



# How might DNA-based information generate value in the beef cattle sector?



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# Overview



- Where might DNA-information generate value?
- Value Proposition for each sector
  - Seedstock breeder
    - ❖ Nucleus → stud bulls to breed bulls
    - ❖ Multiplier → “stock” bull to go to commercial sector
  - Commercial cow/calf producers
  - Feedlot
  - Processor/Retailer
- “Next Generation” value if can solve structural and technological/logistical issues

# US cattle numbers (x 10<sup>6</sup>)

# US Beef operations 766,350  
Million Cows 31.4  
Average herd size 122

**Breeder**

**1.1**

**Seedstock Cows**

**Commercial cow/calf producer**

**35.7**

**“Suckling herd”  
Commercial Cows + replacements**

**Feedlot**

**13.6** (on feed at any one time)  
**25.6** (cattle fed per year in 2009)

**Processing**

**43.2**

**Retailer**

**Other Beef Animals (calves, steers, heifers and bulls)**





# Potential uses of genomic information for beef sectors

## ONLY THESE SECTORS PRODUCE NEW ANIMALS

Use	Seedstock	Commercial	Feedlot	Processor
DNA-assisted selection	X	X		
Parentage	X	X		
Recessive allele testing	X	X		
Control of Inbreeding	X	X		
Mate selection	X	X		
DNA-assisted management	X	X	X	
DNA-based purchasing			X	X
Product differentiation				X
Traceability				X



- Calving ease direct
- Birth weight
- Weaning weight
- Yearling weight
- Yearling height
- Mature weight
- Mature height
- Dry matter intake
- Residual feed intake
- Scrotal circumference
- Docility
- Calving ease maternal
- Milking ability
- Carcass weight
- Fat thickness
- Ribeye area
- Marbling score
- Tenderness

# Lead Today with 50K



**Pfizer Animal Health**  
Animal Genetics

50K SNP chip assays  
50,000 SNPs spread  
throughout genome



# The Power of the IGENITY<sup>®</sup> profile for Angus

The American Angus Association<sup>®</sup> through its subsidiary, Angus Genetics Inc.<sup>®</sup> (AGI), has a vision to provide Angus breeders with the most advanced solutions to their genetic selection and management needs.

Genomic-enhanced Expected Progeny Differences (EPDs) can now be calculated for your animals using the highly predictable American Angus Association database along with IGENITY<sup>®</sup> profile results to provide a more thorough characterization of economically important traits and improved accuracy on young animals.

Using the IGENITY profile for Angus, breeders receive comprehensive genomic results for multiple, economically important traits.

1. **Dry Matter Intake**
2. **Birth Weight**
3. **Mature Height**
4. **Mature Weight**
5. **Milk**
6. **Scrotal Circumference**
7. **Weaning Weight**
8. **Yearling Weight**
9. **Marbling**
10. **Ribeye Area**
11. **Fat Thickness**
12. **Carcass Weight**
13. **Tenderness**
14. **Percent Choice (quality grade)**
15. **Heifer Pregnancy**
16. **Maternal Calving Ease**
17. **Direct Calving Ease**
18. **Docility**
19. **Average Daily Gain**
20. **Feed Efficiency**
21. **Yearling Height**



**ANGUS**  
THE BUSINESS BREED





# American Angus Association performs weekly evaluations with genomic data – recently updated to include new traits



	Igenity	Pfizer
Calving ease (CED)	✓	✓
Growth (BW WW YW Milk)	✓	✓
Residual Average Daily Gain (RADG)	✓	✓
Docility (DOC)	✓	✓
Yearling Scrotal/Height (SC,YH)	✓	✓
Mature Weight (MW)	✓	✓
Carcass (CWT MARB RIB FAT)	✓	✓

<http://www.angus.org/AGI/GenomicChoice11102011.pdf> (updated 11/18/2011)



# Potential Value of DNA information to the seedstock sector



## Estimate the value of using DNA test information to increase the accuracy of beef bull selection in a seedstock breeding program

- The expected returns from using a commercial sire sourced from a seedstock herd using DNA testing
- Additionally, the value of marker information in the selection of replacement stud males to be mated in a seedstock breeding program was also estimated.

