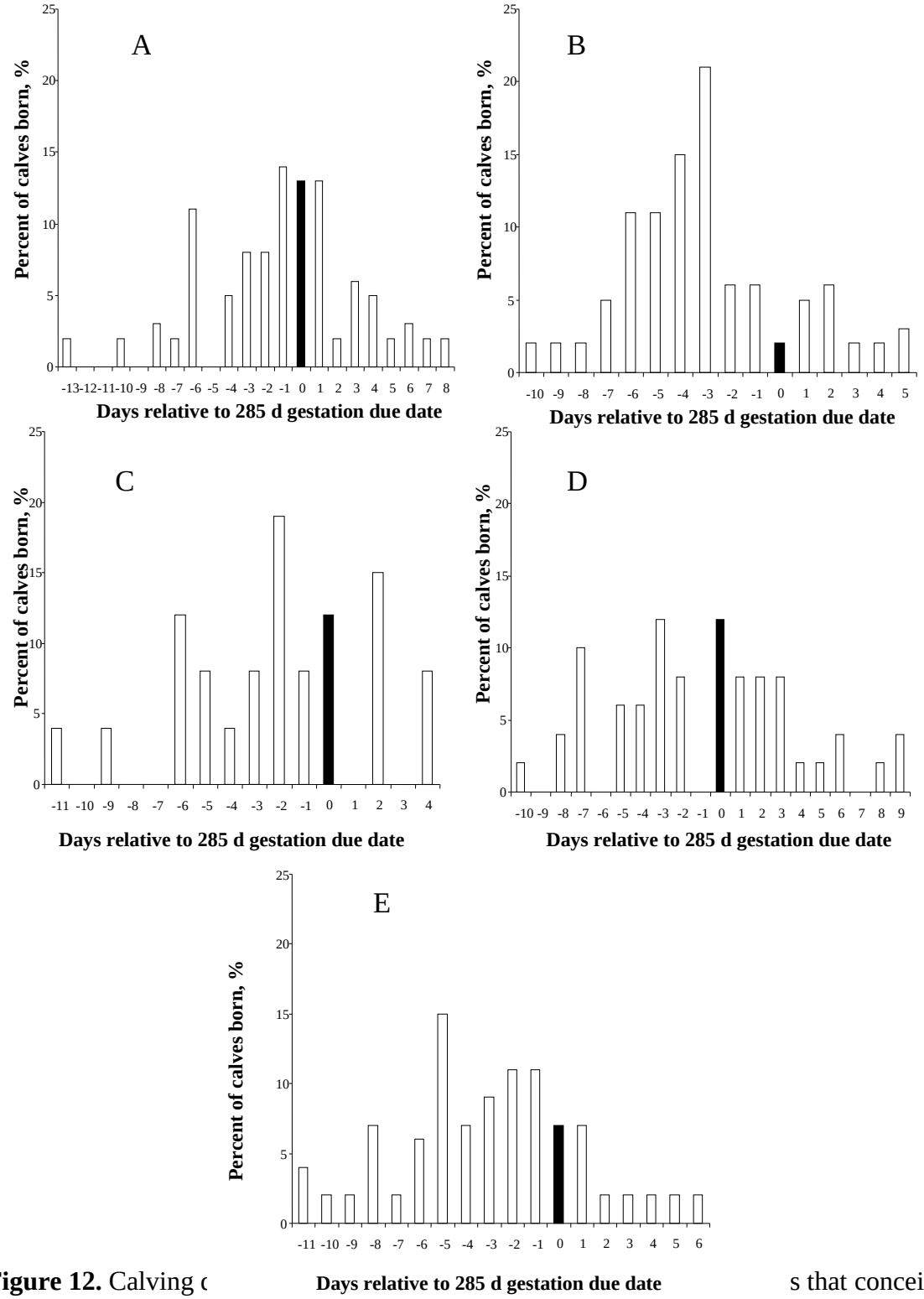


**Figure 12.** Calving d s that conceived to fixed-time AI Calving dates ar ective sires (A, B, C, D, and E) were 21, 16, 16, 20, and 18 days. Sire B at Location 1 and sire E at Location 3 were the same sire. The shaded bar in each graph represents an anticipated 285 day gestation due date. From Bader et al. (2005).

**Consider the impact of estrus synchronization on calving distribution.** Economic considerations related to use of estrus synchronization and choice of the various protocols to use in beef heifers and cows was reviewed by Johnson and Jones (2004). Hughes (2005) reported that opportunities to increase profits for cow-calf operations lie in managing females from the later calving intervals forward toward the first and second 21-day calving intervals. Hughes (2005) reports that added pounds are the economic reward to tightening up the calving interval. The CHAPS benchmark values utilize IRM-SPA guidelines for operating high production herds. These guidelines suggest that 61% of the calves within a herd should be born by day 21 of the calving period, 85% by day 42, and 94% by day 63. Hughes (2005) goes on to say that today's high market prices are generating big economic rewards to intensified management, but more specifically "management as usual" may be what is amiss for many cow calf producers.

Figure 13 illustrates the combined calving data for 3 of 4 locations in the study reported by Schafer (2005). Data from the fourth location was not included in the summary since cows that failed to conceive to AI were sold prior to the calving period. It is interesting to note that in comparison to the recommendation by Hughes (2005), 64% of the cows in this study had calved by day 15, 70% by day 21, 77% by day 30, and 91% by day 42. The economic reward for improvements in calf weaning weight that result from an increase in calf age at weaning, in many cases may offset the cost of implementing estrus synchronization in beef herds.

Finally, Figure 14 illustrates the calving profile for cows at the University of Missouri Forage Systems Research Center in Linneus, MO, over a two year period. This herd maintains a 45-day breeding season, and until the spring of 2004, estrus synchronization and AI were not utilized. Figure 13 illustrates the calving profile of cows that calved during the spring of 2004 as a result of natural service during the 2003 breeding season. Figure 13 also illustrates the calving profile for cows that calved during the spring of 2005 as a result of fixed-time AI performed during the 2004 breeding season (Schafer, 2005; Patterson et al., 2006). This herd has been intensively managed over the years to breed successfully in a 45-day period with natural service. Notice, however, the increased percentage of cows that calved early in the calving period as a result of fixed-time AI performed during the previous year's breeding season. Estrus synchronization at this location in one year resulted in an increase of 7 days postpartum among cows at the start of the breeding period, which translates into an increase in calf age at weaning of seven calf days. These figures (Figures 13, 14) collectively demonstrate that estrus synchronization can be used effectively to influence calving distribution patterns during the subsequent calving period, which in turn impacts the economics of herds at weaning time.

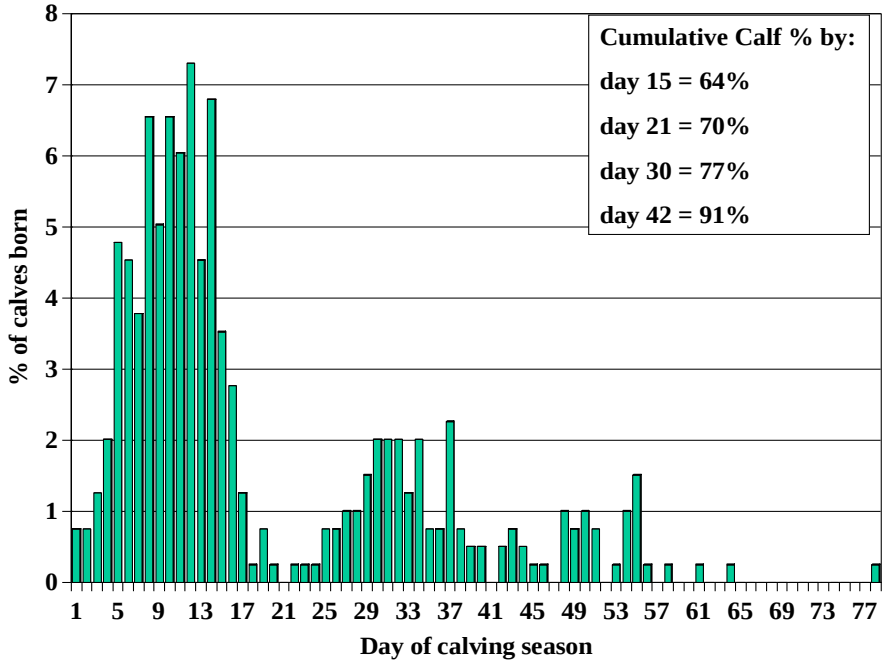


**Figure 13.** Calving distributions combined for 3 of the 4 locations in the study by Schafer, 2005).

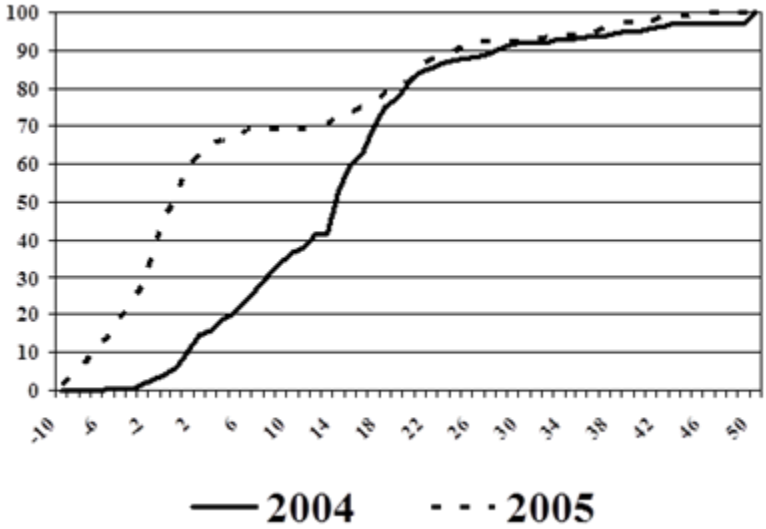


**Figure 14.** Calving profiles for cows at the University of Missouri Forage Systems Research Center in Linneus, MO, over a 2 year period. This herd maintains a 45-day breeding season and until the spring of 2004 estrus synchronization and AI had not been utilized. The figure illustrates the calving profiles of cows that calved during the spring of 2004 as a result of natural service during the 2003 breeding season, and calving profiles for cows that calved during the spring of 2005 as a result of fixed time AI performed during the 2004 breeding season (Schafer, 2005).

