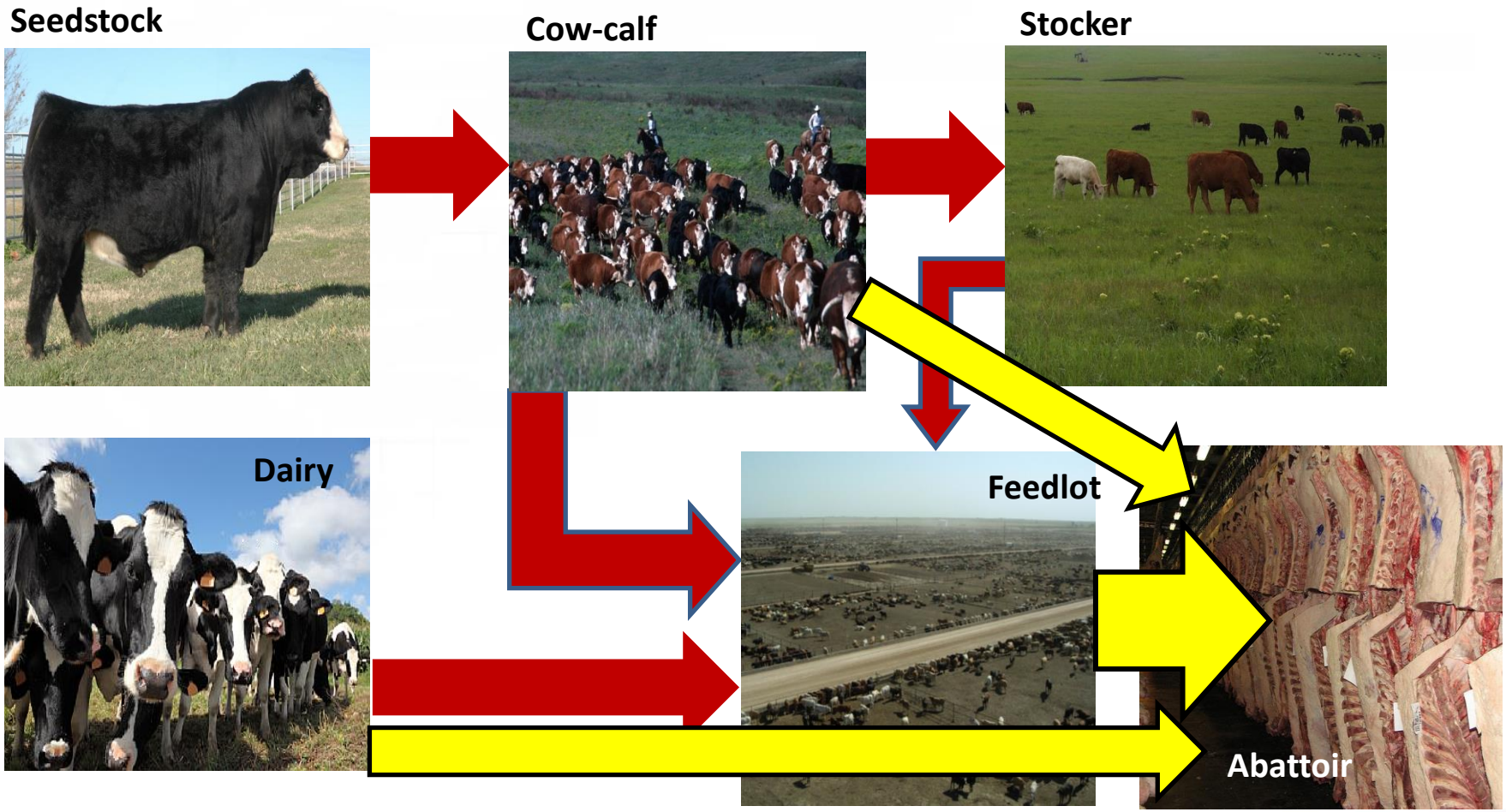
Heterosis Importance to the Industry

Bob Weaber, Ph.D.
Cow-Calf Extension Specialist
Associate Professor
Dept. of Animal Sciences and Industry
bweaber@k-state.edu

U.S. Beef Industry is Segmented



Beef Industry Challenges

- "Sustainability"
  - Land use
  - Profit
  - Petroleum use
  - Animal welfare concerns
  - Social (antibiotic, growth promotants, etc.)
  - Climate
  - Lack of communication between sectors
- Who is (are) our consumer(s)?
- Heterosis, selection part of the solution
  - Improvements in production efficiency positively impact sustainability

Sire Selection in Two Steps

1. Pick the right breed(s)
   - **PLANNED** Crossbreeding
   - Breeding objectives
   - Considerations
2. Chose right individual in that breed
   - EPDs
   - Genetic risk management
   - Selection indexes

How Do I Choose a Breeding Program

- Are you profit or premium focused?
  - Why not both?
- Herd size
  - Efficient bull utilization/manage variation in marketing groups
- How do I generate replacement heifers?
- How do I market calves?
- Constraints
  - Environment
  - Management

Making the Case for Crossbreeding

1. Why crossbreed?
2. What is heterosis ?
3. How does it work for me?
4. Breed Complementarity at work…

Why Crossbreed?