Van Eenennaam, A. L., J.H. van der Werf, and M.E. Goddard. 2011. The economics of using DNA markers for beef bull selection in the seedstock sector. *Journal of Animal Science*. 89:307-320.





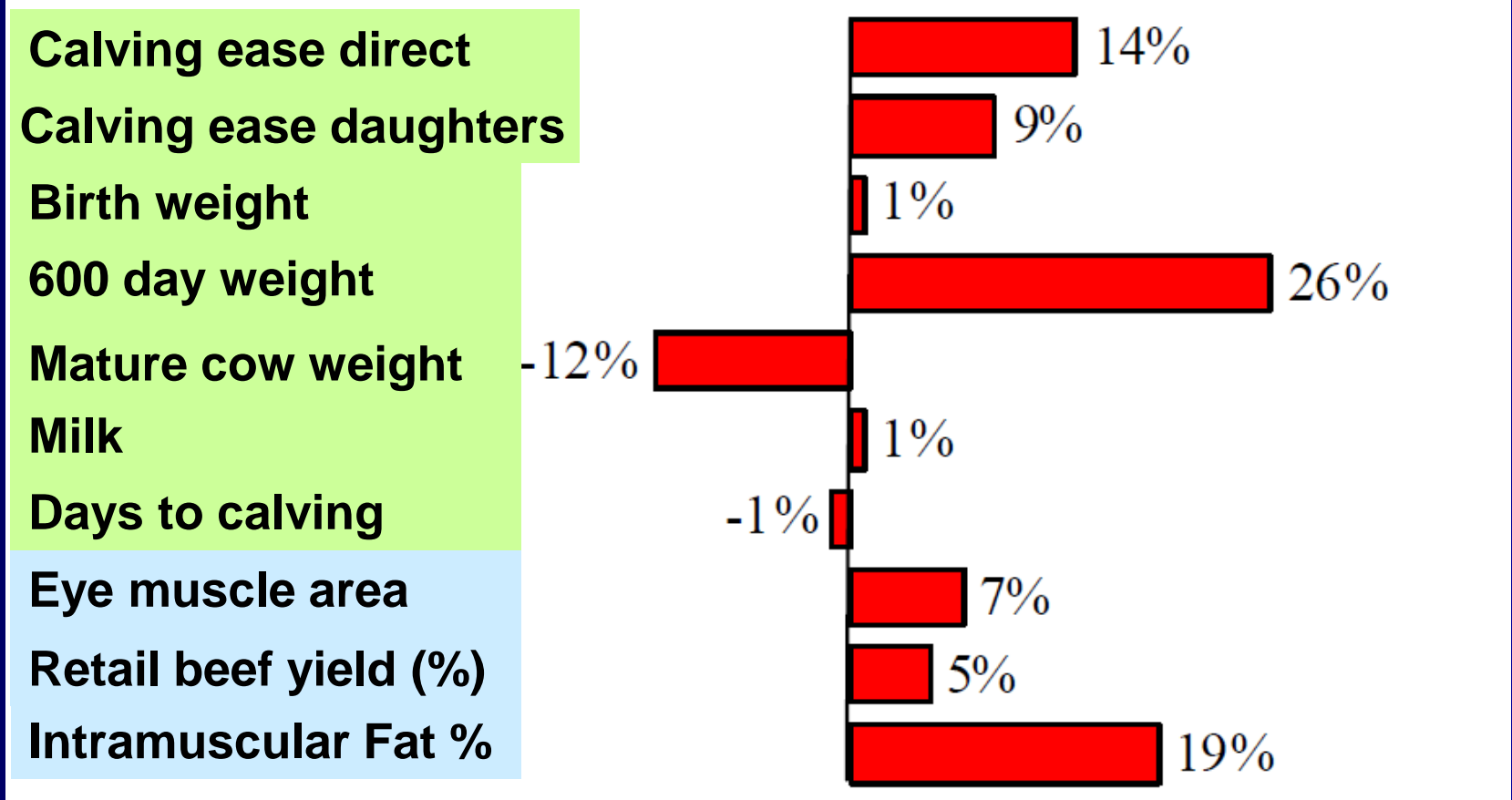
# “Feedlot” \$Index (Whole Industry Good index)