## FIELD DEMONSTRATIONS IN MISSOURI WITH FTAI IN POSTPARTUM BEEF COWS

Table 14 summarizes results from on-farm field demonstrations conducted in Missouri (Figure 15) involving 73 herds and 7,028 cows. The pregnancy rates shown in Table 14 summarize results from FTAI in postpartum beef cows using the CO-Synch + CIDR protocol with FTAI performed 66 hours after CIDR removal and PG administration. Bear in mind, no heat detection was performed on these farms; cows were inseminated at the predetermined fixed-time without detecting estrus. Pregnancy rates resulting from FTAI averaged 62% for the 73 herds. Interestingly, only 7 herds reported pregnancy rates lower that 50%. Producers in these regions and across Missouri now understand that the technology exists to successfully inseminate postpartum beef cows at predetermined fixed times without the need to detect estrus. Increased profits can be achieved through changes in calving distribution patterns of herds and higher percentages of cows will calve during a more concentrated time frame and earlier in the calving period.

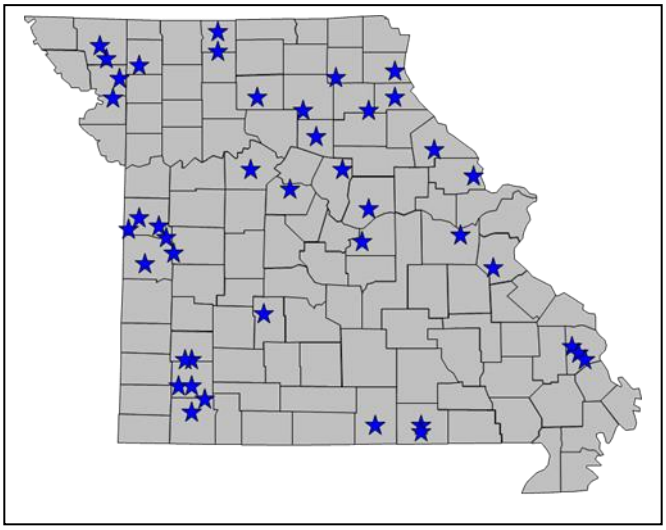

**Figure 15.** Locations of on-farm field demonstrations in Missouri. Cows at these various locations were synchronized using the CO-Synch + CIDR protocol and were inseminated 66 hours after CIDR removal and PG.

**Table 14.** Pregnancy rates resulting from on-farm field demonstrations in Missouri following administration of the CO-Synch + CIDR protocol with fixed-time AI performed 66 hours after PG and CIDR removal.

| | Numbers | | Pregnancy rate | |
|---|---|---|---|---|
| Item | Herds | Cows inseminated | AI pregnancy rate (mean) | AI pregnancy rate (range) |
| Fixed-time AI results | 73 | 7028 | 4327/7028 62% | 38-86%* |

*Only 7 of the 73 herds realized pregnancy rates < 50% resulting from fixed-time AI.

## FIXED-TIME AI AND HIGH-ACCURACY SIRES

Figure 16 illustrates the cumulative calving percentages for the University of Missouri Thompson Research Center over an 11-year period. The graph compares the percentages of calves born during years when only natural service was used, followed by estrus synchronization and AI performed on the basis of observed heat, and finally fixed-time AI. The graph illustrates the respective distributions on the basis of days in the calving season. Notice the increased percentage of calves born early in the calving period during years when AI was performed on the basis of observed heat or at predetermined fixed times in comparison to years in which only natural service was practiced.

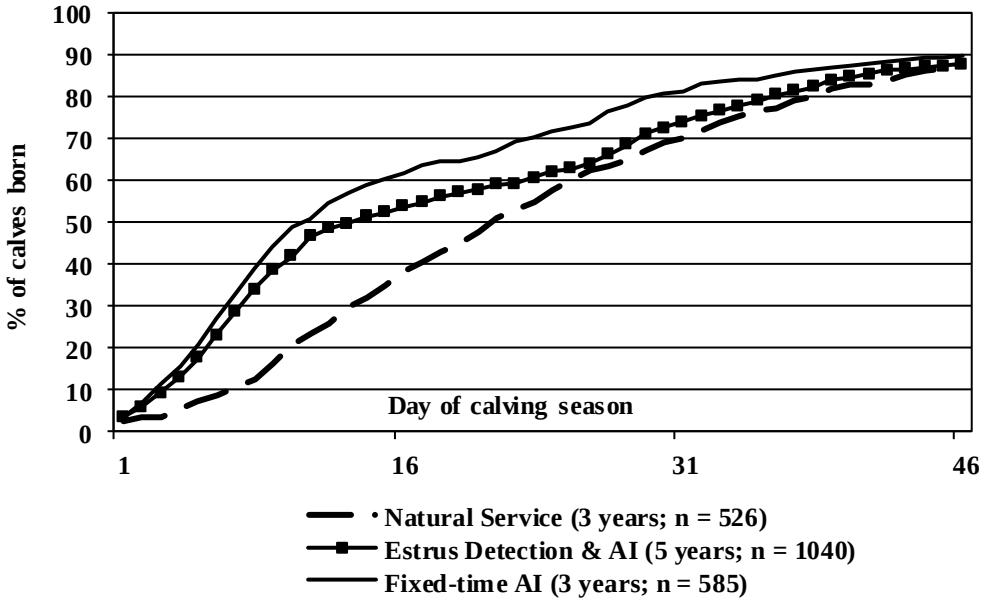


**Figure 16.** Cumulative calf crops for the first 46 days of calving season over 11 years for cows at the University of Missouri Thompson Farm combining years involving natural service, estrus synchronization and AI performed on the basis of observed heat, and fixed-time AI (Patterson et al., 2006).

The research herd at the University of Missouri Thompson Research Center, Spickard, MO provides a valuable resource for development and evaluation of protocols to effectively synchronize estrus in replacement beef heifers and postpartum beef cows. The focus of our research over the past 15 years at this farm was directed in large measure at developing methods to synchronize estrus and ovulation to the extent that fixed-time AI would become a more feasible management practice. At the same time, the focus of the breeding program at this farm was aimed at producing premium, high-quality, white table-cloth beef. The data in Table 15 summarize results from 2008-2011, years in which only high-accuracy sires were used in the AI program. All cows and heifers at this farm are exposed for one round of AI. Clean-up bulls are then exposed to the various breeding groups two weeks after AI for a 60-day breeding period. Table 15 summarizes performance results for steer progeny from the farm that were finished at the Irsik and Doll Feed Yard in Garden City, KS.

**Table 15**. Performance data (2008-2011) for steers from the University of Missouri Thompson Farm, Spickard, MO, that were fed at the Irsik and Doll Feed Yard in Garden City, KS.[1]

| Sire group | Maternal grand sire | No. of steers | Choice or higher (%) | CAB® (%) | Prime (%) |
|---|---|---|---|---|---|
| High accuracy | High accuracy | 153 | 100 | 58 | 30 |
| High accuracy | Low accuracy | 64 | 100 | 61 | 34 |
| High accuracy | Natural service | 35 | 100 | 60 | 14 |
| Totals | | 252 | 100 | 59 | 29 |
| | | | | | |
| Natural service | High accuracy | 58 | 97 | 60 | 12 |
| Natural service | Low accuracy | 17 | 100 | 53 | 18 |
| Natural service | Natural service | 26 | 92 | 27 | 12 |
| Totals | | 101 | 96 | 50 | 13 |

[1]Steers from the University of Missouri Thompson Farm received 1st place in the National Angus Carcass Challenge for the Central Region during the 2nd quarter in 2010 and 2011.

The data presented in Table 15 should be considered within the context of how they compare with averages for the U.S. cattle industry. Currently, the percentage of cattle in the U.S. that grade Choice or higher fall in the range of 65%, with 3.9% grading Prime, and 25.6% of all black-hided cattle qualifying for CAB®.

The take home message from these data highlight the fact that stacking reproductive and genetic technologies (fixed-time AI and high-accuracy sires) is now an effective means of achieving more rapid progress in a breeding program. New opportunities to effectively synchronize estrus and ovulation in an AI program and use of superior, high accuracy sires opens the door for beef producers across the U.S. to take more aggressive control of their breeding programs with the goal of increasing equity in our nation's cow herds, while at the same time adding value to breeding stock and steers leaving the farm. If we analyze historical data from the Thompson Research Center, birth weights (an indicator of calving ease) have decreased by 0.3 pounds per year. Contrary to Lalman et al. 2013 and likely due to the use of exceptional AI sires, adjusted weaning weights have increased by 1.5 pounds per year since 1996. Since 2009, the mean marbling score of the steers increased by 0.47 units per year and the mean carcass weight increased by 4.3 pounds per year (see Figure 16). After adjusting for inflation, the sale price of Thompson Research Center steers has increased an average of $131.69 per year since 2009 (see Figure 17). Most of this change is due to increasing beef prices, but the typical Thompson steers sold for $46.02 above average from 2009 to 2014. The Thompson Research Center averages 85 steers per year, so the steer gross receipts are typically $3,911.70 above average per year. While the change in a single year is small, these incremental increases add up over time. Thus, an important advantage of artificial insemination is access to superior genetics and the resulting genetic improvement.

