Crossbreeding: Considerations and Alternatives in an Evolving Market

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Introduction

Crossbreeding most commonly invokes the free-lunch metaphor within the beef industry. The standard mantra is something to the effect of, "Hybrid vigor is the last free lunch, so get all you can with crossbreeding."

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That's a logical perspective. The advantage associated with the benefits of crossbreeding is a well-documented phenomenon. Research has clearly and repeatedly demonstrated benefits associated with implementation of crossbred mating systems in various production systems. Simply put, crossbred animals outperform their straightbred contemporaries. Moreover, those principles are underscored by similar outcomes in other species of livestock.

Weaning weight serves as the single trait of most importance in a majority of cow-calf operations: weaning weight equals pay weight and thereby represents the overwhelming source of revenue for most producers. Favorably, weaning weight also represents the trait in which the greatest benefits of crossbreeding can be realized. The payoff culminates from several aspects of production. Research literature indicates substantial benefit from the combined effects of both individual and maternal heterosis at weaning time (growth and survivability coupled with milk production and fertility, respectively). The average boost varies across respective trials depending upon environmental conditions and management schemes. In general, though, producers weaning crossbred calves nursing crossbred cows typically realize an improvement of 10% to 20% in weaning weight. Moreover, realization of that crossbreeding advantage doesn't require much in terms of additional inputs—thus summoning that "free lunch" caricature.

Simultaneously, though, it's increasingly apparent that beef producers aren't fully exploiting those benefits. Despite well-documented advantages derived from crossbreeding, cow-calf producers have seemingly deemphasized the pursuit of heterosis within their respective operations. That is, the nation's cowherd has reversed course from the broad and fairly well-entrenched undertaking to introduce heterosis, especially those efforts linked to the establishment of Continental European beef breeds within the United States (more on that topic in the next section). If crossbreeding represents the free-lunch, all-benefit, no-cost scenario outlined above, why are producers seemingly retreating from implementation?

That question merits a deeper look. Ostensibly, there must be some reasonable explanation. Meaningful factors or additional considerations often overlooked by conventional wisdom and proven science must be at work. The purpose of this white paper is to explore some possible explanations for those broader genetic strategies within the U.S. cowherd, not from the perspective of a geneticist, but from that of basic animal science and practical, economical herd management.

Overview of Genetic Management and Crossbreeding in the Beef Industry

USDA's 2008 National Animal Health Monitoring System (NAHMS) survey results indicate that the most common descriptor (45%) used by commercial producers to classify their cowherds is "crossbred,"

albeit comprised of no more than two breeds. However, respondents to surveys performed by BEEF magazine (2010) reveal that nearly half of all producers classify the genetic composition of their cowherds as being high-percentage or straight British. That's further reinforced by several informal surveys that indicate the sector transitioning from a multiple-breed status to one predominately composed of a single breed. The Angus breed now accounts for approximately 70% or more of the genetics in the nation's commercial beef production system, leaving the remainder of the herd mix to be divvied up among other breeds.

Many within the beef industry express frustration at that fact, some even referring to it as "disturbing." Academicians and industry observers voice a common sentiment: "It's a mistake for producers to move back to straightbreeding programs and give up the additional pounds that can be produced from a herd through good, well-designed crossbreeding programs." More importantly, it raises questions about why such a development has occurred over time.

It's important to note that many assumptions about beef cattle crossbreeding are from a one-size-fits-all model. However, the beef industry, especially the cow-calf sector, remains a highly fragmented business comprising 750,000 independent entities. Any attempt to make industry-wide inferences about any topic proves somewhat tenuous and may therefore lead to erroneous assumptions.

Clearly, operational priorities are highly varied across the segment, and that's likely true for a number of management considerations.

For example, 45% of producers indicate breed is an unimportant consideration when purchasing a bull or semen to breed replacement heifers (NAHMS, 2008). As such, a large portion of the industry exemplifies either:

1) Haphazard implementation of crossbreeding within individual herds or,
2) General disregard for the importance of systematic or strategic planning when it comes to genetic management.

Either way, the outcome is the same: despite widely accepted perceptions about genetic management and the importance of crossbreeding, a large number of producers possess no real breeding plan at all – they remain indifferent or unaware of benefits associated with hybrid vigor (at least as implemented in a systematic manner).

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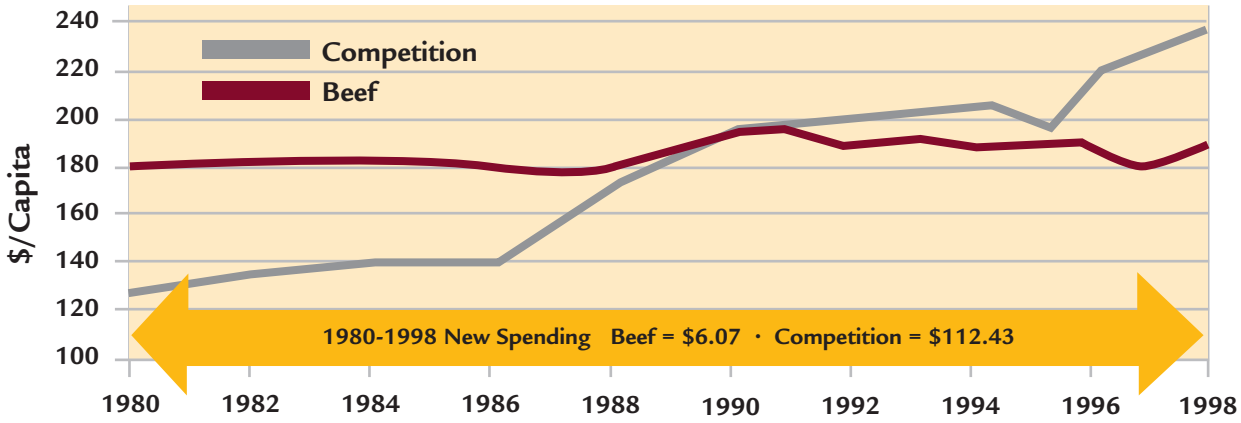
By default, that still leaves half of operators who could be categorized as relatively discerning and strategic about planned mating systems (either crossbred or straightbred). That demarcation, however, underscores the wide gamut of philosophies regarding genetic management. And therein we find the inherent difficulty associated with making broad assumptions about traditional business models and related decision-making across the cow-calf sector.