Profit

Headache

Crux of Straight-breeding

Do the benefits of selection for economically important/convenience traits within breed (straight-breeding) outweigh the improvement of lowly heritable traits via heterosis (especially maternal)?

Selection should be for **BOTH** additive and non-additive genetic merit.

Having Your Cake and Eating it Too

- Commercial cattlemen SHOULD care about BOTH additive and non-additive effects.
  - Selection index/EPDs
  - Hybrid vigor or heterosis
- Seedstock producers SHOULD focus on additive genetic merit, and putting it in a package that helps clientele exploit non-additive effects.

Heritability and Heterosis: Inversely Related

Trait	Heritability	Heterosis
Reproduction (fertility)	Low	High
Production (growth)	Moderate	Moderate
Product (carcass)	High	Low

Heterosis

- Hybrid Vigor
- Superiority of a crossbred animal as compared to the **average** of its straightbred parents
- More divergent parental lines = more heterosis
- NOT available from within breed matings
- Extensively researched in cattle (Google Scholar >13,000 manuscripts)

The Power of Crossbreeding

- Heterosis
  - Especially maternal heterosis
- Breed Complementarity
  - Selection of breeds for core traits that fill the other breed(s) shortcomings

What Are the Benefits of Heterosis?

Table 2. Estimates of biological type heterosis (SE) (British x British, British x Continental and Continental × Continental) for birth, weaning and yearling weight (Model 1)

Covariate[1]	BWT[2], kg	WT205D[2], kg	WT365D[2], kg
B × B	0.47 (0.37)	6.43 (1.80)**	17.59 (3.06)**
B × C	0.75 (0.32)*	8.65 (1.54)**	13.88 (2.63)**
C × C	0.73 (0.54)	5.86 (2.57) *	9.12 (4.34) *
Maternal heterosis	0.41 (0.31)	0.34 (1.84)	3.44 (2.66)

[1]B = British, C = Continental.

[2]BWT = adjusted birth weight, WT205D = adjusted weaning weight, WT365D = adjusted yearling weight.

*$P < 0.05$.

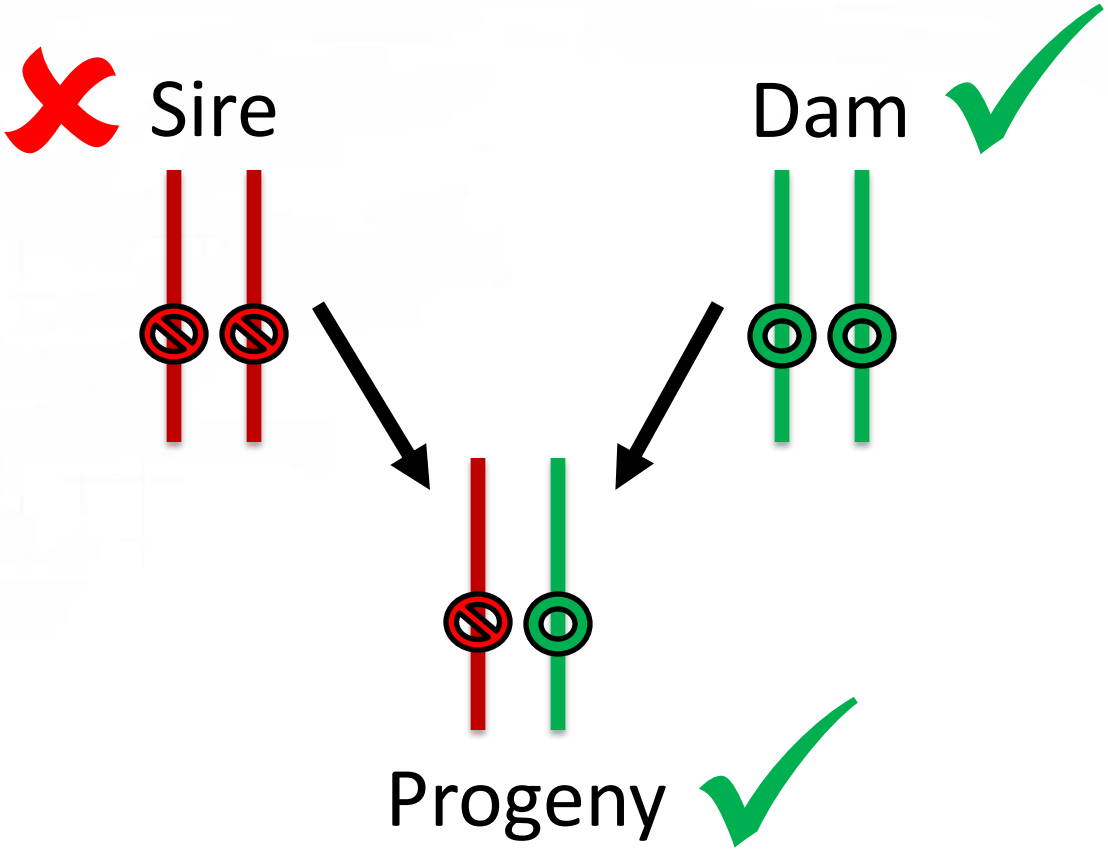
**$P < 0.01$.