Suitable for a self-replacing commercial herd in temperate Australia targeting the production of steers for the long-fed markets that value marbling and 600 day growth.



## TRAIT

## “FEEDLOT” \$INDEX PROFIT DRIVERS





**High** ( $h^2$ ) and **intermediate** ( $\frac{1}{2} h^2$ ) accuracy DNA tests explaining genetic variation in all of selection criteria and traits in the breeding objective were used to test all male progeny from one calf crop



Objective Trait	$h^2$	Selection criteria	$h^2$
Sale liveweight – direct	0.31	Birth weight	0.39
Sale liveweight – maternal	0.04	200 d Weight	0.18
Cow weaning rate	0.05	400 d Weight	0.25
Cow survival rate	0.03	600 d Weight	0.31
Cow weight	0.41	Scrotal Size	0.39
Calving ease – direct	0.10	Days to Calving	0.07
Calving ease – maternal	0.10	Mature Cow Weight	0.41
Dressing Percentage	0.33	P8 fat	0.41
Saleable meat Percentage	0.56	RIB fat	0.34
Fat depth (rump)	0.41	Eye Muscle Area	0.26
Marbling score	0.38	Intramuscular Fat	0.25

Currently no selection criteria for many economically-important traits: Feed efficiency, feedlot performance, feedlot health, stayability/longevity, fertility, etc.



# Value of improved selection response for stud bulls due to DNA-test increase in Long Fed / CAAB \$Index accuracy



Variable	Unit	Accuracy of DNA test used	Long Fed / CAAB \$Index
Increased value derived from $\Delta G$ in commercial sires	AU\$ / bull	Intermediate	16,882
		High	27,901