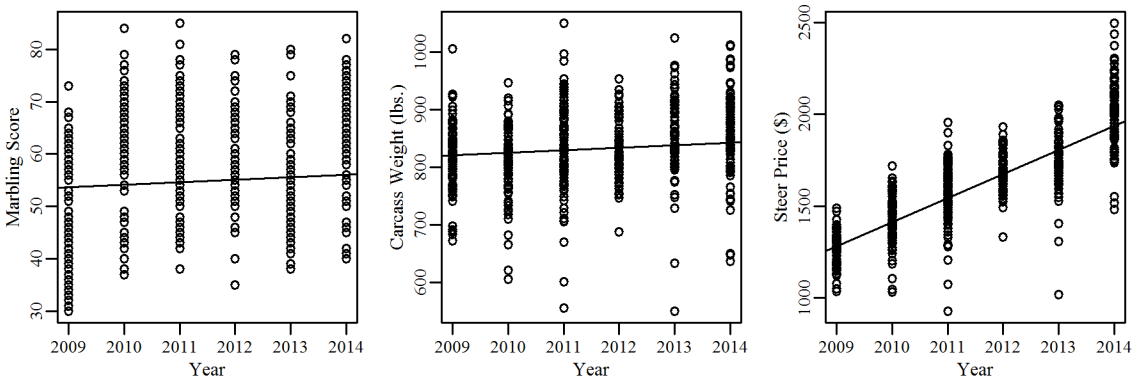


**Figure 17.** Yearly trends for University of Missouri Thompson Research Center steers. First panel is marbling score, second panel is carcass weight, and third panel is price in 2013 dollars. Solid trend lines are from the regressions of the trait on year as a fixed effect and sire and dam as random effects.

## SUMMARY AND CONCLUSIONS

The U.S. beef industry finds itself confronted with a significant long-term decline in cattle numbers driven in part by record input costs and severe drought conditions in many of our nation's major cattle producing states. These recent challenges only add to long-term issues the industry faces, which include an aging producer population, increased global competition, weak domestic demand for beef and increased competition from other meat proteins, and until now a perceived lack of economic incentives to expand the cattle herd. Coincident with the downturn in cattle numbers however, there now exist an array of technologies currently available or emerging that offer the potential to expedite genetic progress, enhance efficiencies of production, and add value to beef cattle produced and marketed in the U.S. Improvements in reproductive technologies have enabled beef producers to utilize artificial insemination without the need to detect estrus; existing and emerging genetic and genomic technologies enable beef producers to make more rapid strides toward improving the quality of beef they produce; and producers' ability to access and target individual marketing grids enable them to be rewarded for specific quality endpoints (Patterson and Brown, 2013) .

Protocols for inducing and synchronizing a fertile estrus in postpartum beef cows in which progestins are used with GnRH and PG now provide opportunities for beef producers to synchronize estrus and ovulation and facilitate fixed-time AI. Table 16 provides a summary of the various estrus synchronization protocols for use in postpartum beef cows. These data represent results from our own published work in addition to unpublished data from DeJarnette and Wallace, Select Sires, Inc., and Johnson et al. (2010). These data suggest that available methods of inducing and synchronizing estrus for postpartum beef cows create the opportunity to significantly expand the use of AI in the U.S. cow herd.

**Table 16**. Comparison of estrous response and fertility in postpartum beef cows after treatment with various estrus synchronization protocols.

| Treatment | Estrous response | | Synchronized pregnancy rate | |
|---|---|---|---|---|
| AI based on detected estrus | | | | |
| 2 shot PG | 241/422 | 57% | 147/422 | 35% |
| Select Synch | 353/528 | 67% | 237/528 | 45% |
| AI performed at predetermined fixed times with no estrus detection | | | | |
| 7- day CO-Synch + CIDR | Fixed-time AI @ 66 hr | | 4327/7028 | 62% |
| 5-day CO-Synch + CIDR | Fixed-time AI @ 72 hr | | 1357/2189 | 62% |

Collectively, these data point to the fact that the U.S. beef industry finds itself at a unique point in time, unlike any other. Improvements in reproductive technologies enable beef producers to utilize artificial insemination without the need to detect estrus; existing and emerging genomic/genetic technologies enable beef producers to make more rapid strides toward improving the quality of beef they produce; and producers' ability to access and target specific marketing grids enable them to be rewarded for specific quality endpoints. In an editorial authored by Troy Marshall in BEEF magazine (2011), Marshall proposed that as prices and costs increase, traits of efficiency and quality will be become bigger drivers of profitability than ever before, and the commodity model of U.S. beef production in all likelihood will no longer be viable. Beef producers in the U.S. have the tools in hand to ensure our country's ranking as the leading global supplier of high quality beef. As we look to the future, the challenge our industry faces is whether these tools will be used to the extent that enables future generations in the U.S. to compete in a global arena, and if so, how effectively.

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**Marketing Opportunities for AI Bred Heifers and AI Sired Progeny**

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The U.S. cattle inventory was at 87.7 million head at the beginning of 2014, the lowest inventory for the beef industry since 1951. Severe drought and sharply higher feed costs have led many U.S. cattle producers to downsize their herds in recent years. But as cattle markets have risen to record price levels in recent months, many producers will be looking to rebuild their herds to capture the expected future profits that today's strong beef demand levels and falling feed costs are pointing to. Genetics, production, and management decisions made in the near term will determine the future success of the beef industry. More importantly, beef producers must strive to provide products that will meet consumer desires in order to sustain and improve beef demand as that will ultimately drive the size of the cattle industry moving forward.

The short supply of cattle today combined with strong demand has led to record cattle prices that many in the industry would have never assumed possible just a few years ago. Missouri feeder cattle prices have exploded to over $2.50 per pound in 2014, which is over $1 a pound higher than year ago levels. To put this into perspective, Missouri 600 to 650 pound feeder steers were less than $1.00 a pound to start 2010. This nearly tripling of feeder cattle prices has had ripple effects throughout the cattle industry. The value of bred heifers and replacement females has also risen to record levels.

The case is being made by some in the industry that cattle inventories will not grow any time soon. Although the path to a larger cattle herd will take time, the positive economic signals are undeniable. The fact that beef cow slaughter is about 20 percent lower this year relative to 2013 is some indication that producers are holding cows in the herd for another year. The Livestock Marketing Information Center (LMIC) is currently projecting cow-calf returns at $490 per cow in 2014 and $482 per cow in 2015. For this agricultural economist, the old adage that the cure for high prices is high prices will eventually prove to be true yet again, but the amount of time that it will take for market adjustment to occur could take a while in this case.

It is important to consider some long-term expectations for cattle markets before analyzing the economic impact of AI bred heifers or progeny. In today's red hot market, every decision has been an economic winner for cow-calf producers the past few years. That may lead some in the industry to suggest any focus on genetic improvement is not valuable or needed. Taking that short-term view of cattle markets is dangerous as markets will adjust over time.

The value of any replacement female should be looked at relative to her future stream of expected returns. That future stream of returns is uncertain and risky. Risk enters this equation from both the production side through factors such as calves weaned and input costs and the output price side with the many uncertainties that exist with domestic and international beef demand.

Ultimately, the value of marketing opportunities for AI bred heifers or AI sired progeny rest in how markets returns are increased and/or economic risks are reduced through the use of genetic information. There is mounting evidence in the marketplace of the economic benefits attributed to the use of an AI program. Those that are investing now in superior genetic cattle may in fact be the ones best able to survive the next cattle cycle.

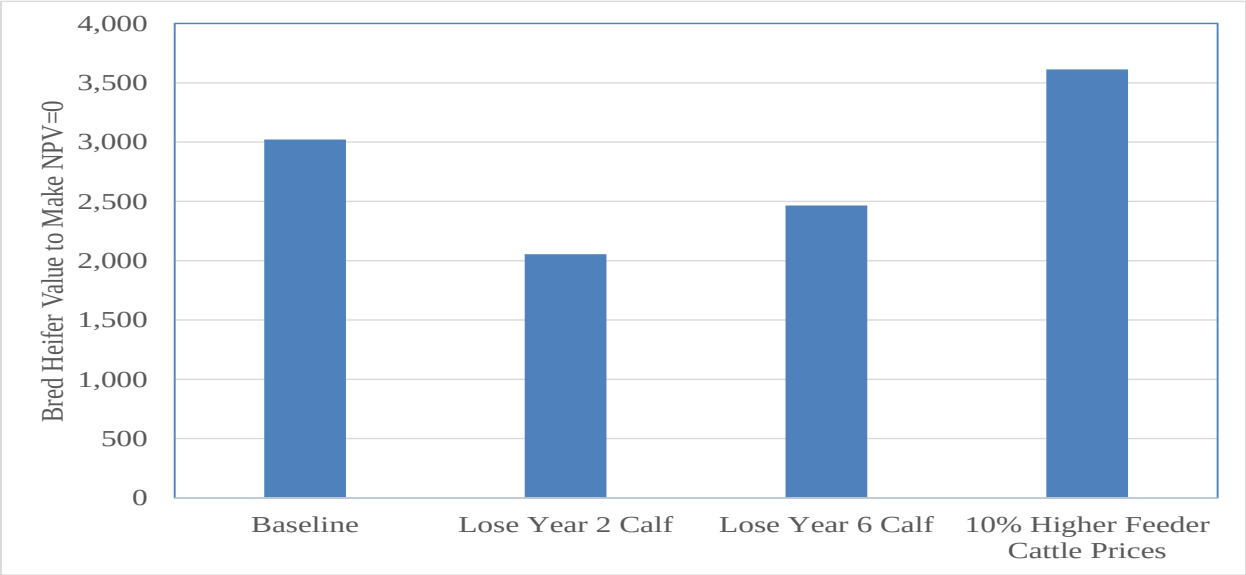
# Net Present Value of AI Bred Heifers

Harlan Hughes (1999) reported that, "The timing of herd expansion, and the buying and selling of females, seem to be particularly critical to the long-run profitability of a beef cow herd." This statement has always been the case in the cattle industry with producers making herd decisions in the face of an uncertain future. Those that made a decision to expand at the "right" time found strong economic returns while those who expanded at the "wrong" time faced tough economic pressure.

Economic theory provides that a cow-calf producer should invest in herd expansion when the expected Net Present Value (NPV) of the stream of future returns exceeds the current market value of the female. The inherent problem is that future prices expectations play a pivotal role in the decision and producers find it difficult to assign cattle prices 8 to 10 years into the future. However, it may be instructive to look at the possible economic gains that can accrue to AI bred heifers relative to average heifers by examining the possible economic gains that result from a more predictable genetic base.

Nearly every land grant university has an online tool that automates the process of computing the NPV of a possible female herd addition. At the University of Missouri a replacement calculator can be found at: http:// beef.missouri.edu/tools/index.htm. Cow-calf producers can use this tool to estimate the return on investment of a cow purchase and calculate the break-even bid price for a cow. Also, they can use this tool to assist with the keep or cull decision by comparing the net present value of a heifer to her current market value (see figure 1).