Schiermiester et al., 2015 JAS

An emerging hypothesis…

- For many years the source of heterosis has been thought to be increased ‘heterozygosity’
  - The inverse of linebreeding/inbreeding
  - Inbred animals less ‘fit’ across environments, crossbreds more ‘fit’
- Genomics and sequence data provide a new look at potential source of heterosis or dominance effects
  - Recovery of gene function in crossbreds from parents homozygous for LOF mutations.

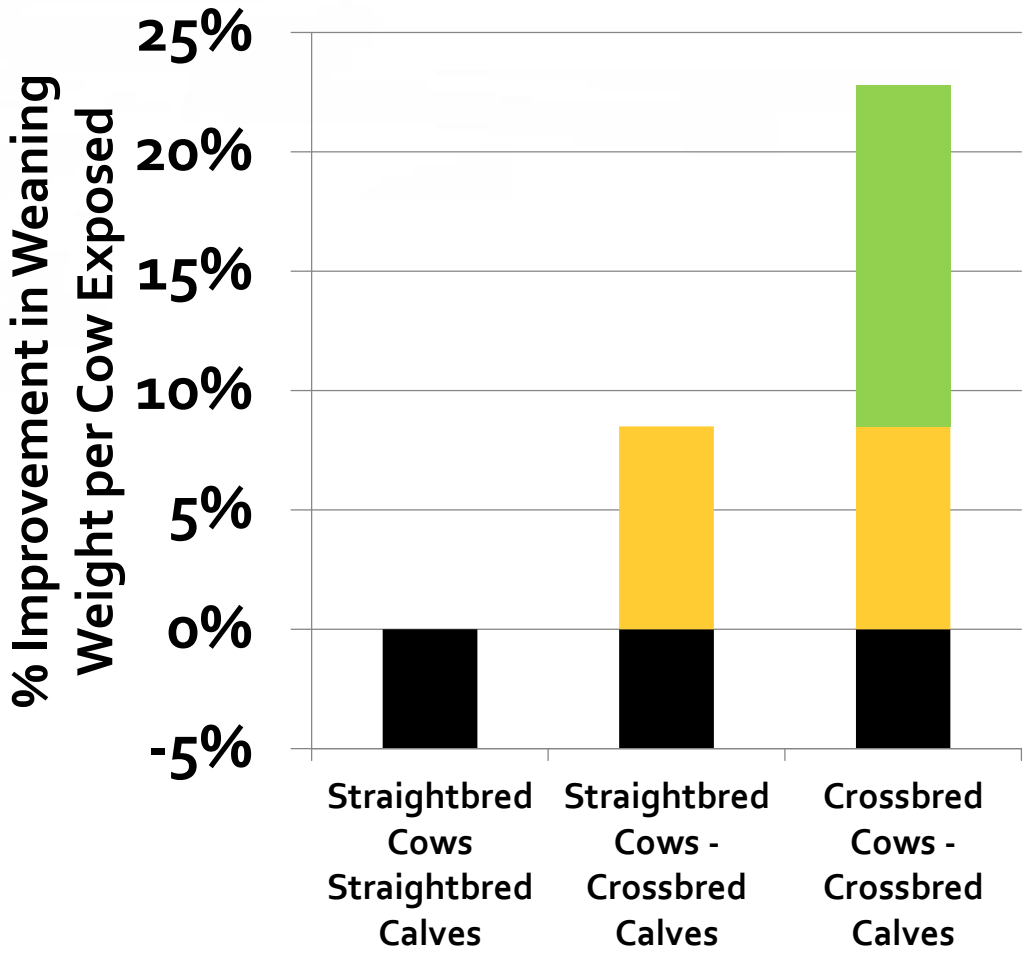
Recovery of Gene Function in Crossbreds



Benefits of Heterosis

- Heterosis increases production 20 to 25% per cow in *Bos taurus x Bos taurus* crosses; *50% in Bos indicus x Bos taurus* crosses in subtropical regions
- More than half of this effect is dependent on use of crossbred cows

Jenkins, MARC



Advantages of the Crossbred Cow

Trait	Observed Improvement	% Heterosis
Longevity	1.36	16.2
Cow Lifetime Production:		
No. Calves	0.97	17.0
Cumulative Wean. Wt., lb.	600	25.3

Adapted from Cundiff and Gregory, 1999.