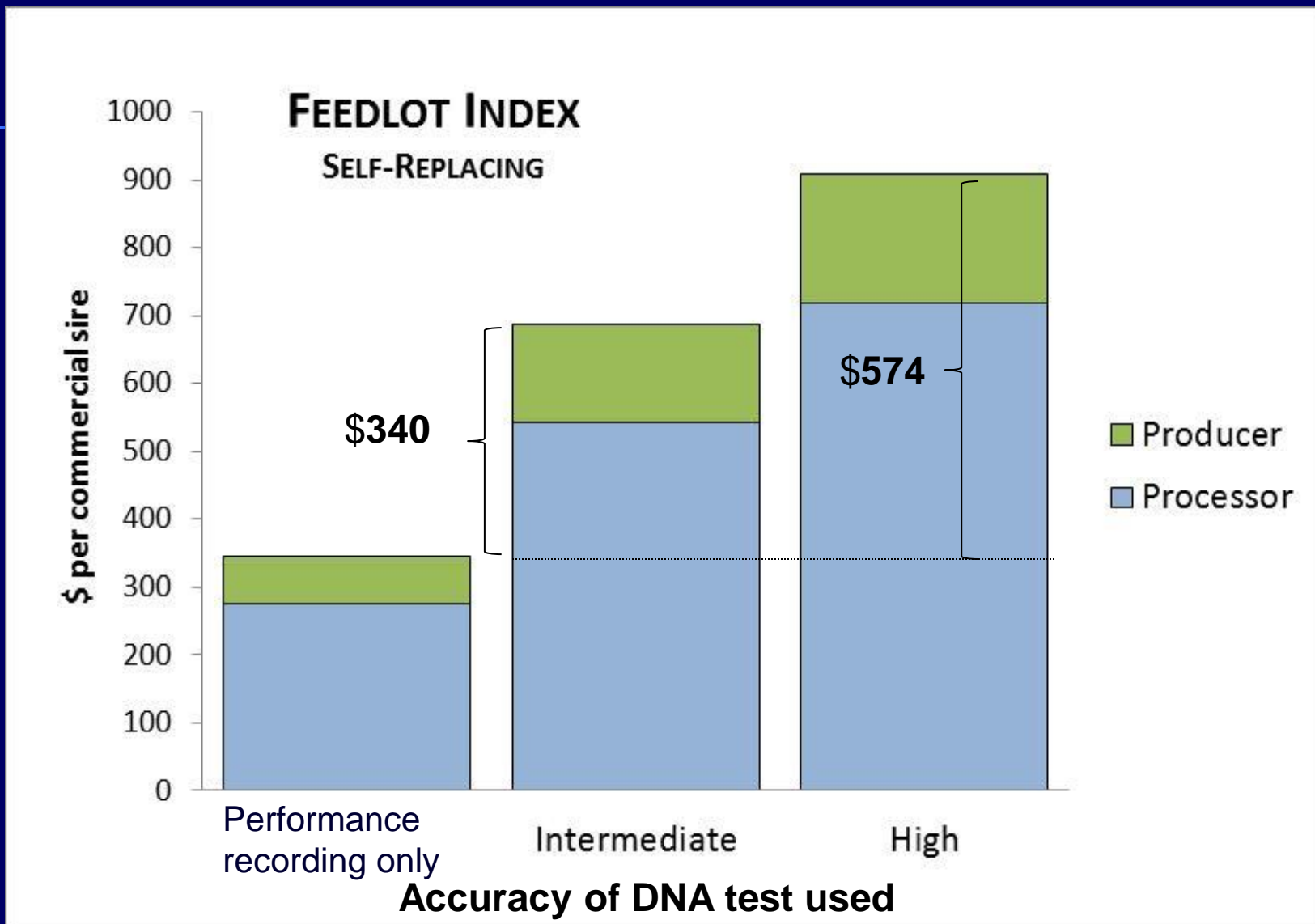
# Value of improved selection response for commercial bulls due to DNA-test increase in Long Fed / CAAB \$Index accuracy



Variable	Unit	Accuracy of DNA test used	Long Fed / CAAB \$Index
Increased value derived from $\Delta G$ in commercial sires	AU\$ / Bull	Intermediate	340
		High	574



# Where are returns from genetic gain ( $\Delta G$ ) in commercial bulls realized?





# Results: Value of genetic improvement ( $\Delta G$ ) per DNA test in commercial and stud sires



Variable	Unit	Accuracy of DNA test used	Long Fed / CAAB \$Index
Increased value derived from $\Delta G$ in stud sires	AU\$/test	Intermediate	506
		High	836
Increased value derived from $\Delta G$ in commercial sires	AU\$/test	Intermediate	170
		High	282