Figure 1. Predicted bred heifer values



This tool was employed to examine a few scenarios that can reflect the additional value that can be realized from an AI bred heifer. First, using a recent long-term forecast developed by the Agricultural Markets and Policy (AMAP) group at the University of Missouri http://amap.missouri.edu/images/research/Aug2014AMAPLivestockUpdate.pdf, feeder cattle prices were entered into the tool. The projected feeder cattle prices decline over the period by nearly $0.50 per pound returning to levels in 2020 that are near the 2012 levels. Cow-calf costs are also important to the NPV calculation and are based on the same long-term forecast that generated the feeder cattle price estimates.

In taking the baseline case of the feeder cattle prices discussed in the previous paragraph and assuming the potential herd replacement successfully produces a calf every year for 9 years before the cow is ultimately culled suggests that a current bred heifer value of $3,022 would result in a NPV of zero. That is, a producer would be economically indifferent between selling the bred heifer at that price versus putting it in the herd for the next nine years.

The zero NPV outcome assumes there is zero risk in the cattle price outlook, cost outlook or the production of calves when in fact all of those carry significant risk in this type of calculation. Unfortunately, the risk associated with cattle prices and costs is difficult to mitigate over the long term. However, there are steps that can be taken to reduce the risk of losing a calf along the way through a focus on genetics that start with calving ease. To put the importance of producing a calf each year into perspective, taking the same NPV example above and assuming one calf was lost in year two of her productive life results in the zero NPV purchase price falling to $2,055 or a $967 decline.

This steep decline results from the fact that the second calf born in the string of nine is one of the most valuable given the cattle price projections and that losing dollars early in the investment is worse than losing a calf later in her productive life because of the effect of the discount rate. To provide some additional perspective, losing a calf in year 6 of her productive life results in the purchase prices declining to $2,466 or a decline of $556.

The above simple example begins to provide some framework to economically value an AI bred heifer relative to average bred heifers. The comparison makes the assumption that improved genetics from using an AI approach results in a bred heifer with an increased probability of successfully calving over her productive lifespan. The missing assessment is the degree to which calving percentage increases as a result of using a more predictable AI sire.

There may be additional risk reduction possibilities from an AI bred heifer. Beyond increasing the chance of successfully raising a calf, the value of the offspring when it is sold can also be increased with some genetic focus due to the increased productivity of the offspring and the quality of the beef when sold.

One way to examine this effect in context of the value of an AI bred heifer is to provide a premium to feeder cattle prices reflective of what is seen in the marketplace today. For example, the range in the 600 to 650 pound Missouri feeder cattle price suggests that top-end calves have obtained roughly a 10 percent premium relative to the average price over the past several years. Applying that 10 percent premium to feeder cattle price projections used in the calculator

example above suggests the purchase price that equates to a zero NPV is increased by $591 to $3,613.

These two simple examples can provide the framework to begin to economically value the effects of an AI bred heifer relative to a bred heifer where few specifics about the genetic background are known. It is instructive to examine real world data that provides some feedback on the different economic values of bred heifers depending on whether or not they were AI sired.

## The Show-Me-Select™ (SMS) Heifer Program

The SMS program that was started in the mid-1990s at the University of Missouri by Dr. David Patterson provides a robust set of data on the selling prices of bred heifers enrolled in the SMS program. There have been 128 bred-heifer sales that sold over 27,000 bred heifers at a gross value in excess of $34 million. By segmenting the data depending on the type of bred heifer sold, the difference in selling prices provides another comparison relative to the NPV approach above.

All SMS bred heifers must meet minimum specific requirements to be eligible for the program that include service sire EPD requirements for maximum birth weight and minimum calving ease that depend on the breed. In addition, all sires used in conjunction with artificial insemination must have a minimum accuracy value of 0.6 on a scale of zero to one. There are other program requirements such as minimum vaccination requirements (see http://agebb.missouri.edu/select/prgmreq.htm for full program details).

The SMS program created another tier relative to the original program requirements, Tier 2, which added minimum accuracies for: calving ease (direct), calving ease (maternal), weaning weight, carcass weight and marbling.

In summarizing the sales data over the fall 2010 to spring 2014 sales period, interesting value differences emerge depending on the type or tier of bred heifer sold. For example, a Tier 1 natural service bred heifer sold for $1,702 over this period. A Tier 1 AI bred heifer fetched $1,978 over the period or an additional $276. The Tier 2 values also show added value relative to the Tier 1 natural service bred heifer value. A natural service Tier 2 bred heifer value averaged $1,934, a gain of $232 relative to a natural service Tier 1 bred heifer while a Tier 2 AI bred heifer added $407 to the sales price reaching $2,109.

Although somewhat anecdotal evidence, the $407 additional value obtained by a Tier 2 AI bred heifer over a Tier 1 natural service bred heifer is similar in magnitude to the value obtained from using the NPV approach discussed at the beginning of this article. These two alternative approaches to estimate the value of AI bred heifers begin to provide a range on the added value that is assigned in today's marketplace.

It is important to keep the SMS bred heifer values in perspective. The Tier 1 natural service bred heifer value of $1,702 exceeds the $1,314 average value of bred heifers sold at

Oklahoma City over the same time period, showing that the SMS program requirements add value to all heifers sold in the program.

## University of Missouri Thompson Research Center Steer Values

The Thompson Research Center located near Spickard, Missouri has been using an AI program for a number of years. The breeding program led by Dr. David Patterson has focused on increasing the genetic potential of the herd from both the calving success side of the equation as well as a focus on additional traits such as marbling. This roughly 200 head beef cow operation has a set of females that look very consistent. An AI program has been in place for a long time at the Center.

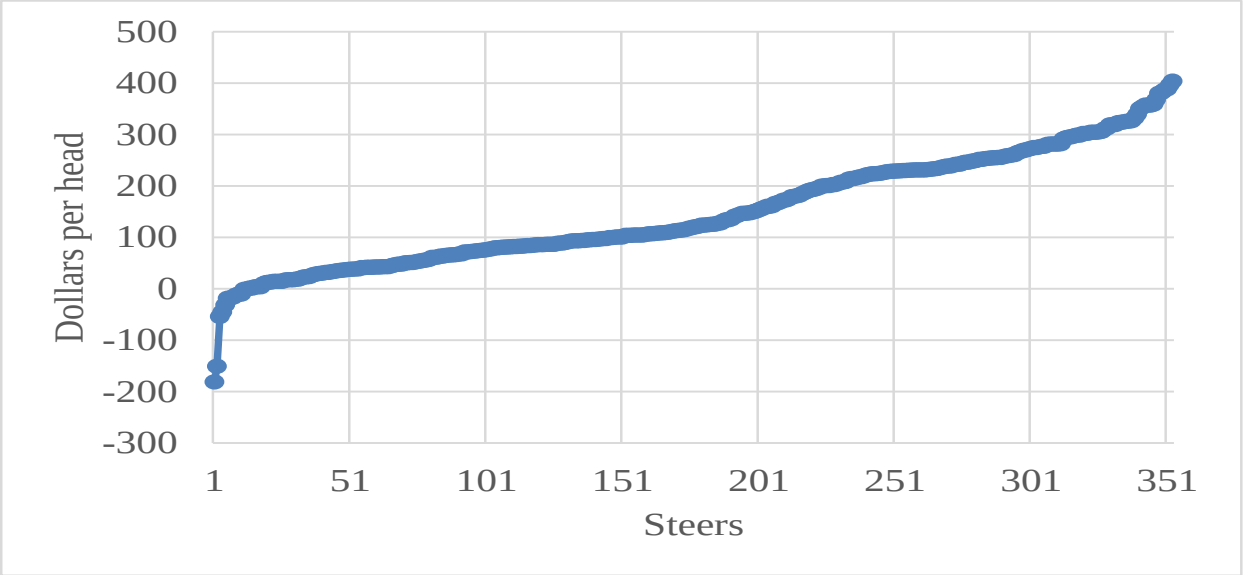
For the past several years, the steer calves have been fed in a western Kansas yard. Carcass data received back from the feed yard has been used to economically evaluate the effect of this focused breeding program. The results have been phenomenal in terms of the quality grade outcomes of each set of steers fed the last few years. However, more important is the measurement of economic opportunities from applying this breeding program. It is important to recognize that the Thompson Research Center steers have averaged between 25 and 30 percent prime without experiencing much if any discount from the yield grade side of the equation. That is amazing when one realizes the average percentage of prime in the country today is less than 5 percent.

This gathered data set provides a great way to evaluate the economic effect of the genetic gain these steers provided in the feed yard. The results show a consistent story that the Thompson Research Center steers had added value in the feed yard.

The calculations done for comparisons looked at how the steers would have sold as feeder animals the day they went to the feed yards relative to their value when slaughtered (see figure 2). The data provide by USDA-AMS on St. Joseph, Missouri feeder steer prices were used to value the steers. With multiple years of data available, the results include periods of time where both feed costs and cattle values moved significantly in both direction. These large moves allow for robustness in the results.

Some results jump off the page. First, not a single steer that graded prime was worth less at slaughter than when it was valued as a feeder animal the day it went to the feed yard. Of the 199 steers that were Certified Angus Beef qualified, only one steer did not show a value gain over the feeding period.

Figure 2. Economic returns from feeding Thompson Research Center steers versus selling as feeder cattle




The average value gain across approximately 350 steers fed over the 2008 to 2012 period was $148.37. This gain is the difference between their feed yard closeout and their calculated value at the time they went to the feed yard.

This does not suggest that cow-calf producers should get into the cattle feeding business because of the genetic gain that can be accomplished through proven genetics. However, it highlights the value addition shows that these feeder steers are worth more to cattle feeders. The added gain per steer shown here is very near the 10 percent increase in feeder cattle prices assumed in the NPV approach in the beginning.

## Economic Gain Shown From Available Data

The summary of the data available from the SMS bred heifer sales and the Thompson Research Center steer feed outs show that the value of these heifers and steers increased as an AI breeding program was implemented.