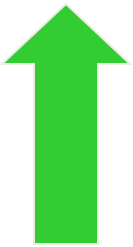
Advantages of the Crossbred Calf

Trait	Observed Improvement	% Heterosis
Calving rate	3.2	4.4
Survival to weaning	1.4	1.9
Birth weight	1.7	2.4
Weaning weight	16.3	3.9
ADG	0.08	2.6
Yearling weight	29.1	3.8

Adapted from Cundiff and Gregory, 1999

Impact on Profit

Profit = Revenue - Costs



Heterosis Impact

The Dollars of Heterosis

100 cows, 80% Weaning Rate, 575 avg. weaning weight, 10 year horizon

Calf Survival to Weaning (6%) = 48 hd.
Weaning wt. (4%) = +18,400 lb.

Weaning wt. per cow exposed (23%) = **+105,800 lb.**

…or the equivalent of 18 more 575 lb. calves/year

Heterosis is worth ~$150/cow/year

($1.50/lb for 5-6 cwt calves)

Decreases breakeven by $0.28/lb…straightbred would have to generate an additional *$198* per head to be equivalent

Impact of Increased Reproductive Rate

- Increase % Calf Crop Weaned
- Increase revenue
  - Let's assume a 7% increase, 83-90%, 100 cows
  - 7 hd. of 500 lb calves, $145/cwt, grosses $5,075
  - Equivalent to increasing revenue by $61.44/hd
  - Decrease breakeven by $11.27/cwt
- No matter how you sell calves, pay wt. drives the bus (#head * avg. wt)

How Valuable is the Improvement?

- Heifer Pregnancy
  - **Easy:** Heterosis: +7% FSCR, +5% HP (45 d)
  - **Difficult:** Selection: +8% (avg. vs top 1% HP RAAA)

- Longevity
  - **Easy:** Heterosis: +16% (~1.4 years)
  - **Difficult:** Selection: +9% (avg. vs top 1 % STAY ASA)
    - 9% fewer replacements-~$20,000 cost savings per 100 cows…that's $200 per cow/lifetime

Retained Heterosis

- Mating of crossbred animals leaves you with 0 heterosis…**WRONG**
- Heterosis is retained in future generations
- Related to the probability of alleles from different breeds pairing together
  - Note that expected and realized heterosis may differ due to the relationship of breeds
  - Heterozygosity and heterosis are not linearly related

One Bull to Do It All…

Antagonisms

Retained Heterosis

Breed Complementarity

Selection tools/trait focus

Separate Maternal and Terminal Mating Decisions

More Flexibility

Suggested Mating System Goals

1. Optimize the utilization of calf and maternal heterosis.
2. Utilize breed complementarity to match cows to their environment and their progeny to market targets.
3. Minimize variation in progeny phenotypes by stabilizing breed inputs.
4. Use Adv. Repro tech to help structure mating system (i.e. AI, gender sort semen)

Breeding Programs

- Terminal
- F1, Hybrid, or Composite Seedstock
- Rotational 2, 3, 4 breeds
  - if your operation is (very) large enough
  - ♦ Retained Heterosis
  - ♦ Stabilization of Breed Percentages

Systems, Benefits, Constraints

Table 7. Summary of crossbreeding systems by amount of advantage and other factors.[a]

Type of System		% of Cow Herd	% of Marketed Calves	Advantage (%)[b]	Retained Heterosis (%)[c]	Minimum No. of Breeding Pastures	Minimum Herd Size	No. of Breeds
2-Breed Rotation	A*B Rotation	100	100	16	67	2	50	2
3-Breed Rotation	A*B*C Rotation	100	100	20	86	3	75	3
2-Breed Rotational/ Terminal Sire	A*B Rotational	50	33			2		
	T x (A*B)	50	67			1		
	Overall	100	100	21	90	3	100	3
Terminal Cross with Straightbred Females[d]	T x (A)	100	100	8.5	0[e]	1	Any	2
Terminal Cross with Purchased F_1 Females	T x (A*B)	100	100	24	100	1	Any	3
Rotate Bull every 4 years	A*B Rotation	100	100	12-16	50-67[f]	1	Any	2
	A*B*C Rotation	100	100	16-20	67-83[f]	1	Any	3
Composite Breeds	2-breed	100	100	12	50	1	Any	2
	3-breed	100	100	15	67	1	Any	3
	4-breed	100	100	17	75	1	Any	4
Rotating Unrelated F_1 Bulls	A*B x A*B	100	100	12	50	1	Any	2
	A*B x A*C	100	100	16	67	1	Any	3
	A*B x C*D	100	100	19	83	2	Any	4

Figure 1. Two-breed rotation.