Background: Business Transition

The beef industry has traditionally operated within a highly segmented, fragmented commodity framework. As referenced earlier, the primary revenue driver for most cow-calf operations rests wholly on weaning weight. Historically, there's been little differentiation within the marketplace in terms of quality discounts or premiums. Therefore, profitability within the cow-calf sector was, and remains today, largely determined by operational efficiency. The advantage goes to those who managed to increase output (pounds of weaning weight) while keeping production costs in check. That equation explains the overwhelming emphasis that beef educators have placed on crossbreeding in recent decades.
However, it's also important to note the beef industry began to undergo significant transformation during the early 1990s. As such, some historical perspective is useful here. Notably, the beef industry's market share began slipping in the early 1980s. Misperceptions about beef's health attributes were gaining traction within the medical community and subsequently spilled over into the general public. Adding insult to injury, it became apparent during the '90s that beef was also losing its primary market advantage: palatability. That was especially concerning given it's the foremost purchasing motivation among consumers and provides opportunity to derive price premiums relative to the competition. Convergence of these factors coupled with aspects of product inconsistency, lack of preparation convenience and a disproportionate rise in costs placed the industry in a tenuous situation.

The competition took advantage of the opening. Pork and poultry were successfully advancing their respective perceptions among consumers while also becoming increasingly efficient. Beef was burdened in terms of product price/value relationship. Growth stalled: between 1980 and the 1998 low point in beef demand, new spending on beef products was meager, just $6/person. Meanwhile, new spending on pork and poultry grew by $112/person. Stated another way, beef garnered only five cents out of every new spending dollar while the competition teamed up for 95 cents (see Figure 1).

Figure 1: Per Capita Meat Expenditures: Beef vs. Pork/Poultry Combined
(Adapted from USDA: ERS)



Beef was working within a haphazard system that encouraged commoditized production. Cattle (and their carcasses) were often forced to fit systems they weren't suited for. Cooler sorts proved unreliable in meeting customer specifications. Shortfalls and inefficiencies had to be minimized. Bolstering competitiveness would require the industry to become more customer-centric and move away from its commodity approach.

The industry had to establish systematic, process-driven incentives to ensure a reliable, steady supply of cattle in the future to meet customer demands. Towards that end, the National Beef Quality Audits (NBQA) began initial work in 1991 to identify critical quality shortfalls while finding the baseline of system performance. NBQA 2005 identified those components as an ongoing concern, while the audit's top three industry goals for 2010 were: 1) clarification of market signals that encourage production of cattle, carcasses and cuts that conform to industry targets; 2) foster communication among groups and segments of the beef supply chain; and 3) increase age and source verification to build supply lines to fit domestic and export markets.

Those objectives establish the premise of industry coordination based on objective and verifiable market signals. Industry economics began to change, increasingly reflecting the entire value chain. That's brought favorable change to the beef industry's supply chain by facilitating production systems that are increasingly responsive to end-user specifications. Ultimately, those market signals began to shift the profit equation and subsequent management decisions for cow-calf producers.

Background: Genetic Influence and Beef Quality

The mandate to increase beef competitiveness discussed in the previous section brought about renewed interest in beef quality research - including the influence of breed composition. With respect to quality grade and Warner-Bratzler Shear (WBS) values, rankings generally show Angus as superior to Hereford, and British cattle superior to Continental-European cattle (Koch et al., 1976). Similarly, other researchers have ranked British cattle relatively superior to Continental-European cattle in marbling score or USDA quality grade (Adams et al., 1977; Huffhines et al., 1993; Koch et al., 1979; Koch et al., 1982; Speer, 1993).

Table 1. Sensory Panel Ratings and Warner-Bratzler Shear (WBS) Force Values
(Adapted from SAFS, 1993)

			% in WBS categories		
Breed Type X Quality Grade	Overall Palatability Rating	WBS (kg)	Tender < 3.9	3.9-4.5 kg	Tough >4.5 kg
British Choice	4.58	3.13	91.2	8.8	2.9
British Select	4.57	3.49	78.0	22.0	8.5
Continental Choice	4.45	3.39	76.6	23.4	1.6
Continental Select	4.31	3.65	65.7	34.3	11.0

The Strategic Alliances Field Study (SAFS; NCA, 1993) evaluated the influence of breed on beef tenderness (as evaluated by Warner-Bratzler shear values – see Table 1). Shear force value rankings revealed that British cattle averaged 3.26 kg while Continental cattle averaged 3.53 kg; moreover, "Continental cattle were more than twice as likely to have steaks with a shear force value of more than 8.5 lb (3.9 kg) [the threshold at which steaks are categorized as being "tough"] – 32.1% versus 14.4% for British and British-crossbred cattle." As follow-up, the 1995 Beef Customer Satisfaction Study (Reagan et al., 1995) also evaluated breed-type effects relative to palatability ratings and reported findings similar to SAFS results. Consumer "Overall Like" ratings resulted in the following rankings (from most to least favorable): British heifers, British steers, Continental steers, Continental heifers and Brahman crossbred steers.

Such research and real-time market signals reinforced British influence within the cowherd during the past 20 years. That emphasis is evident in the 2010 Alliance Yellow Pages (BEEF, 2010) listing of 33 consumer-based programs: 22 of those specify breeds and 19 of the 22 require either 50% Angus minimum (9), 50% British minimum (7) or British influence (3). Clearly, the most important breed differentiation revolves around Angus or Angus-derived cattle. The breed provides producers with a historical carcass database that is vastly larger than that of other breeds. Using that resource, cow-calf producers opting for retained ownership are able to select for fast-growing cattle with a well-established genetic base for enhanced carcass performance.

Background: Value-Added Programs

Crossbreeding hasn't been the only educational emphasis within the academic realm for beef producers. Much of the influence of the industry's market transition detailed above has resulted in new opportunities to more fully participate in the value chain and transition away from the traditional, weight-centric marketing model. And as such, over the course of the past 20 years, producers have also increasingly been encouraged to add "value" to their cattle through various types of management programs and/or implementation of new marketing strategies. Correspondingly, Schulz et al. (2009) noted that, "...while it is important for producers to recognize those factors that impact feeder calf prices, they need to be cognizant of the fact that the market is dynamic such that the relative premiums and discounts change over time."

From strictly a breed perspective, such influence has significantly worked its way into the feeder cattle market. For example, Schulz et al. (2009) explain that, "Cattle buyers paid the greatest premium for Angus ($3.10) and Angus X Hereford crossbred calves ($2.72) compared to the base breed (Hereford influenced calves)...A significant premium was paid for black ($2.49), white ($1.01), and mixed hide colors ($1.89) when compared to red colored calves. Because the premiums and discounts are additive, this implies a black Angus calf would bring $5.59 per cwt premium ($3.10 + $2.49) relative to the base animal (red Hereford)." Such premiums are justified on several counts including access to subsequent grid marketing, quality grade and *Certified Angus Beef*® (CAB®) brand premiums (more later).