In the case of the SMS bred heifers, a Tier 2 AI bred heifer was worth an additional $407 on average over a SMS Tier 1 natural service bred heifer. In the case of Thompson Research Center steers, they were worth an additional $148.37 per head relative to the average feeder cattle price they would have brought had they been sold as feeder cattle.

These economic gains generally follow the NPV approach that suggested a bred heifer is worth an additional $591 if her offspring garners a 10 percent premium in the marketplace. The economic value of a bred heifer successfully producing a calf every year of her reproductive life

is also large and similar to the distinction shown in sales of SMS AI bred heifers relative to natural service bred heifers.

The opportunity to grow the cattle herd lies ahead for the industry. The cattle industry has a chance to invest in better genetics that makes the cattle industry more competitive with the other meat sectors. This investment is likely critical for the cow-calf producers who will likely see lower economic returns 5 to 10 years down the road.

Using an AI program to increase the genetic advancement of producers' herds appears to provide a way to reduce the risk of increasing herds. Cattle producers can't reduce long-term cattle price risk but can use a reproductive program that includes the use of an AI program to increase the genetic potential of the herd which will increase the likelihood of a calf and result in cattle that grow efficiently and capture quality premiums available in the marketplace.

# Should Beef Quality Grade be a Priority?

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## Summary

In the wake of severe weather conditions and higher feed costs in recent years, the U.S. cattle inventory has continually been downsized. The decades-low U.S. cattle inventory has many in the livestock industry discussing the potential for growth. Now, with improved economic conditions and strong beef demand affecting today's market situation, beef producers will likely begin to grow their operations and rebuild their herds in the near future. However, uncertainty regarding the "correct" rebuilding strategy remains.

This study aims to provide insight on the importance of beef quality as part of a rebuilding strategy by differentiating beef demand for various quality types including USDA Prime, USDA Choice/Branded, USDA Select, and the *Certified Angus Beef* ® (CAB®) brand. Ordinary least squares (OLS) regression procedures were used to estimate single demand equations for each quality category, producing monthly own-price, cross-price, and income elasticities.

Own-Price

- Results show Prime beef to be more own-price elastic than other beef quality types at -2.33%. In other words, as the price of Prime beef increased by 1%, the quantity of Prime beef consumed should fall 2.33%. Similar to Prime beef, CAB® has an own-price elasticity of -2.26%.
- However, results show Select beef has an own-price elasticity of -1.24%.
- These findings lead to the reciprocal (1/*n*), or Price Flexibility of -.43% for Prime, -.44% for CAB® and -.81% for Select. A price flexibility expresses the expected price change that would result from changes in quantity supplied to the market.
    - As the supply of CAB® and Prime beef increases, the market premium is less likely to decline than when lower quality beef supply increases. (A 1% increase in Prime beef supply could bring a 0.43% decline in price, but a similar increase in Select beef could bring nearly twice as much price decline.) That's good news for producers who can hit the higher quality targets.

Cross-Price

- Cross-price elasticities were positive across all beef categories, implying substitution among beef quality categories and between beef quality categories and competing meats. However, the degree of substitution differs between quality categories. Lower quality beef faces the strongest price-pressure from competing meats.

Income

- Income elasticities are strong for most beef quality types. As income increases by 1%, demand for CAB® products, specifically, increases by 1.63%. As income increases, consumers are likely to eat more beef, especially higher quality beef.

Trend

- A significant trend was found independent of prices and income that suggests stronger demand for higher-quality beef and weaker demand for lower-quality beef. This trend term identifies all factors that influence consumer demand beyond economic factors. Examples include factors such as increased product consistency or quality or marketing programs that build consumer awareness about the products.

Value

- Production of higher-quality beef adds value to the beef industry. From 2005-2013, quality premiums associated with prime and branded grades added nearly $4.5 billion to the beef industry.

Analyzing beef demand differentiated by quality type suggests that beef quality should be a key component of any rebuilding strategy. However, it is important to remember that quality beef is the result of many factors of production such as genetics, handling, and nutrition. Beef production and management decisions made in the near term will determine the future success of cattle herds across the U.S., and ultimately, the success of the U.S. beef industry.

## Introduction

The U.S. cattle inventory was at 87.7 million head at the beginning of 2014, the lowest inventory for the beef industry since 1951 (USDA, 2014). Severe cases of drought, greater instability of markets, and higher feed costs led many U.S. cattle producers to downsize their herds in recent years. Given strong beef demand, cattle producers will be looking to rebuild their herds as more favorable economic conditions arise. Genetics, production, and management decisions made in the near term will determine the future success of the beef industry. More importantly, beef producers must strive to provide products that will meet consumer desires in order to sustain and improve beef demand, the ultimate factor driving the size of the cattle industry moving forward. The objective of this study is to provide empirical estimates of own-price, cross-price, and income elasticities for beef quality types including USDA Prime, USDA Choice/Branded, and USDA Select beef, as well as *Certified Angus Beef* ® (CAB®). This approach allows for comparison of these estimated elasticities to help determine the best production focus for the future of the beef industry.

Regarding consumer beef demand, recent studies suggest a strong consumer focus on quality (e.g. Schroeder et al, 2013; NBQA 2011). Quality can embody many factors in today's beef industry including nutritional value, healthiness, animal welfare, and environmental concerns. However, Schroeder et al (2013) addressed beef product quality, in terms of flavor, color, tenderness, and juiciness. Throughout this study, "beef quality" will refer to these beef sensory characteristics. Beef quality as it is defined here is largely determined by USDA quality grade as beef of a higher quality grade will have more intramuscular fat which improves flavor, juiciness, and perceived tenderness. Such characteristics contribute to an enjoyable eating experience for the consumer which ultimately drives customer satisfaction and beef demand (Schroeder et al 2013).

With product quality being an important and feasibly influenced determinant of beef demand as addressed by Schroeder et al, differentiating beef demand by quality types (USDA Prime, Choice, Select, and Branded) will help determine whether a quality focused rebuilding strategy could pay long-run dividends for the beef industry.

## The Importance of Branded Beef: CAB® Leads the Way

Looking back at some big events in the beef industry, beef demand fell nearly 50% from the mid 1970s to the late 1990s (Schroeder et al, 2000; Grimes, 2004). Since the late 1990s, the beef industry has made significant progress rebuilding beef demand with the introduction of branded beef programs being one of the industry's most influential efforts. *Certified Angus Beef* ® (CAB®) was introduced in 1978 as the first United States Department of Agriculture (USDA)-certified beef program and has remained the largest beef brand. Additional branded beef programs developed slowly after the introduction of CAB®, but from 1998 to 2012, 129 new programs hit the market place (Speer, 2013). In 1995, Brester and

Schroeder linked branded beef advertising to increased meat consumption and also found substitution among meat commodities as a result of brand advertising. Due to branded programs' influence on beef demand and their important role in the beef industry, it will be useful to consider branded beef when differentiating beef demand by quality grade. A large portion of today's beef supply is made up of beef grading Choice. Focusing on programs, such as CAB®, that target the upper end of the Choice grade may provide further information regarding consumer demand for higher-quality beef.

## Consumer Demand for CAB® branded products and USDA Quality Grades

While there is plenty of research available regarding beef demand, very little research has focused on disaggregating beef demand for various quality grades. Going back to 1966, Colman estimated the elasticity for two grades of ground beef. Although the USDA grading system has gone through several changes since Colman conducted this research, his findings are still useful. He showed that beef is not a homogenous commodity and that each grade has its own demand characteristics, supporting the idea of differentiating beef demand by quality grade. Furthermore, his single equation demand model may still be useful in estimating elasticities across various beef quality types present in the beef marketplace today.

In 2001, Lusk et al estimated demand for wholesale quality differentiated boxed beef and looked at the effects of seasonality on beef demand. Choice and Select beef own-price elasticities estimated by Lusk et al were -0.43 and -0.63, respectively, and demand for Select graded beef was more elastic than demand for Choice graded beef across all four quarters of the year. Additionally, Lusk et al examined seasonality effects, identifying more inelastic demand for both Choice and Select graded beef during the summer months. Lusk et al made significant contributions to differentiating beef demand across beef quality types. However, a more comprehensive study including Prime, Choice, Select, and Branded beef demand analysis will provide a more detailed picture of consumer beef demand differentiated by quality type.

More recent research by Zimmerman and Schroeder (2013) compared CAB® with commodity beef to allow for better understanding of consumer demand and where the CAB® brand stands within the beef industry. Their study presented estimates for wholesale beef demand separated into USDA Choice-and-higher, CAB®, and non-branded USDA Choice using USDA boxed beef and CAB® data. Demand elasticities were not estimated, but were obtained by surveying expert livestock economists. The survey resulted in an annualized elasticity of -0.54 and -0.87 for USDA Choice-and-higher and CAB®, respectively. Results from Zimmerman and Schroeder's study showed Choice-and-higher beef demand declined in recent years while CAB® demand continued to improve.

This research takes a different approach to evaluate consumer beef demand, estimating own-price, cross-price, and income elasticities for USDA Prime, CAB®, USDA Branded/Choice, and USDA Select quality categories using monthly USDA load data and single equation OLS regression procedures.