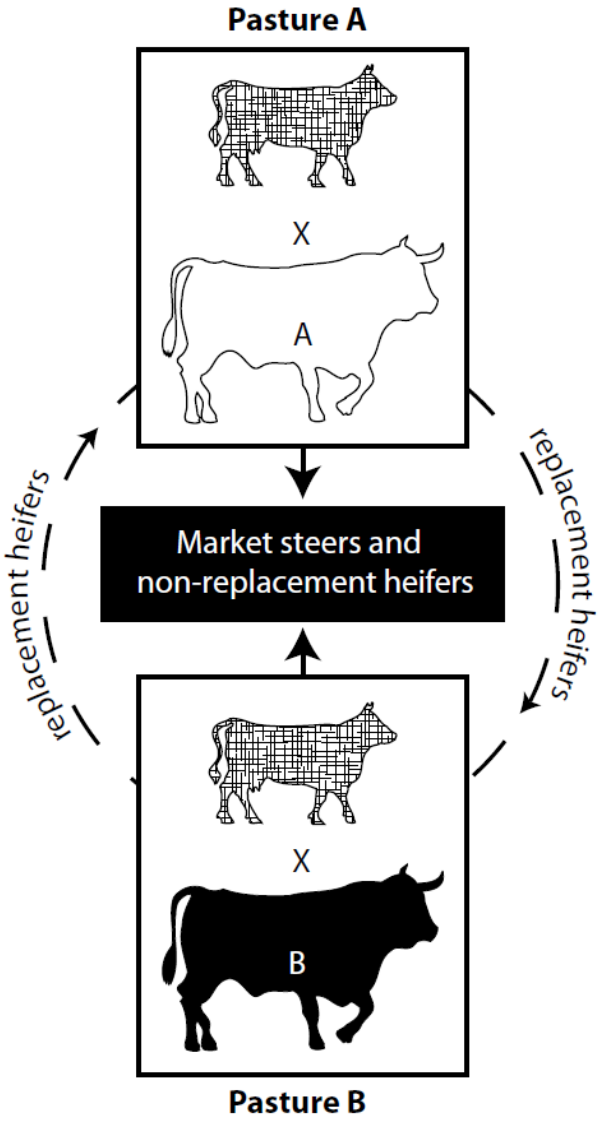


Figure 2. Three-breed rotation.