# Are bull buyers willing to pay more for high indexing bulls?



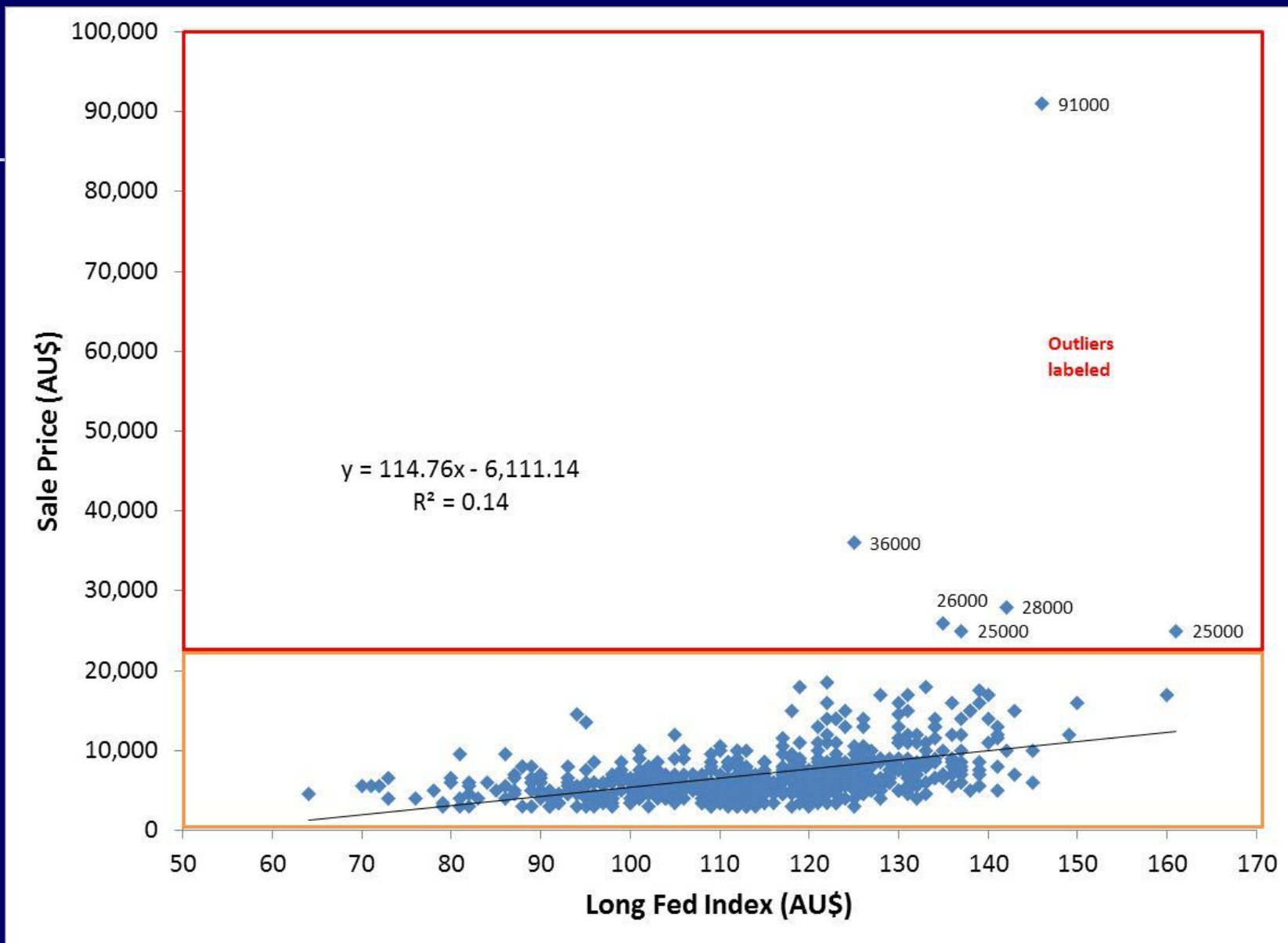
Long Fed/CAAB \$Index\* value was compared to bull purchase price from 645 bulls sold in Australia in 2011/2012. Six sales were examined – four studs were included stud 1 (n=44), stud 2 (n=200), stud 3 (n=45); and stud 4 with 3 sales represented Southern 2011 (n=115), Northern 2011 (n=96), and Southern 2012 (n=145) – 2/29/2012