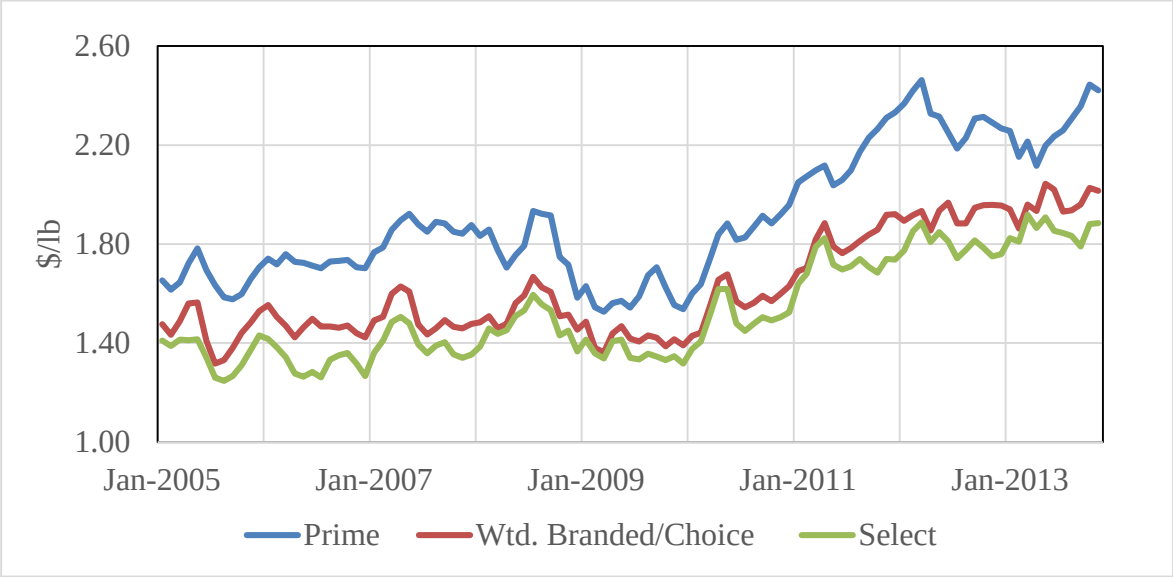
## Data

The ultimate focus of this research is to examine consumer beef demand differentiated by quality categories. While retail beef data would prove most useful in estimating consumer beef demand at the supermarket level, analyzing wholesale markets includes the effects of beef demand developments in food service and international markets. Also, given that retail beef data differentiated by quality type is not available, wholesale level beef quantity and price data were used to estimate consumer beef demand from 2005-2013.

Monthly quantity and price data for USDA Prime, Branded, Choice, and Select loads of boxed beef were gathered from the Agriculture Marketing Service (USDA-AMS) through the Livestock Marketing Information Center (LMIC). Since USDA Branded boxed beef is made up of branded upper 2/3 and lower 1/3 Choice beef, Branded and Choice quantity data were combined into one quality category, with price

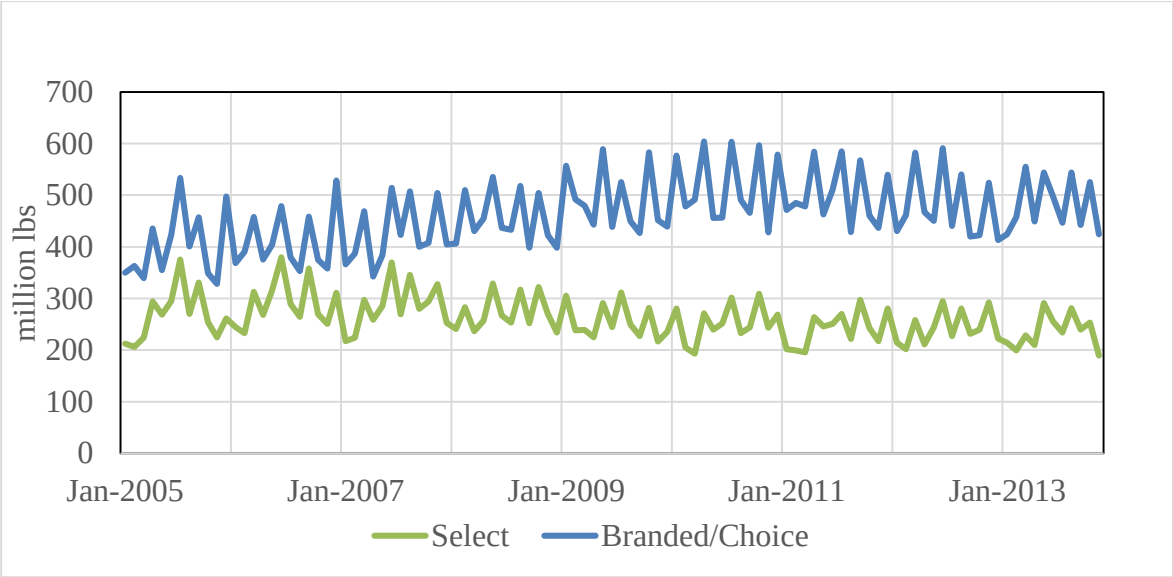
determined by using a weighted average. Prime, Branded/Choice and Select price and quantity information are shown in Figures 1, 2, and 3 below.

Figure 1. Boxed Beef Cutout Values



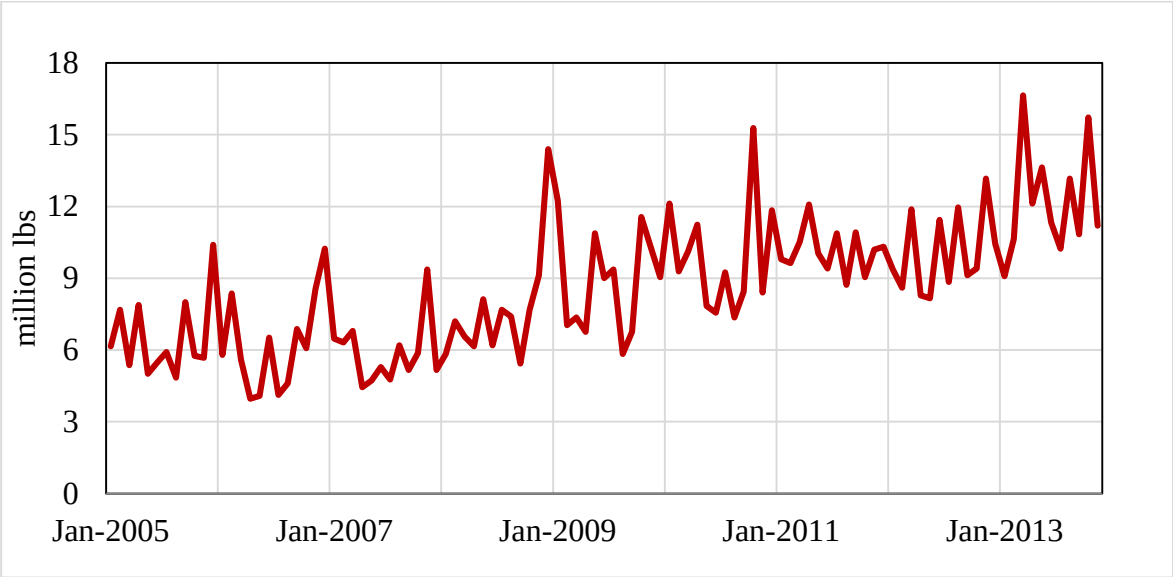

Source: United States Department of Agriculture, Agricultural Marketing Service, Livestock Marketing Information Center

Figure 2. Select and Branded/Choice Quantity Sold




Source: United States Department of Agriculture, Agricultural Marketing Service, Livestock Marketing Information Center

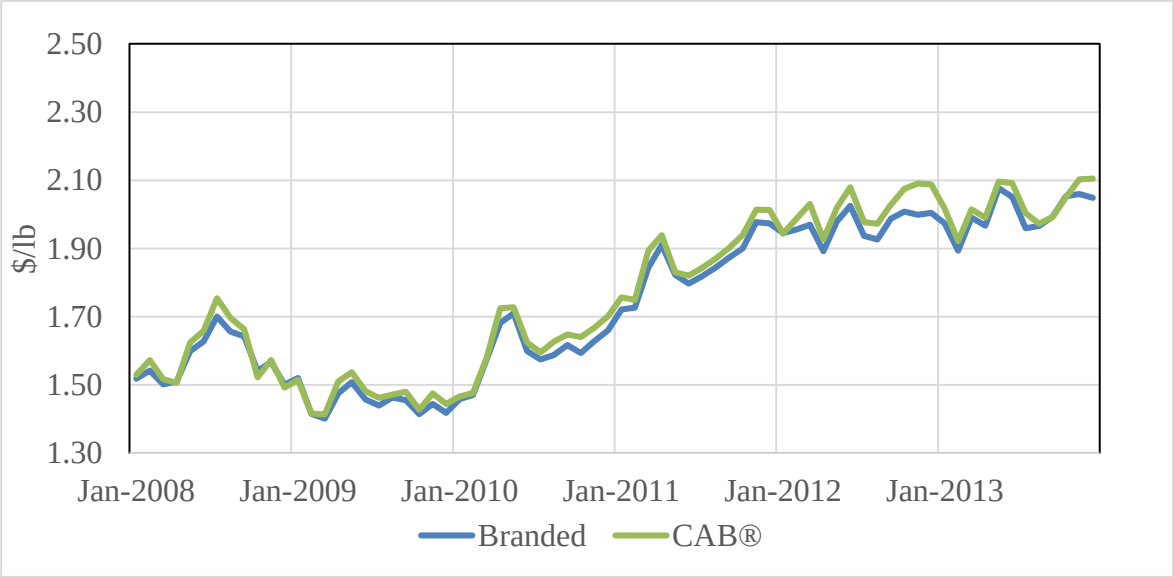
Figure 3. Prime Quantity Sold




Source: United States Department of Agriculture, Agricultural Marketing Service, Livestock Marketing Information Center

CAB® provided monthly quantity and price information for CAB® product. However, for consistency reasons, CAB® price data was only available back to December of 2007, after the latest change in price reporting. Typically, the CAB® cutout value is higher than the USDA Branded cutout value, but the two values have very similar price patterns as shown in Figure 4. Thus, USDA Branded cutout values were used to estimate the own-price elasticity for CAB® demand over the 2005-2013 estimation period to allow for a longer estimation period than would have been available using the CAB® price data.

Figure 4. Branded vs. CAB® Cutout Values



Income influences demand for beef and is represented in each model by monthly Real Personal Consumption Expenditure data obtained from the United States Department of Commerce: Bureau of Economic Analysis.

Furthermore, monthly pork cutout values and wholesale chicken prices were gathered from the Economic Research Service (ERS) to estimate cross-price elasticities for these competing meats.

## Estimation

OLS regression procedures were used to estimate single demand equations with ln-ln specifications. This approach allowed for the empirical estimation of income and own-price elasticities for USDA beef quality grade categories including Prime, Branded/Choice, and Select, as well as for CAB®, and to estimate cross-price elasticities between quality grade categories and competing meats. Cross-price elasticities allow us to determine the degree of substitution between beef-quality types and competing meats.