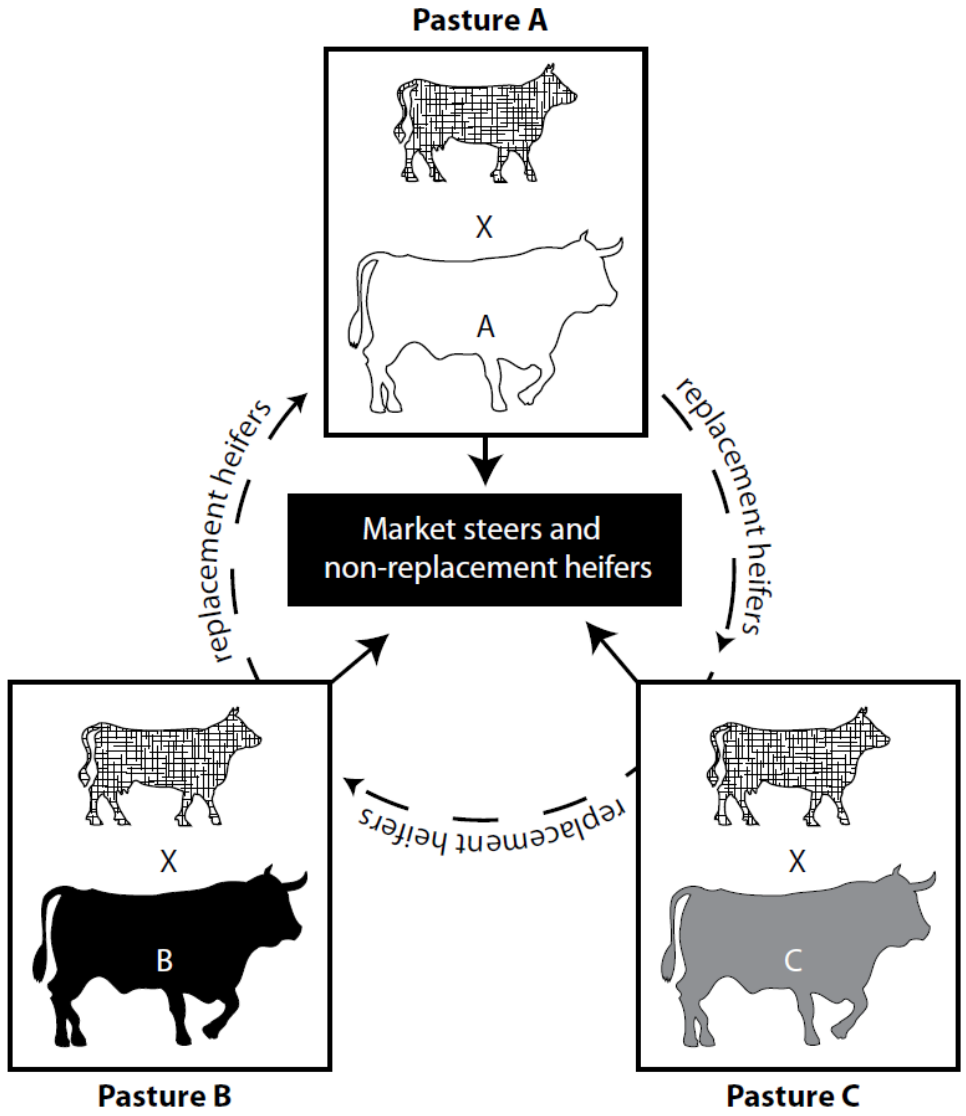


Figure 3. Two-breed rotational/terminal sire.

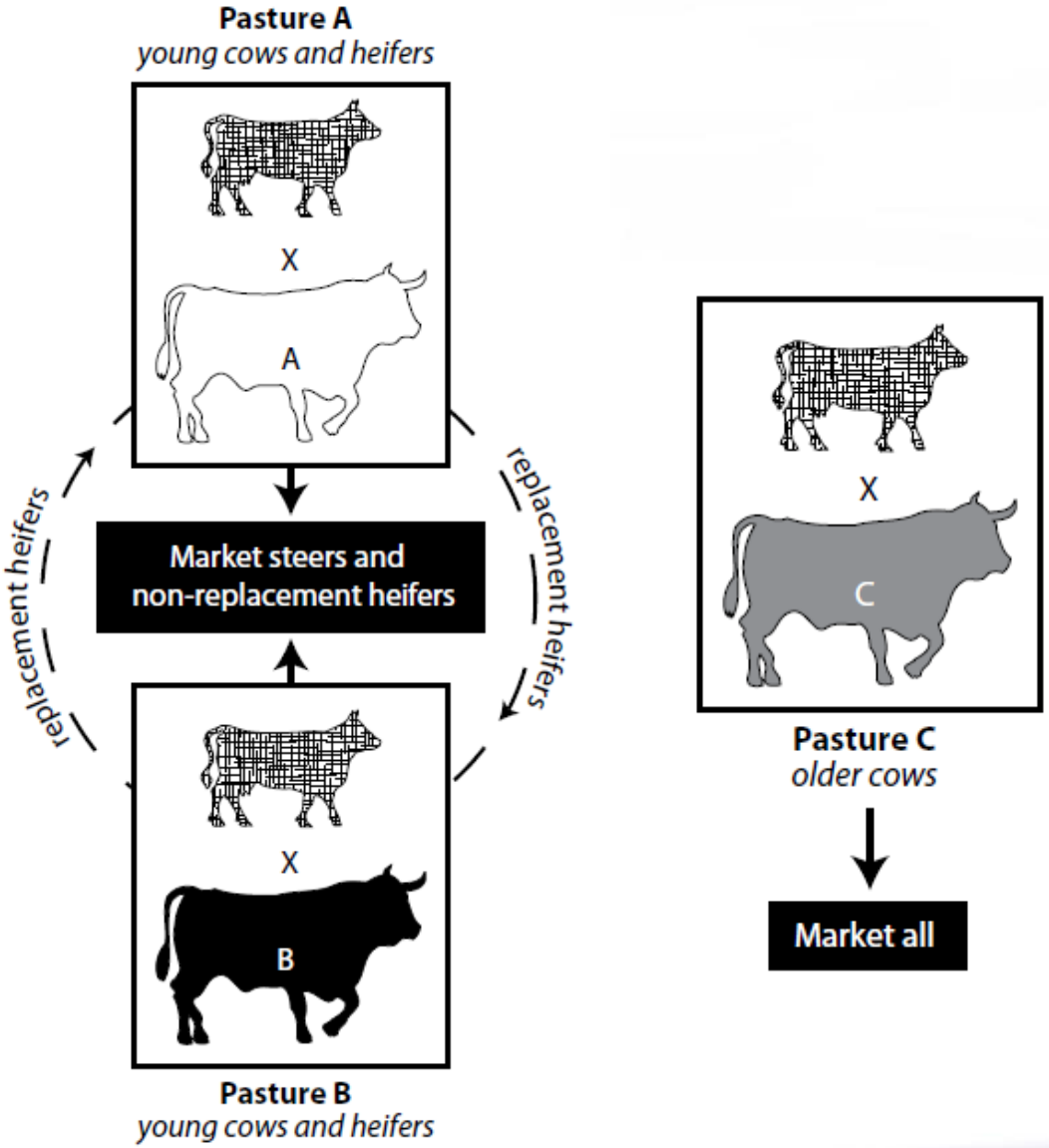


Figure 4. Terminal cross with purchased F_1 females.