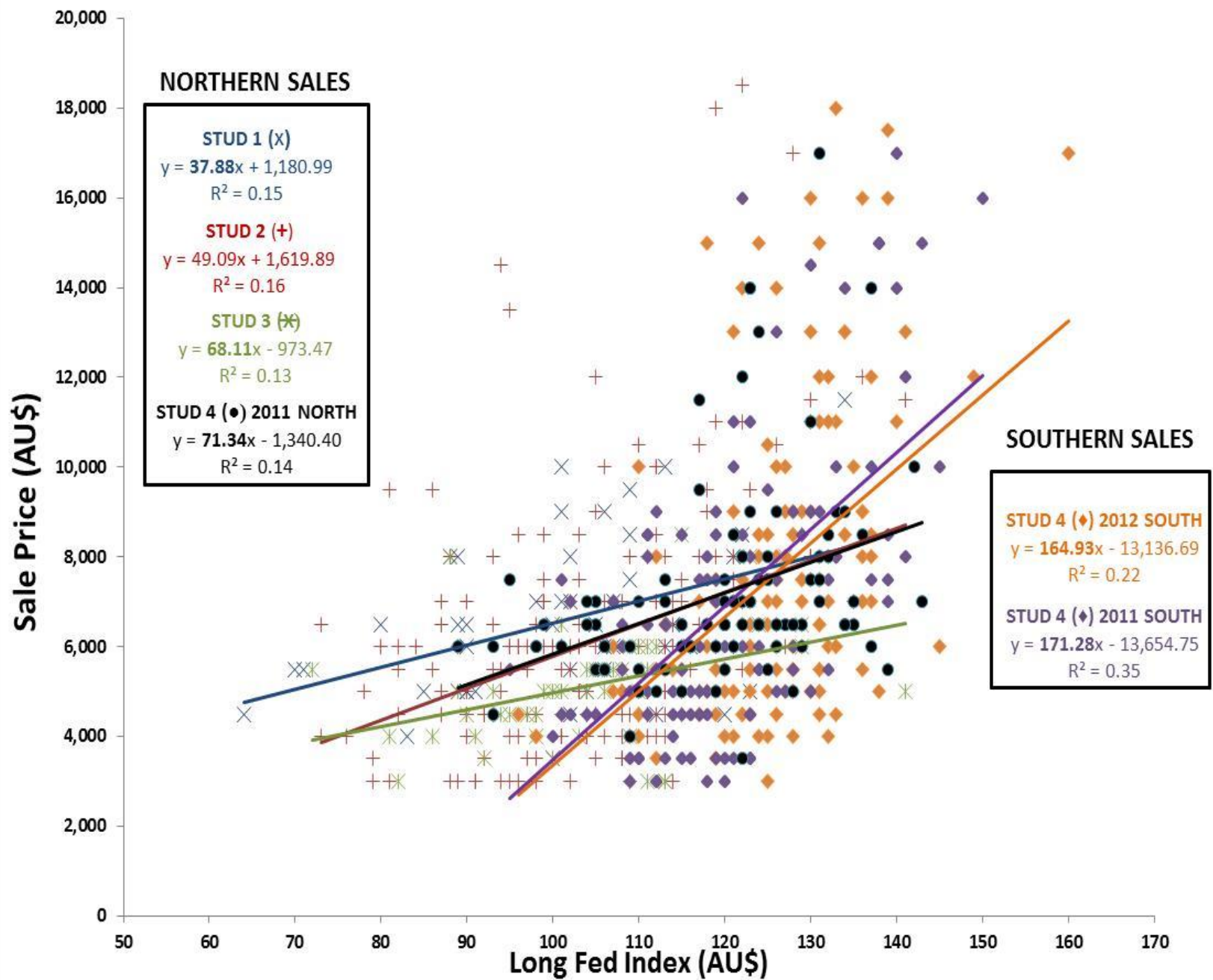
Removed outlier bulls (>3 sd from average price)

\* <http://breedplan.une.edu.au/tips/Interpreting%20Australian%20Angus%20Selection%20Indexes.pdf>



# All bulls included









# Value of genomic information for recessive genetic defects



- Arthrogryposis multiplex (AM) is a lethal recessive deletion for which a DNA test was developed in 2008
- In the 11 months following the release of the test, the American Angus Association posted the results of tests for AM on about 96,247 cattle.
- **@\$25/test this amounts to \$2.4 million in tests**
- Of these, 20% (19,529) were carriers of AM. **That leaves 23,638 bulls and more than 53,000 heifers which tested as free of AM.**
- **At \$4K/bull and \$2K/heifer ~\$200 million**