Background: Consolidation

The beef industry's cow-calf sector has undergone significant transition on several fronts during the past 20 years. Perhaps most significantly, the U.S. beef cow inventory has experienced considerable liquidation (see Figure 2). Moreover, indicators point to that trend likely continuing, a phenomenon that has many analysts rethinking commonly-held paradigms about beef cattle cycles. During the 20-year period between 1992 and 2011 approximately 160,000 beef cow operations exited the business (Figure 3). And while relatively small operations (<50 cows) still comprise the majority of beef cow operations in the United States, they also represent the category that overwhelmingly accounts for decline in the beef operation census.

Those dynamics represent significant consolidation and reallocation of beef cow inventory in the United States: the 2007 Ag Census (NASS) reveals that operations with 200 cows or more account for just 3.8% of all farms or ranches but manage nearly 37% of the total beef cow inventory. It should be noted that trend is not likely to reverse, given ever-increasing operating costs and initial capital investment associated with farm and ranch ownership.

Figure 2: U.S. Jan 1Beef Cow Inventory (mil cows)

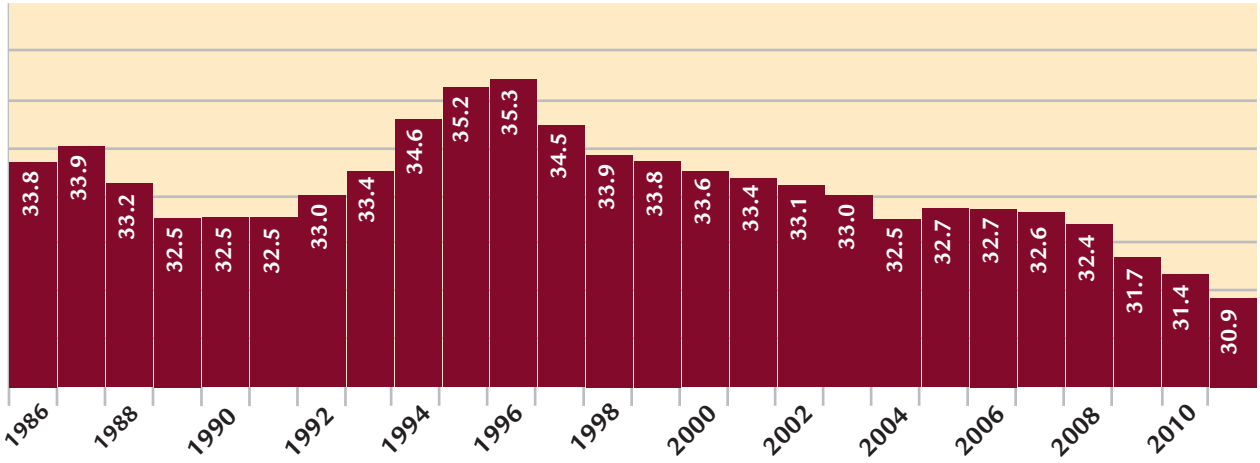
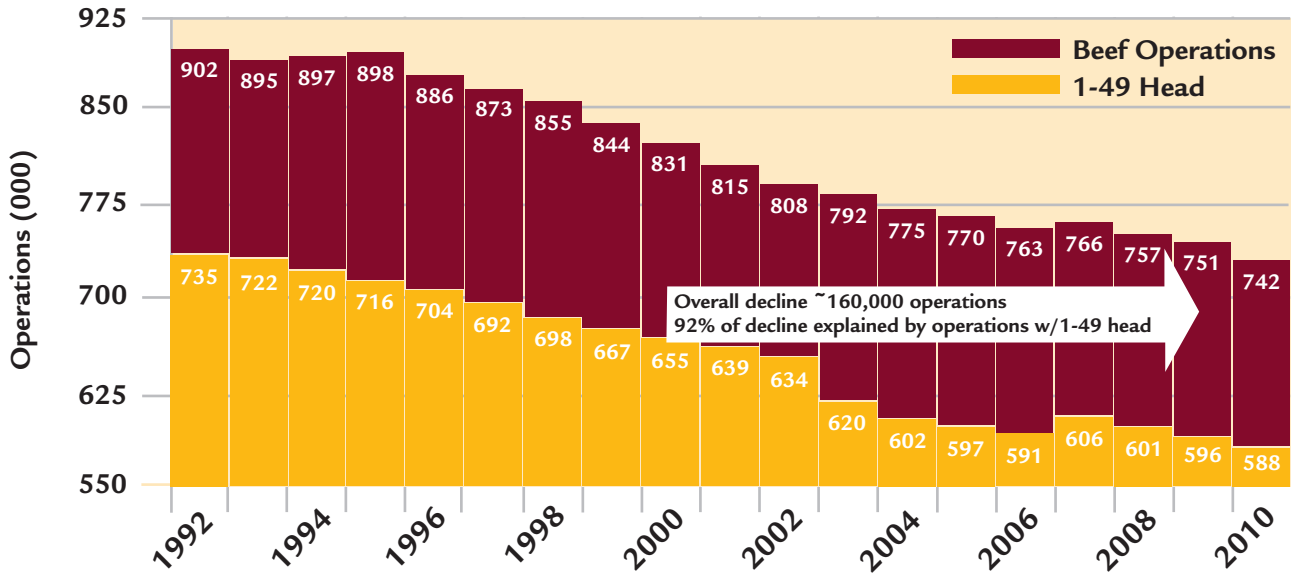


Figure 3: U.S. Beef Cow Operations



More specific to this discussion, the trend suggests some important implications in terms of commerce and associated business mentalities within the beef industry that will be discussed later in the paper. Producer survey results (Akel and Associates, 2003) reveal a perception of greater sophistication among larger producers: level of education, knowledge of technology, awareness of issues, business skills and openness to new relationships are all perceived to be more advanced relative to the previous generation (who likely operated smaller operations). Declining margins and increasing operation size leads successful managers to recognize that profitability is not driven strictly by increased production; rather, net income growth stems from greater emphasis on controlling input costs, financial oversight, risk management, value-added marketing and opportunities for further adoption of economies of scale.

Business Convergence and Retained Ownership

Increasing consolidation and the appearance of new market-value signals have altered the business

landscape. They are mutually reinforcing. As operations get larger they have the tendency to move from strictly a "weigh-up" focus to one of more specified marketing targets (to take advantage of marketplace premiums and avoid discounts); with opportunity to achieve critical mass, market signals become even stronger. That development has given rise to a multitude of value-added programs not available 15 to 20 years ago. As a result, the relative worth of feeder cattle has shifted from strictly commodity-oriented pay weight to more comprehensive considerations (a market further framed by relative discounts and premiums).

In other words, revenue opportunities within the cow-calf sector have proliferated dramatically in recent years, especially in light of significant new value-creation systems. Those include access to a plethora of new market premiums (and corresponding discounts) coupled with the opportunity to exploit genetic and management inputs through retained ownership. Structural shifts and market transition have reinforced one another. Market signals for cattle that fit various programs have influenced the supply chain; the production sector has responded accordingly and produced the critical mass of inventory to meet those needs. At the end of the day, supply/demand dynamics have established a virtuous loop for beef producers where uniformity, consistency and meeting end-user specifications are increasingly rewarded. The beef industry decreasingly "works" in a system that rewards weight only.