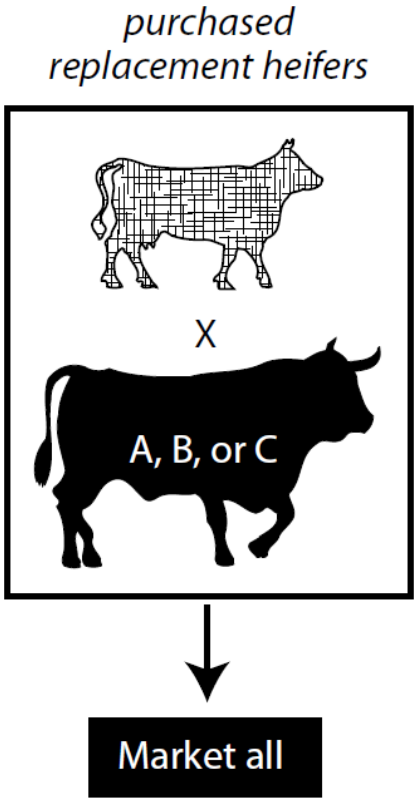
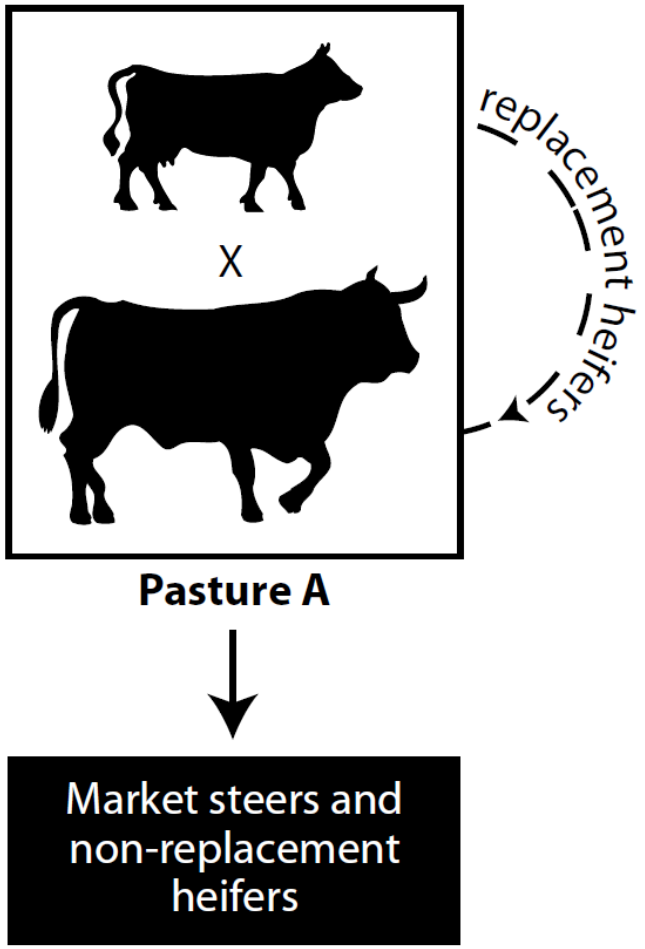
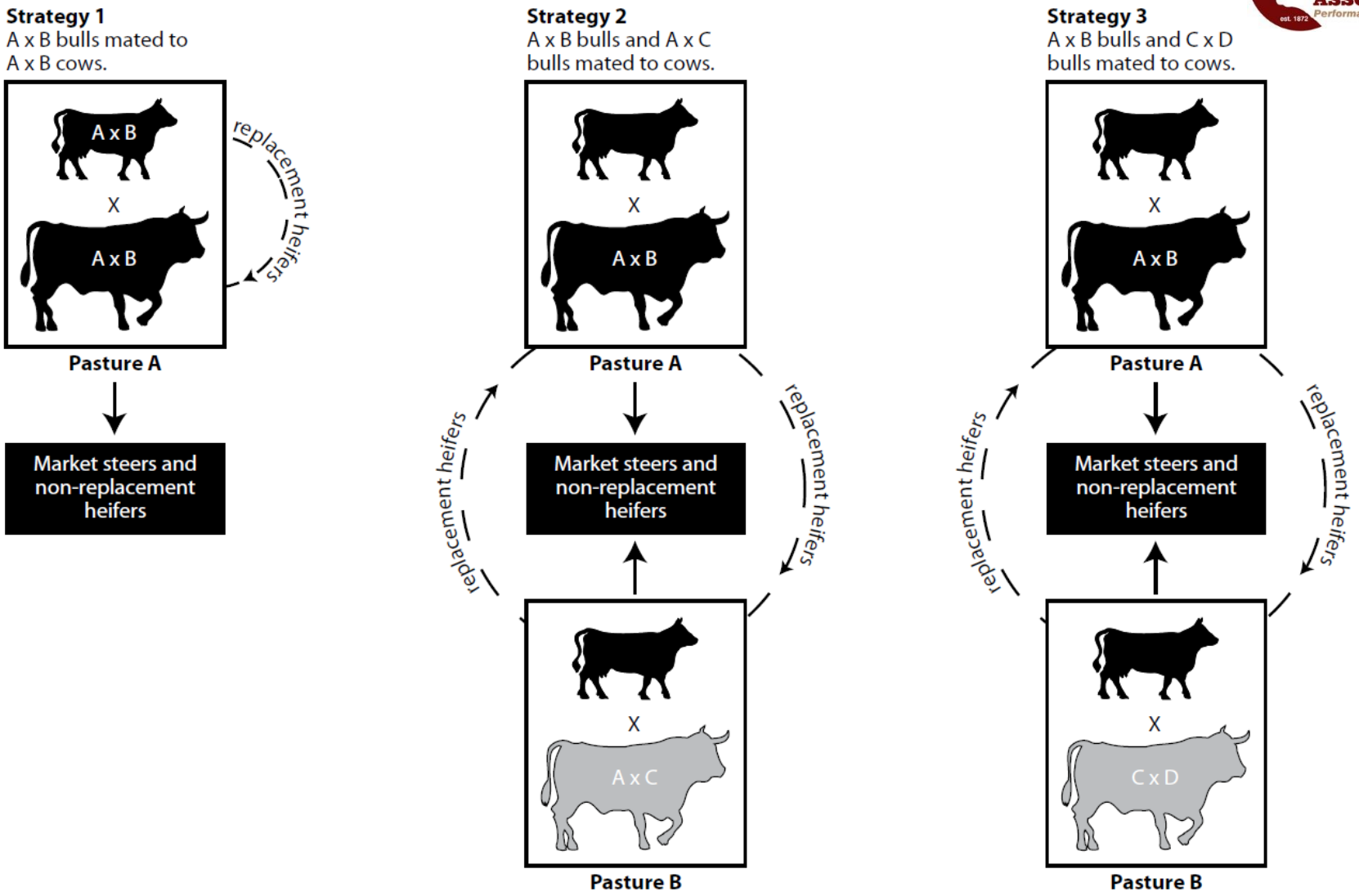