Seasonality of beef demand was accounted for in each model. Pork and chicken prices were combined, using a weighted average, into one competing meats price variable in the Prime, Branded/Choice, and Select beef demand models to reduce the number of estimated parameters.

Because Select and Competing Meats price elasticities are very similar for the Branded/Choice beef demand model, the Select beef price was combined with the Competing Meats price in the CAB® model by means of a weighted average.

## Results: Prime, Branded/Choice, and Select Beef Demand

Elasticities for Prime, Branded/Choice, and Select graded beef are shown in Table 1.The ln-ln specifications of each equation allow coefficients to be directly interpreted as elasticities.

The estimated elasticities show that a 1 percent increase in the Prime price (cutout value) decreases the quantity of Prime beef consumed by 2.33%. The fact that Fig. 3 shows an increase in Prime consumption in the face of higher prices can only be accounted for by the logarithmic trend (Fig. 2) that shows other factors countering the imputed elasticity.

If the price of competing meats were to increase by 1%, the quantity of Prime, Branded/Choice, and Select beef consumed would increase by 0.21%, 0.24%, and 0.30%, respectively. Those differences appear small, but in relative perspective, Select beef is two-thirds more likely to be affected by a decision to buy competing proteins than Prime.

A 1% increase in income would increase the quantity of Prime, Branded/Choice, and Select beef consumed by 1.34%, 0.03%, and 1.26%, respectively. The apparent discrepancy in Branded/Choice may be due to the wide variation in quality from top to low Choice. For example, income elasticity for CAB® (Table 3), is higher than that for Prime at 1.63. The first-, second-, and third-quarter estimates address changes in quantity of beef consumed due to seasonality.

Finally, a logarithmic trend was included in each model to account for additional factors that may influence beef demand. The trend is significant across beef quality types, indicating a 0.16% and 0.07% increase in consumption of Prime and Branded/Choice beef each month and a 0.05% decrease in consumption of Select beef each month, not accounted for by demand factors already explicitly included in each model. Again, the wide variation in Branded/Choice that included CAB® product must be noted. With that trend number for CAB® showing a 0.14% increase, it is likely that the lower end of Choice included product with a negative trend in consumption.

Table 1.

| Beef Demand by Quality Grade | | | |
|---|---|---|---|
| | **Prime Quantity** | **Branded/Choice Quantity** | **Select Quantity** |
| **Constant** | -2.65 | -3.17 | 0.83 |
| **Prime Price** | -2.33** | 0.25 | 0.30 |
| **Branded/Choice Price*** ** | 1.53 | -1.04 | 0.13 |
| **Select Price** | 1.18 | 0.22 | -1.24* |
| **Competing Meats Price[a]** | 0.21 | 0.24 | 0.30 |
| **Income*** ** | 1.34 | 0.03 | 1.26 |
| **1st Quarter** | -0.14* | 0.00 | -0.08 |
| **2nd Quarter** | -0.29** | 0.04 | 0.07 |
| **3rd Quarter** | -0.21** | -0.06 | 0.03 |
| **Trend*** ** | 0.16** | 0.07** | -0.05** |
| | | | |
| **R-squared** | 0.70 | 0.65 | 0.74 |

[a] Competing Meats price is the weighted average of pork and chicken prices.
* and ** indicate significance at the 5% and 1% level, respectively.
*** Wide variability within Choice likely affected data in these categories.

Prime beef is the most elastic beef product.

USDA Prime beef is more own-price elastic than the other beef quality types. As the own-price increases by 1% for each quality type, quantity of beef consumed changes the most for Prime beef at -2.33%. Many in the cattle industry suggest that the premiums available for high-quality beef are driven in large part by limited supplies. While supplies do play a role in determining market clearing prices, relative demand elasticities also play an important role in determining premiums available for high-quality beef, as demonstrated with the Prime own-price elasticity, and its inverse, price flexibility. The latter suggests that a change in quantity supplied elicits a smaller change in price. Thus the market can, to some extent, absorb an increase in the quantity of Prime beef supplied without much of a change in current quality premiums.

Income elasticities are strong for most beef quality types.

Demand for CAB® (Table 3) is the most responsive to changes in income, followed by demand for Prime, Select, and Branded/Choice beef. From these results, we can infer that as incomes allow, consumers will demand more high quality beef.

Significant trend data suggests stronger demand for higher-quality beef products moving forward.

A logarithmic trend applied from 2007 to 2013 is significant across each beef quality category. This existing trend suggests additional factors are increasing demand for Prime and at least the upper end of Branded/Choice beef and decreasing demand for Select beef. While it's difficult to quantitatively identify exactly what is causing this trend, Table 2 shows significant changes in demand of each quality category if the trend were to continue through 2020. While Prime and Branded/Choice beef consumption would increase, Select beef consumption would drastically decrease under the assumption of a continued trend.

Table 2.

| Annual Change in Demand if Trend Continues Through 2020 (millions of pounds)* | | | | |
|---|---|---|---|---|
| | Prime | Branded/Choice | Select | CAB |
| 2015 | 2.65 | 47.53 | -17.97 | 15.62 |
| 2016 | 2.40 | 42.63 | -15.89 | 14.13 |
| 2017 | 2.20 | 38.67 | -14.24 | 12.91 |
| 2018 | 2.03 | 35.41 | -12.89 | 11.90 |
| 2019 | 1.89 | 32.67 | -11.77 | 11.05 |
| 2020 | 1.77 | 30.33 | -10.83 | 10.32 |
| Total | 12.95 | 227.24 | -85.60 | 75.93 |

* The Branded/Choice data implicitly includes the separate CAB® changes suggesting most of the increase in the Branded/Choice trend results in the upper quality portion of this broad category.

Lower quality beef faces the strongest pressure from competing meats.

The regression results show positive elasticities for all cross-prices across all beef quality categories. These results imply substitution among beef quality grades and between each beef quality grade and competing meats. However, the degree of substitution differs across beef quality categories. According to the results, a change in the price of competing meats elicits the strongest response in quantity of Select beef demanded followed by quantities of Branded/Choice, and Prime beef demanded. In other words, Select beef faces stronger competition with pork and chicken than beef that grades prime. In fact, the competing meats cross price elasticity for Prime beef is only two-thirds that of Select beef.

After several years of high feed prices, the livestock industry is finally seeing lower feed costs. The expected response for both the pork and poultry industry is to increase production. Increased production of these competing meats will drive pork and chicken prices down and create more price pressure on beef. The estimation results show Select has the highest degree of substitution with competing meats, suggesting lower-quality beef will face the most price-pressure from other meats going forward.

## Results: CAB® Demand

CAB® demand estimates in Table 3 can be interpreted in the same manner as the estimates in Table 1. For instance, a 1% increase in the Branded price (cutout value) should result in a 2.26% decrease in quantity of CAB® product consumed. The fact that this decrease has not occurred implies a shift toward stronger demand, as suggested by the logarithmic trend. As with the demand estimation for USDA quality grades, a significant logarithmic trend shows alternative factors are positively influencing demand for CAB®. Note that a 1% increase in income should elicit a 1.63% increase in CAB® quantity consumed.

Table 3.

| CAB® Demand | |
|---|---|
| | **CAB® Quantity** |
| **Constant** | 10.64 |
| **Prime Price** | 0.39* |
| **Brand Price** | -2.26 |
| **Choice Price** | 1.33 |
| **Competing Meats Price[a]** | 0.28* |
| **Income** | 1.63** |
| **1st Quarter** | 0.02 |
| **2nd Quarter** | 0.06** |
| **3rd Quarter** | 0.05** |
| **Trend** | 0.14** |
| | |
| **R-squared** | 0.90 |

[a] Competing Meats price is the weighted average of Select beef, pork, and chicken prices.
* significant at the 5% level
** significant at the 1% level

Similar to Prime beef, CAB® also has a more elastic own-price.

> If the price of CAB® branded products were to increase by 1%, quantity of CAB® products demanded would be expected to fall by 2.26%. That this has not happened suggests this elasticity is mitigated by logarithmic trend and income elasticity.

CAB® demand has strong income elasticity.

> As income increases by 1%, demand for CAB® products increases by 1.63%. Again, the results suggest consumers are drawn to higher-quality beef as their incomes increase.

CAB® demand has a positive trend, in place since at least 2007.

> The trend term suggests something external to the own price, cross price and income variables is causing an increase in demand for CAB® every month. Continuing this trend term alone through 2020, U.S. consumer demand for CAB® is projected to increase by 59.78 million lb. from 2014, as shown in Table 2.

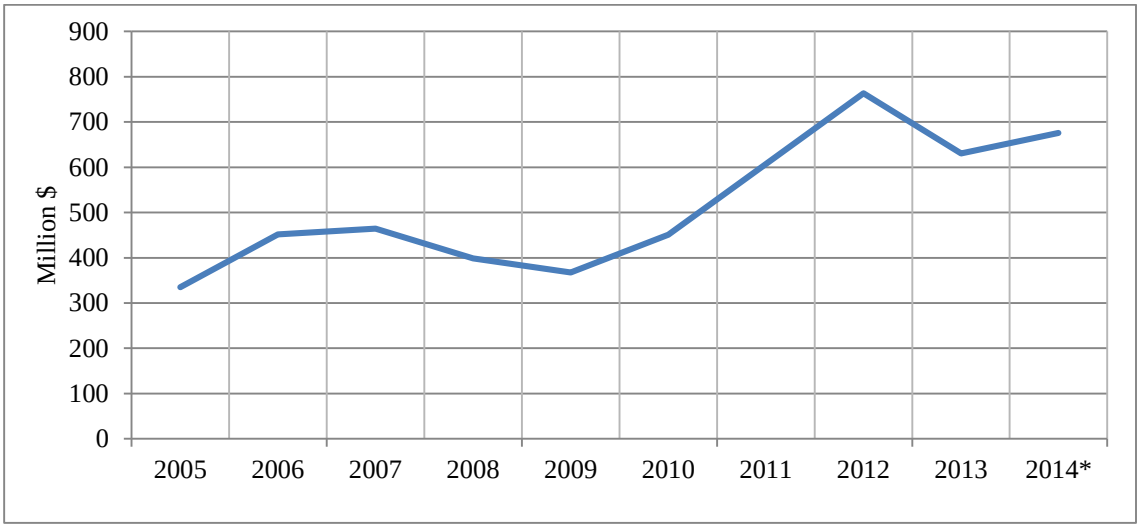
## What is the Value of Quality Beef?