That shift alters the traditional profit equation with such signals working upstream to the cow-calf level:

> Determining true feeder calf value will likely become increasingly complex in the future as the industry increasingly turns to vertical cooperation and value-based marketing. Within that framework, genetic uniformity, carcass merit, and cattle health will become higher priorities. Producers are encouraged to prepare themselves by creating and documenting value as inter-segment communication increases. (Speer, 2001a)

Many cow-calf producers have actively pursued and leveraged their increased access to those value-added programs. That outcome has clear impact upon genetic management.

The higher volume of fed cattle marketed through value-based programs places greater importance on management that improve health status of calves (Speer et al., 2001b). In reference to cattle health and as it interacts with genetic selection, several studies reveal that heterosis provides no direct benefit in the feedyard. Straightbred Angus cattle incurred lower morbidity rates and remained healthier through the feeding period compared to their crossbred contemporaries. More significantly, straightbred and high-percentage Angus cattle subsequently required lower treatment costs and generated higher-value carcasses (see Table 2; Reiman, 2010; Busby et al., 2010).

Meanwhile, one of the more popular options to increase revenue involves retaining ownership of the calf crop (or some portion thereof) through the feedyard. The strategy has allowed many operations to benefit from both genetic and management inputs at the ranch. Nearly 20% of cow-calf producers (BEEF, 2010) and one-third of stocker operators (BEEF, 2007) indicate retained ownership as an important component of the marketing program.

Retained ownership establishes a more comprehensive and far-reaching revenue model compared to strictly selling the calf crop at weaning or as yearlings. Participation in such a system provides new opportunities, but it also represents risk that must be mitigated. Confidence in consistency of performance is critical. Economic incentives shift in a retained ownership model (albeit weight remains the

Table 2. Health Performance Across Breed Categorizations
(Adapted from Reiman, 2010 and Busby et al., 2010)

Breed Categorizations Analysis based on Decatur County Feed Yard Data: 2003-2009 (56,438 head)

Item	Solely Angus	Predominately Angus	Other Breeds	Unknown
Treatment Cost ($/hd)	2.88	3.77	4.44	3.81
Final Weight (lb.)	1214	1178	1189	1178
ADG (lb./day)	3.53	3.32	3.21	3.27
CAB Acceptance Rate (%)	19.19	11.93	5.84	9.19

Percentage Angus Analysis based on Tri-County Steer Carcass Futurity
Data: 2002-2009 (47,526 head)

Item	Low (9.2%)	Half (48.6%)	Three-Quarter (74.2%)	Straight (99.4%)
Treatment Cost ($/hd)	7.72	5.54	6.72	5.60
Days on Feed	175.2	169.1	167.4	163.9
ADG (lb./day)	3.1	3.2	3.2	3.3
CAB Acceptance Rate (%)	8.9	15.8	16.7	27.3

primary influence on revenue) towards a more quality-driven system that rewards overall performance and avoidance of significant non-conformance. That is, economic returns are increasingly (if not completely) dominated by feedyard performance and carcass merit (especially when selling cattle on a grid basis) with value determination dependent on weight, quality grade, yield grade, program incentives and various other factors.

In many cases, cattle are no longer marketed in a traditional commodity system where weight is the sole economic driver. In those scenarios, weight and value are not mutually exclusive: producers do not have to sacrifice production to attain marketplace premiums. Closeout analyses across nearly 450,000 head (Professional Cattle Consultants Jan. 2004 through Dec. 2009; Walter and Hale, 2010) reveal that most profitable steers exhibited the best feedyard performance and produced the heaviest carcasses while also generating the highest percent of Choice and Prime grading carcasses: "The analysis appears to disprove some common perceptions about tradeoffs between feeding and carcass performance. High-grading cattle had better average daily gains, heavier carcass weights and were more profitable than low-grading cattle."

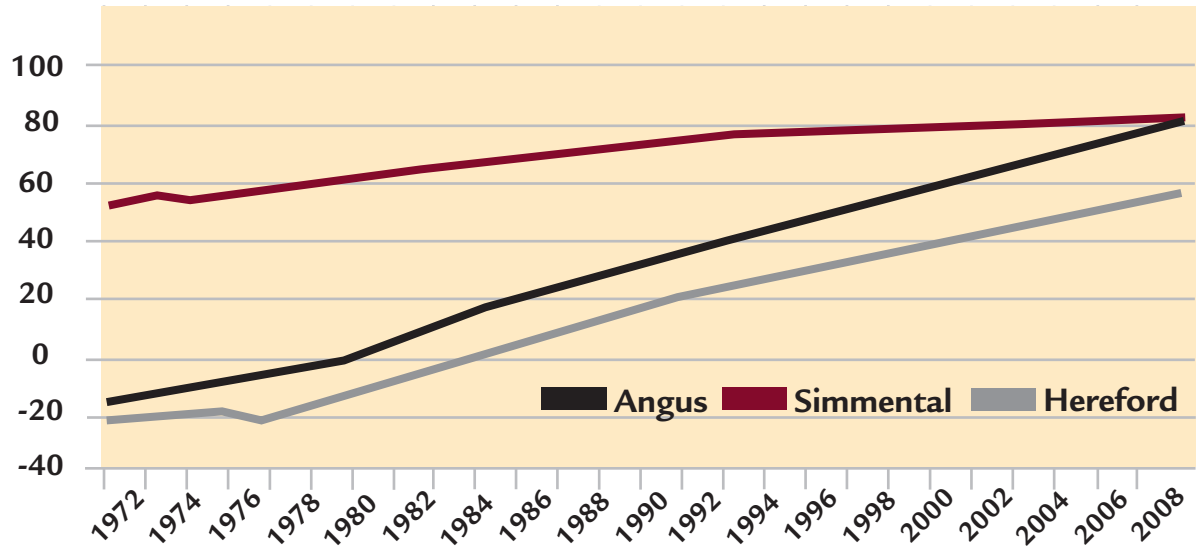
Access to those marketing programs has clearly influenced the seedstock sector and subsequent purchasing and breeding decisions. For example, the BEEF magazine Cattle Production Genetics 2010 Survey revealed that 45% of respondents are involved in some type of "value-added production and marketing" endeavor. Nearly 40% of all seedstock producers provide their customers opportunities to network or participate in value-added programs including calf age, preconditioning, source of origin and verified genetics services. Meanwhile, 24% of seedstock respondents indicated plans to offer new services in the next three years while NONE planned on eliminating any type of additional service.