Figure 6. Composite breeding system.



2, 3, 4 Breed composites

Figure 7. Rotating F_1 bulls.

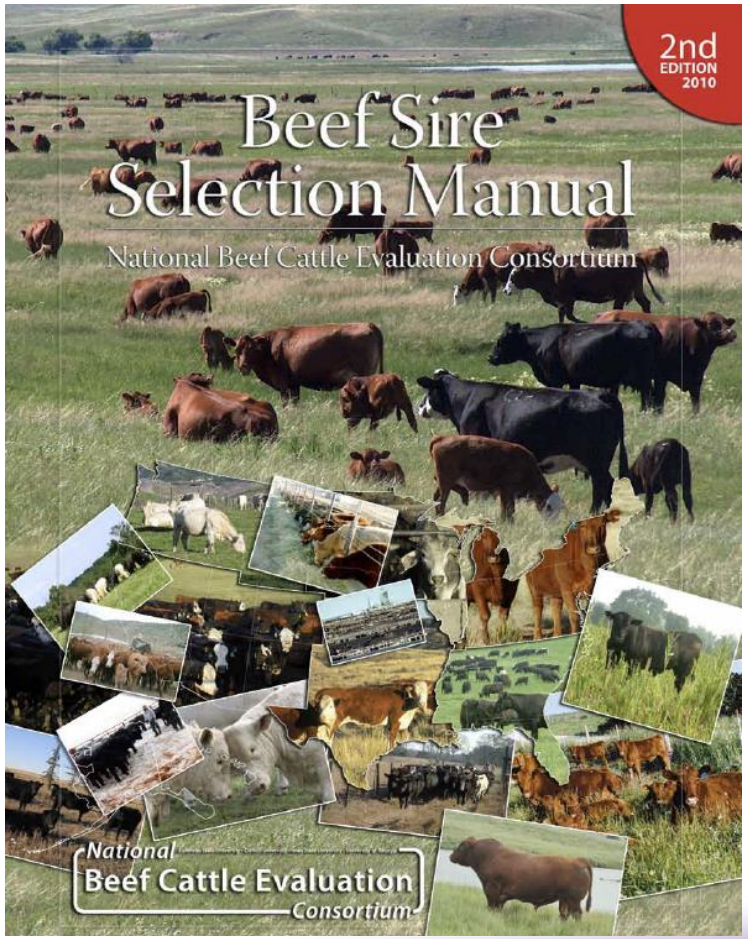


Crossbreeding Done RIGHT!

- Build a plan – set attainable goals
- Considerations
  - Marketing end points
  - Replacement females (cows must have heterosis)
  - Environment
  - Management
- Stick to it!

Systematic Sire Selection

- Set Goals
- Assess Cow Herd
- Assess Resources
- Breed Selection
- Bull Selection
  - Reproduction
  - Structure
  - Performance
  - Visual Appraisal



http://www.nbcec.org/producers/sire.html

Thank You!

Questions