In an effort to quantify the added value from quality premiums, a premium cutout value was compared to a baseline cutout value, similar to the methods used in the CattleFax report "Value of Quality Analysis." The baseline cutout was a composite of USDA Choice and USDA Select cutout values based on grading percentages. The premium cutout followed the same composite method with the addition of Prime and Branded beef values. The comparison of these two values gives an idea of the value of higher-quality beef.

From 2005-2013, quality premiums made up approximately 1.3% of the value of U.S. cattle and calf production, adding nearly 4.5 billion dollars to the beef industry. In 2013 alone, quality premiums

added 630 million dollars to the beef industry. Furthermore, Figure 5 shows the quality added premium/cwt has largely been trending upward since 2005. Increasing demand for higher-quality beef, as suggested in this study, provides an incentive for increased production of high-quality beef. With quality categories such as Prime and CAB® being more own-price elastic, the market can, to some extent, absorb an increased supply of beef products in these categories without driving quality premiums down. Consumers have shown a willingness to pay premiums for higher quality beef, and producing a greater supply of higher-quality product will increase the value added by beef quality, an already significant contribution to the beef industry.

Figure 5. Value Added to U.S. Beef Production through Quality Premiums




* 2014 value estimated from eight months of data

## Conclusion

The decades-low U.S. cattle inventory has many in the livestock industry discussing the potential for growth. With improved economic conditions and strong beef demand affecting today's market situation, beef producers will likely begin to grow their operations and rebuild their herds in the near future. The intent of this work is to help better define the focus for rebuilding cattle herds in the U.S.

Results imply rising consumer demand for beef of higher-quality such as USDA Prime, USDA Choice, and branded beef such as CAB®. Demand figures can be found in the Appendix.

While these findings suggest a focus on beef quality to be an excellent rebuilding strategy, others have suggested a commodity focus toward more ground beef production. Even if the beef industry moves toward more ground beef production it is likely the quality grind products to target price conscious consumers, beef quality can still play an important role in satisfying consumer beef demand with restaurants such as Five Guys® and Smashburger® creating a place for higher-quality beef in the ground beef market (Corah, 2014).

Looking at beef demand differentiated by quality type suggests beef quality should be a key component of any rebuilding strategy. However, it is important to remember that quality beef is the result of many factors of production such as genetics, handling, nutrition, etc. Beef production and management decisions made in the near term will determine the future success of cattle herds across the U.S. A focus on quality appears to be a viable plan to rebuild the U.S. cattle inventory and sustain and build beef demand going forward.

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# Appendix

Figure 1A. Prime Beef Demand

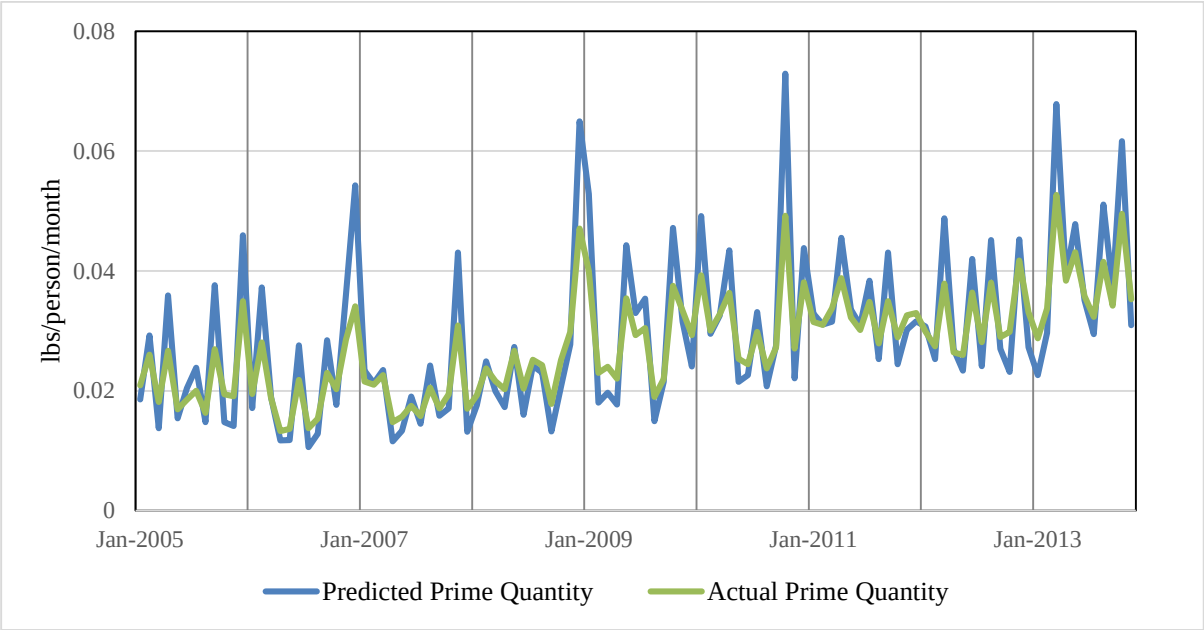


Figure 2A. Branded/Choice Beef Demand

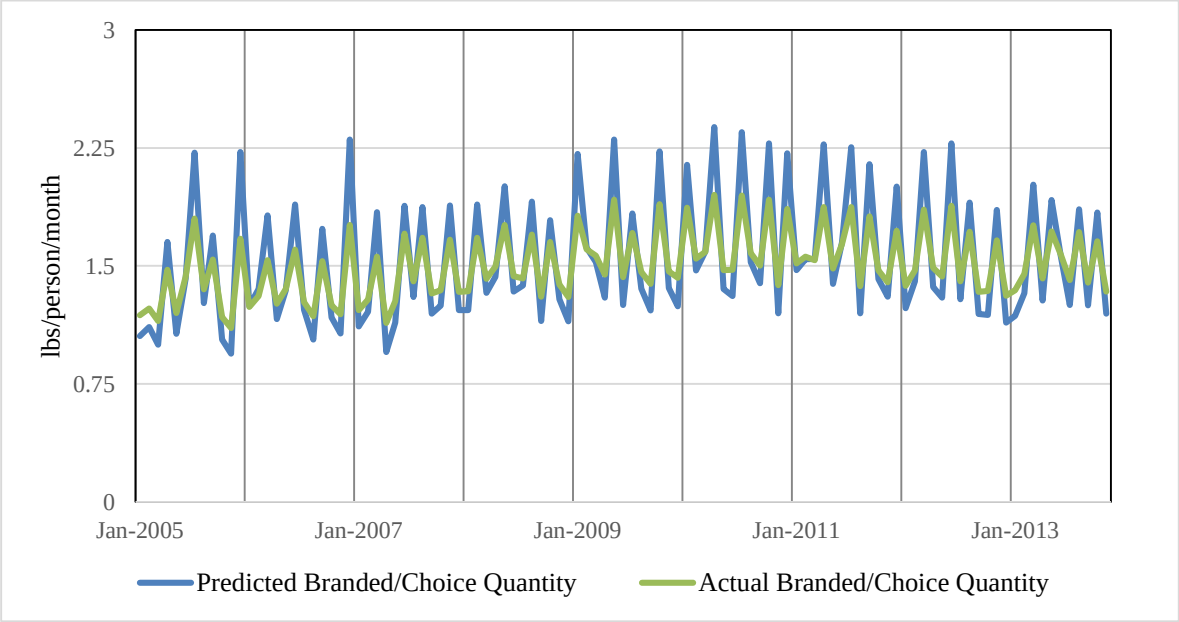
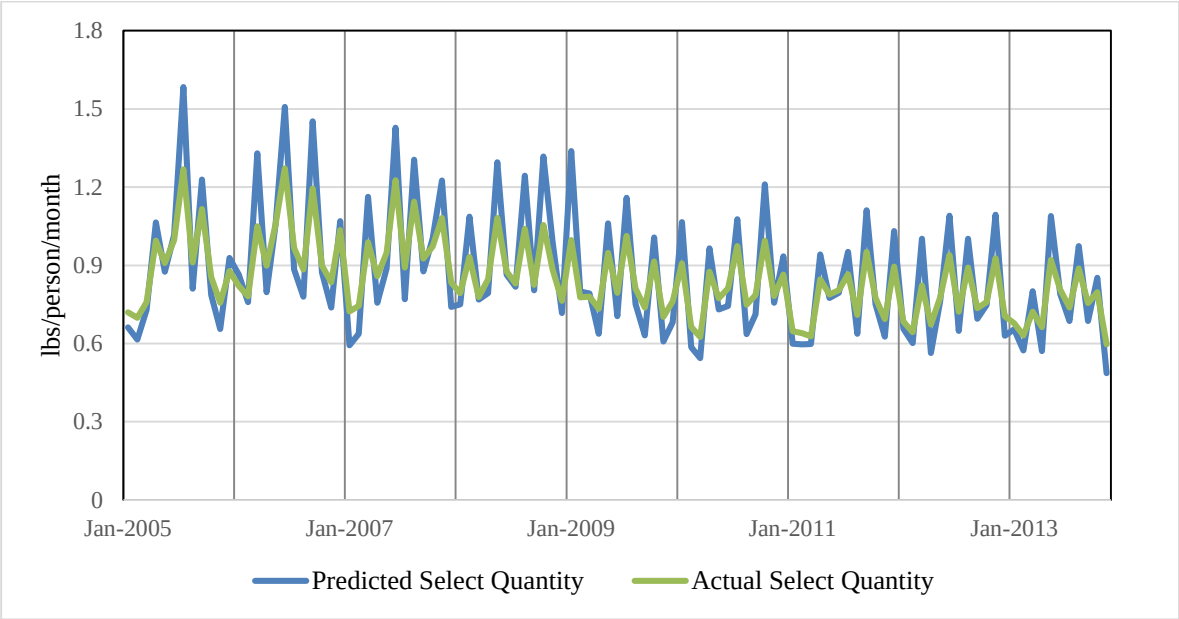
Figure 3A. Select Beef Demand