Business Intangibles

Much of the discussion above references relatively tangible drivers: the direct influence of heterosis on weaning weight and the shifting business environment around the revenue equation for beef operators. Such influence is easily accounted for and evaluated within most cow-calf operations. But declining emphasis on crossbreeding and those benefits of heterosis within the nation's cowherd likely reflect other considerations as well, and those inherently lead to questions about shifting priorities across an array of intangible factors.

First, breed differences have diminished over time. Research reveals that performance disparities have narrowed over time, especially with respect to growth and/or growth rate (see Figure 4): British breeds in the U.S. are now comparable to Continental breeds (see Table 3). (Note: Breed comparison estimates provided in this paper derive from studies performed by the U.S. Meat Animal Research Center, Clay

Figure 4: Yearling Weight Genetic Trend (lb)
Adapted from USDA: MARC Across-Breed EPD Trends (Kuehn et al., 2011)



Center, NE and serve as base values for the purpose of establishing across-breed EPD adjustments. Such values are to be utilized to evaluate genetic differences across populations while across-breed EPDs are most appropriately utilized to compare EPDs of individuals of different breeds.)

That influence cuts both ways. One, from a selection standpoint, the differential or marginal additive effect shows less potential across breeds over time. Two, from a mating standpoint, it's also reasonable to assume that as breeds have become more similar, cow-calf producers have realized less heterozygosity and ensuing performance benefits when crossbreeding. As such, the boost realized from heterosis isn't what it used to be and hence being deemphasized within the commercial sector.

What's more, within the context of diminishing differences between breeds (and smaller opportunity to achieve better performance from both additive and non-additive genetic perspective), the risk/reward relationship must also be weighed carefully: increased potential for heterosis versus potential shortfalls in functional traits. Seemingly, over time there's a broad realization of narrowing breed differences coupled with a renewed focus and priority within many cowherds to minimize problematic outliers.

Table 3. Breed of sire means for 2009-born animals
(Adapted from Kuehn et al., 2011)

Breed	Birth Wt.(lb.)	Weaning Wt. (lb.)	Yearling Wt. (lb.)	Maternal Milk (lb.)	Marbling Score (4.00=Sl00, 5.00=Sm00)	Ribeye Area (sq in)	Fat Thickness (in)
Angus	91.8	594.9	1031.3	585.1	5.80	12.77	.578
Hereford	96.2	590.4	1002.2	561.4	5.09	12.70	.517
Red Angus	92.1	578.3	997.8	578.3	5.44	12.51	.494
Shorthorn	98.1	582.0	1014.8	585.1	5.25	12.87	.405
South Devon	96.8	594.3	1020.7	580.2	5.76	12.90	.463
Beefmaster	97.0	604.1	1000.2	567.7			
Brahman	103.1	604.1	976.6	590.9			
Brangus	94.7	586.4	1007.1	575.1			
Santa Gertrudis	98.1	587.1	978.1		4.73	12.38	.420
Braunvieh	95.4	573.5	983.1	593.5	5.24	13.58	.510
Charolais	98.9	613.2	1039.5	574.1	4.98	13.61	.343
Chiangus	95.5	566.3	973.9		5.08	13.16	.404
Gelbvieh	94.9	593.8	1012.8	591.3			
Limousin	95.2	592.6	997.2	570.6	4.64	14.10	
Maine-Anjou	96.0	578.8	997.9	578.9	4.80	13.66	.358
Salers	93.6	588.8	1015.1	583.1	5.34	13.40	.349
Simmental	95.5	606.9	1030.7	582.0	5.01	13.61	.363
Tarentaise	93.5	597.6	999.4	585.7			

That's especially true when considering the aggregate effect of misdirected attempts at crossbreeding over the years; singular emphasis on boosting weaning weight through non-additive genetic effects (facilitated through mating systems) have seemingly led to implications that functional traits on the cow side (facilitated through selection) no longer matter. Producers inadvertently ignored or unintentionally introduced a variety of problems that need to be fixed or corrected within the cowherd.

Background: Time / Labor Management Priorities

The cow-calf sector is highly varied in terms of operational priorities and management strategies: only one-out-of-four beef operations identify the cowherd as a primary source of income (USDA: NAHMS, 2008). As such, 75% of the nation's cowherds represent a supplemental source of income. Therefore, it is neither the primary financial emphasis nor occupation for most operators. That makes it difficult to pinpoint, from a financial perspective, the major cost factors incentivizing cow-calf producers.

However, consolidation trends within the industry possess some important ramifications and provide some important indicators with respect to crossbreeding trends. Most notably, production bias is shifting away from smaller operations towards larger, more diversified businesses; these farms and ranches

tend to be more profitable than their predecessors and increasingly operated by younger, better-educated producers who utilize hired labor (see table 4; Short, 2001).

Table 4. Selected Characteristics of Cow-Calf Operations: Categorized by Number of Cows Maintained
Adapted from Short (2001)

	Number of cows maintained			
	<50	50-99	100-249	250+
Age Distribution (% of respondents)				
< 50 years old	30	35	30	42
50 + years old	70	65	70	58
Education (% of respondents)				
High School or less	65	48	42	32
Attended college	19	24	23	32
Completed college	16	28	35	36
Labor Efficiency (hrs / bred cow)				
Paid	2	2	3	6
Unpaid	30	25	18	10
Total	32	27	21	16
Cattle production value ($)	7,823	19,581	50,636	186,885
Farm production value ($)	36,124	77,644	143,617	325,359
Total acres operated	340	1,008	2,403	8,744

Operations with 250+ cows dedicate half the time per cow compared to those with fewer than 50 cows. Accordingly, time utility and labor efficiency are increasingly important, especially to larger operations, and these considerations impact trait prioritization. (Emphasis on time utility and labor efficiency are underscored by data highlighted in table 5.) Meanwhile, the smaller operator is already committed elsewhere, while the larger operator must commit more time to other aspects of the diversified farm or ranch.

From the standpoint of overall operational profitability, the beef enterprise cannot be afforded the luxury of incurring indirect costs associated with labor:

> Time utility and labor efficiency are inherently related and amidst trends both are escalating in importance as operations increase in magnitude. Those relationships are a function of two likely factors: 1) most obvious – an advantage in terms of economies of scale, and 2) less obvious – increased diversification causes labor resources to become more widely dispersed over other entities reducing commitment to the beef enterprise. Meanwhile, data indicates that cowherd inventory is positively related to operational size, inferring that cattle production is increasingly

Table 5. Beef Cow-Calf Production Management Practices: Work Time Devoted to Cow-Calf Operation
(Adapted from NAHMS, 1997)

Cowherd Size

	<50	50-99	100-299	300+	Overall
Operator's work time devoted to cow-calf operation (%)	29.1	42.9	55.8	78	34.5
Time devoted to cow-calf operation (hours / cow / week)	3.1	1.2	.93	.83	2.55

> neither the primary focus nor the core competency for many operations. Labor resources, whether paid or unpaid, are not available to deal with unexpected or chronic problems requiring additional time investment and distract from scheduled, productive activities. From the stand point of overall operational profitability, the beef enterprise cannot be afforded the luxury of incurring excessive indirect costs sourcing from inordinate allocation of labor resources. (Speer, 2004)

Regardless of enterprise size, the overwhelming cost (and subsequent priority) of operating a cow-calf operation is related to cow maintenance and care. Labor resources, regardless of operational size, are not available to deal with unexpected or chronic problems that mandate additional time investment and distract from scheduled, productive activities.

Functional Traits and Problem Mitigation

Establishing the value of a replacement female is dependent on several factors. First, consideration of direct metrics: replacement value can be determined by calculating the net annual income (revenue less expenses) she is expected to produce over her productive life. Moreover, the greatest expense incurred in any operation is the maintenance of an open cow. Second though, are the indirect metrics. Those include the functional- or convenience-trait factors described earlier that often represent a time drain on cowherd management (feet, udders, eyes, dystocia, disposition, etc.). The outcome is that cows are often sold (culled) for reasons other than pregnancy status or even failure to wean a calf:

> Nearly two of three operations (62.3%) sold cows for purposes other than breeding. The highest percentages of these operations sold cows (culls) because of age or bad teeth, and pregnancy status (55.7% and 41.8% respectively). The share of operations that sold at least one cull cow in 2007 because of pregnancy status ranged from 25.0% of those with 1 to 49 beef cows to 83.6% of operations with 200 or more beef cows. In general, the percentage that sold at least one cull cow in 2007 for physical unsoundness, bad eyes, udder problems, or producing a poor calf in creased as herd size increased. (USDA: NAHMS, 2008)

In other words, management priority is largely focused on simply identifying and eliminating or avoiding problems versus maximizing productivity.

From that perspective, commercial producers seek management simplicity to the point of sacrificing or precluding additional production advantages. Most commercial operations, regardless of size, possess neither the time nor resources to deal with bad feet, udders, dystocia and the like (more in the next section). Accordingly, the 2010 BEEF survey reveals that disposition, birth weight, hoof and leg soundness all ranked above weaning weight and yearling weight in terms of genetic prioritization among commercial producers. In other words, time savings has more value than additional weight or production. The inference is that the marginal benefit of heterosis isn't sufficient if it's associated with the added marginal cost of purchasing genetics that might represent the risk of requiring more time and labor.

"The marginal benefit of heterosis isn't sufficient if it's associated with the added marginal cost of purchasing genetics that might represent the risk of requiring more time and labor."

Calving Ease Considerations

One of the most time-consuming practices for beef operators is management of the calving females – especially heifers and in the general case of dystocia. In an ideal world, calving females would be observed regularly, but in most cases that simply isn't possible; time constraints don't allow for such luxury. Consider that only 60% of calves are born in a defined calving season of February through April and approximately 55% of all operations adhere to no set calving season at all (APHIS, 2011). Meanwhile, to ensure a high percentage of live-born calves, the rule of thumb is that no more than three hours should elapse between observation of calving females; however, only one in four operators observe calving cows more than twice daily (APHIS, 2011). Therefore, three out of four operators devote relatively minimal time to active observation of calving cows or position themselves to actively provide assistance if needed.

As a result of those choices in time use, predictability of calving ease is essential to most beef producers. The BEEF (2010) survey results indicate that information related to actual birth weight and its EPD were the two highest-ranking items of information required by bull buyers (71.7% and 71.3%, respectively) and reported such information vital to making a purchase. The next two items were actual weaning weight and, reinforcing the calving-ease issue, calving-ease-direct EPD (56.1% and 55.0% of buyers, respectively). Clearly, live calves – light or heavy at sale time – generate more revenue than dead calves (not to mention the consideration of potential breed-back problems and cow mortality in the event of dystocia).

Heterosis has a positive effect on growth and all traits that are reflective of that influence. That's favorable when considering traits such as weaning weight or post-weaning growth. However, it's unfavorable when it comes to birth weight. Holland and Odde (1992) explain that crossbred calves not only weigh more at weaning time but also weigh more at birth:

> Heterosis can profoundly influence birth weight in cattle depending upon the breed or breed-type utilized. Heterotic effects observed between crosses of standard British or European breeds range from 0% to 5%. ...Additionally, moderate effects of heterosis may be observed in crossed lines of cattle within a given breed.

Simultaneously, maternal heterosis also exerts an influence that should be considered; MARC data reveals that crossbred (F1, F2 and F3) females had calves that weighed an average of approximately 5.5 lb. more than purebred calves at birth – albeit the "heterotic effects on cow size are likely sufficient to accommodate increased calf birth weight resulting from heterosis without increasing dystocia" (Gregory et al., 1991).

Nonetheless, it appears that beef producers have overwhelmingly emphasized calving ease predictability from a large and reliable data base; the risk/reward relationship of losing calves at birth versus heavier calves at weaning is heavily tilted towards the former. Per that point, with respect to genetic selection, the most significant advancement during the past 30 years has been development and refinement of expected progeny differences (EPDs). As many predicted, EPDs have become more important in terms of purchasing criteria over time; bull buyers now have access to objective, quantifiable information for a plethora of economically-important traits. Development, innovation and reliability of such tools are largely dependent on the size of available databases; a larger database inherently leads to improved precision for calculation purposes.

Within that consideration, Angus cattle possess an overwhelming advantage; table 6 outlines registration trends among the significant cattle breeds in the U.S. in recent years (NLPA, 2011). Angus registrations outnumber all other breeds and roughly outnumber the next seven breeds combined (utilizing reasonable estimates for 2008 Gelbvieh registrations). As such, bull buyers have increasingly emphasized informational availability and precision when purchasing new bulls.

Table 6. Registry Statistics History
(NLPA, 2011)

Breed Association	2006	2007	2008
American Angus	347,572	347,755	333,766
American Inter. Charolais	74,569	74,030	65,954
American Hereford	69,344	69,754	63,943
American Simmental		51,166	45,500
Red Angus	47,064	47,011	48,061
International Brangus	25,097	21,903	29,643
North American Limousin	37,742	34,690	28,928
American Gelbvieh	36,222	34,405	n/a
American Shorthorn	19,700	18,000	15,715
Beefmaster Breeders	18,202	17,390	14,692
American Maine-Anjou	12,316	10,127	10,368
American Brahman Breeders	8,300	8,364	8,500
Santa Gertrudis Breeders	7,500	7,500	7,500
American Chianina	9,270	7,000	9,756
American Salers	6,586		6,552
Braunvieh Breeders	3,500	4,000	3,500

Cowherd Maintenance Considerations

Crossbred females wean heavier calves than their straightbred contemporaries due to improved fertility and milk production. Moreover, those benefits increase during times of environmental stress. The outcome being that cow-calf producers would readily attempt to realize the benefits of crossbreeding. It's also well established that crossbreeding allows producers to take advantage of breed complementarity: herd production can be optimized when mating systems enable breeds, utilized in combination within the production system, to contribute their respective strengths. However, as previously noted in Table 3, differences between breeds have lessened over time, and the concept may be at odds with value-based strategies to improve cow families by stacking traits to rise above averages.

Furthermore, with respect to cowherd management, Ritchie (2001) notes that some demarcation of the "optimum" cow (or cowherd) is a moving target and will likely "vary with the production environment and the requirements of the marketplace." Ritchie further notes (citing Taylor, 1994) that some measure of maximum profitability is likely achieved before maximum productivity: "the profit maximizing level of input use and subsequent output is less than the output maximizing level." In other words, weaning weight is NOT the only measure of profitability for cow-calf operators – whether or not it is influenced by direct or maternal heterosis or some combination of both.

The question of an enduring pursuit of more weight (when not economically feasible) or simply pursuing heterosis-for-heterosis-sake assumes a different perspective when considering the beef industry's incredible advancement in recent years. McMurray (2008) explains it this way:

> In 1975, a calf that weaned and went to market weighing 400 lb. was considered a good calf. Today, a 400 lb. calf would not generate a positive net return in most operations. With the in creasing costs of production, it now takes calves weighing nearer to 600 lb. to generate a positive net return. Over the last 30 years, the cow-calf segment has improved weaning weights to close to 600 lb. This has been accomplished by incorporating a number of improvements in technol ogy ... As a result of these improved technologies, weaning weights in calves have increased about 200 lb. in the last 30 years. It should come as no surprise that during this same period, carcass weights of both fed steers and heifers have increased substantially. During this same period, not so coincidently, carcass weights of both slaughter bulls and cows have also increased. This, of course, makes perfect sense considering that these bulls and cows are the sires and dams of these larger fed steers and heifers. Just as weaning weights have increased significantly since 1975, so have the carcass weights of all classes of cattle. During this 30-year period, cattle were selected for growth – or, more specifically, average daily gain and yearling weight – and it worked. It worked so well, in fact, that there has been considerable discussion about carcasses that yield cuts that are too large to "fit the box." What also worked was exactly what animal breeders warned about: If producers focused too intently on direct growth traits, the mature size of breeding cattle would increase as well because of the high genetic correlation between growth and mature size. The carcass weights of cows have increased by nearly the identical amount as steers. This is not surprising, either; after all, they are the mothers of the steers. The bulls in creased more than the others simply because selection efforts were focused on sires, and those that did not reach standards were castrated ... it is well within the realm of possibilities that the average mature weight of cows in the U.S. today is about 1,350 lb., an increase of about 300 lb. since 1975.

McMurray goes on to point out that steer and heifer carcass weights increased 144 lb. and 194 lb., respectively between 1975 and 2005. In fact, beef production during the 1990s increased steadily at approximately 7 lb. annually per beef cow. (As a side note, that trend effectively created more cows over time due to improvements in both genetics and management, and leads to some pertinent questions about the state of the industry; Speer, 2002).

Ritchie (2001) ultimately summarizes by stating that, "each producer must analyze his own situation and fit the cow to that situation, but with a look to the future and enough flexibility to make subtle alterations as conditions change." Ritchie highlights two renowned commercial operations (Jack Maddux, Wauneta, Neb., and Rob Brown, Throckmorton, Texas) highlighting maximum specifications (see Table 7 below). Given those specifications and current performance of cattle, perhaps those maximums have been achieved. And when further considering the current seedstock pool available to commercial operations, it's likely that uniformity and consistency are being prioritized versus simply generating more pounds.

Table 7. Commercial Herd Targets
(Adapted from Ritchie, 2001)

Trait of Importance	Maddux (1992)	Brown (1992)
Birth Weight	100 lb. maximum	
Weaning Weight	600 lb. maximum	600-650 lb. at 7 1/2 months of age 50%-60% of dam's weight
Cow Weight	1200 lb. maximum	
Feedlot / Carcass Performance	1200 lb. maximum	1200-1300 lb. at 15 months of age Feeder conversion 6:1 60% Choice or better

Implementation Considerations

The very consideration of implementing crossbreeding can be somewhat daunting. Many operations would rather forego such effort if production can be maintained while also ensuring relative absence of problems. As a result, producers are often encouraged to utilize composite bulls as a simplified means to boost heterosis and subsequent production. That approach, though, contains several complications that need to be considered.

First, composite bulls don't necessarily boost maternal heterosis if such genetics match what already exists in the cowherd; in fact, in many instances composite bulls actually represent backcrossing and may actually reduce heterosis potential, versus utilization of a breed that serves as a total outcross. Second, referencing some discussion regarding informational availability, one must also consider the relative deficiency or reliability of comparable EPDs available for most composite bulls.

Second, there exists an additional item of consideration surrounding the relationships between industry consolidation and active breed registrations trends. As commercial operations become larger, there's an increasing need to purchase bulls in volume that provide both uniformity in the calf crop and deliver on the various traits of interest. Angus breeders have managed to dramatically outpace breed rivals on that front. Commercial bull buyers have access to larger sale offerings when shopping for Angus bulls

compared to other breeds; that provides the opportunity to purchase half- or even full-brothers in volume and ensure improved performance consistency across a variety of traits. That opportunity simply doesn't exist when considering composite bulls.

Third, realization of benefits of crossbreeding is difficult to measure and monitor (Daley, 2009). That scenario provides some explanation for a point mentioned earlier; the seeming indifference about genetic composition of the cowherd on the part of many producers. Nonetheless, that outcome is somewhat of a double-edged sword. On one side, the educational community promotes crossbreeding. However, on the other side, field data is relatively limited from a whole-herd perspective. That's especially true in context of recent information made available through USDA: ERS (McBride and Mathews, 2011). Table 8 details various production practices of U.S. beef cow-calf farms categorized by type of operation and number of cows maintained. Less than two-thirds of beef operations follow a defined calving season while less than half utilize or implement some type of individual cow-record system, rendering total herd management practices and measurement of productivity inconsequential for most operations: "Most beef cow-calf production occurs on large farms, but cow-calf production is not the primary enterprise on many of these farms. Findings suggest that operators of beef cow-calf farms have a diverse set of goals for the cattle enterprise (McBride and Matthews, 2011)."

Table 8. Various Production Practices of U.S. Beef Cow-Calf Farms
(% of Operations) (Adapted from McBride and Mathews, 2011)

Type of Operation	Defined Calving Seasons	Artificial Insemination	Individual Cow Records
Cow-Calf Only	54	4	40
Cow-Calf / Stocker	66	11	50
Cow-Calf / Feedlot	79	19	56
Number of Cows Maintained			
20 – 49	55	5	41
50 – 99	57	7	44
100 – 249	73	13	55
250 – 499	78	19	58
500+	82	24	50

That type of observation is highlighted by the fact that less than 5% of producers participate in any type of standardized analysis. The absence of economic monitoring within the sector is underscored by Jones (2000): "Unfortunately, the lack of participation in Standardized Performance Analysis and other detailed enterprise analysis programs across the nation is symptomatic of the fact that the cow-calf sector has very few producers developing annual financial statements that measure true profit." Therefore, the decision-making process with regards to crossbreeding is neither straightforward nor necessarily logically consistent across all operations. However, it also means that prescribed solutions are highly presumptive in the absence of comprehensive data.

Lastly, and most importantly, bull purchases are greatly contingent on personal relationships. Nearly two-thirds of commercial producers indicate the last bull they purchased was Angus – nearly 75% of those were repeat customers (BEEF, 2010). There is a high level of trust and confidence among buyers in their bull suppliers; such customers consider seedstock producers as "preferred suppliers," requiring some compelling reason to change. And clearly, many of those purchases in the past decade have favored Angus bulls. Given the dynamics of the supplier/customer relationship, wide-scale industry change is unlikely to occur.

Summary

The intent of this paper is to serve as a meaningful foundation for deeper, more comprehensive discussion about crossbreeding within the beef industry. Many widely-held views and perceptions regarding genetic management maintain a strong focus on the favorable attributes of crossbreeding (most notably, growth and maternal) and their relationship to profitability. For example, a recent extension publication noted that, "...crossbreeding can increase the performance of any herd with little to no additional costs to the producer."

Those perceptions are largely drawn from the vast amount of research data available detailing the advantages of heterosis. However, research analyses often occur from a very linear standpoint the single variable of weaning weight and subsequent influence on operational prosperity: crossbreeding equals extra pounds and more revenue at sale time. Those assumptions are often too simplistic. Real-world production does not often fit ideal models.

"Those assumptions are often too simplistic. Real-world production does not often fit ideal models."

Long-standing assumptions regarding crossbreeding need to be reconsidered due to several key factors including:

1) Ever-expanding arsenal of accurate genetic selection tools available to beef producers.
2) Evolution of new business paradigms at work in the marketplace.
3) The industry's genetic base has evolved over time; many pre-conceived notions of breeds and breed differences have narrowed; producers now have access to genetics which facilitate both growth and marketplace premiums.
4) The straight-forward perspective overlooks changing structure of the industry and shifting priorities among most cowherd operators.
5) Arguments for crossbreeding disregard both direct and opportunity costs associated with its implementation.

In summary, profitability is a model of complexity. And within that framework there exist a number of interacting variables that determine whether an individual producer should facilitate or pursue additional heterozygosity in the cowherd. While not an exhaustive list, various considerations include some of the following:

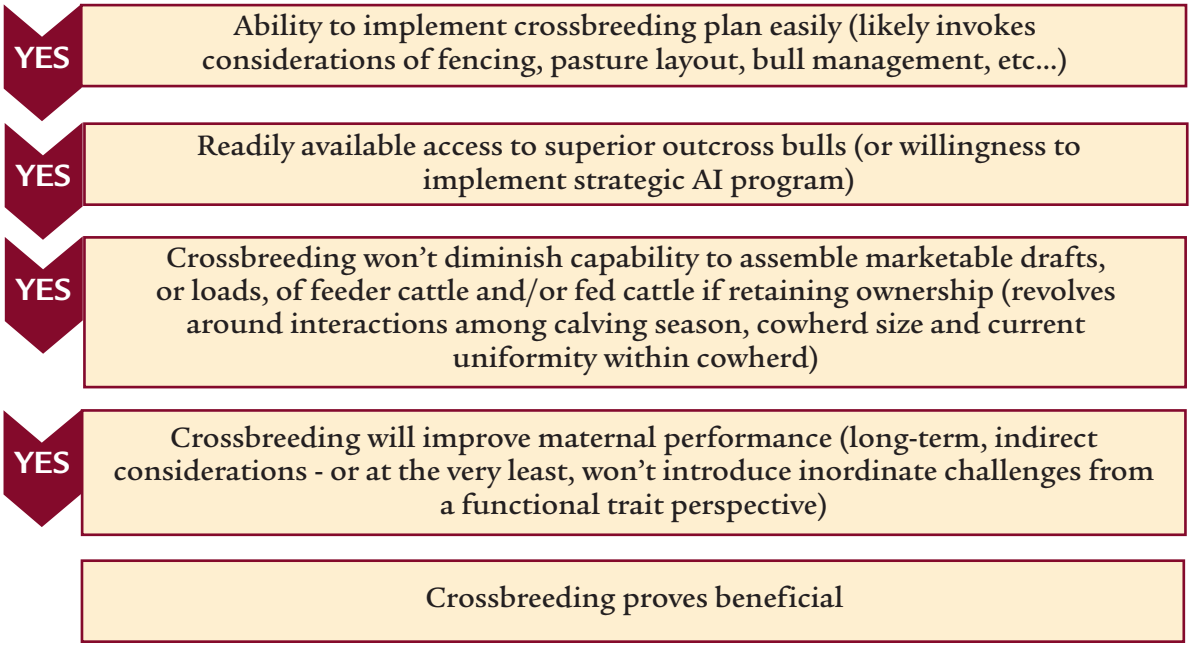
- Herd size and ability to assimilate load lots
- Capability for additional management inputs (AI, health programs, QSA, etc.)

· Heifer retention strategies
· Marketing strategies (auction market, video sales, retained ownership)
· Reliability, focus and proximity of seedstock providers
· Manifestation of defined calving season (associated with sale lot size)
· Capacity for effective and strategic crossbreeding implementation

Historically, beef producers have been encouraged to match cow size, milk level and overall biological type to the operation's available resources. And within that pursuit, the paradigm surrounding heterosis has typically been favorable. However, as the business environment has shifted, more heterosis-for-heterosis-sake may is not always a favorable solution – especially given modern genetics. In fact, sole pursuit of heterosis emphasizes pounds while deemphasizing other considerations (see Figure 5) and is no more tenable than single-trait selection for any genetic trait. One should appropriately evaluate the costs associated with chasing that heterosis "free lunch."

As such, beef producers are encouraged to comprehensively consider relationships around traits of economic importance within the context of current market signals. Doing so will facilitate both effective selection and mating strategies to enhance operational profitability.

Figure 5: Crossbreeding Decision-Maker:
Marginal Cost/Benefit Considerations (Beyond the traditional perspective associated with just additional weight adveantage)



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