# Estimates of US and Australia genetic testing costs (Angus)



	US	AUSTRALIA
AMF (Arthrogryposis multiplex)	113,526	12,021
NHF (Neuropathic Hydrocephalus )	77,067	9,936
CAF (Congenital Contractural Arachnodactyly)	28,837	2,532
<b>TOTAL NUMBER</b>	<b>294,054</b>	<b>34,991</b>
<b>COST (@ \$25/test)</b>	<b>\$7,351,350</b>	<b>\$874,775</b>

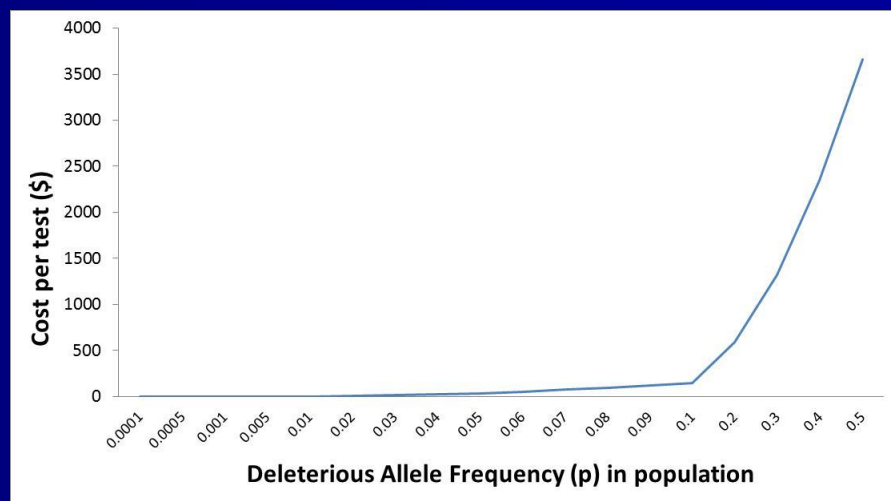
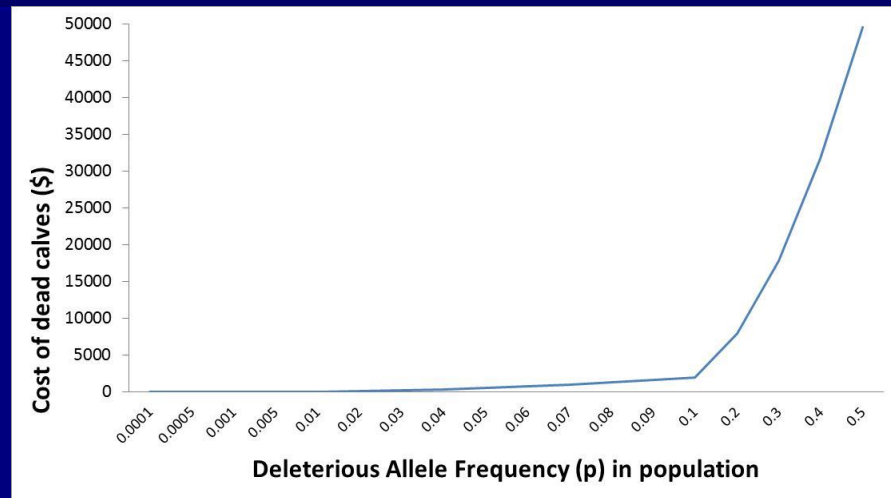
Numbers kindly shared by Bryce Schumann, American Angus Association; and Carel Teseling, Angus Australia; current as of 5/2011



# Break even cost of DNA testing to eliminate randomly selected carrier sires from entering a herd over a range allele frequencies ( $p$ ) for a recessive lethal allele (*assuming herd frequency of allele is also $p$* ). The value increases substantially if the sire is very likely to be a carrier.



Allele frequency ( $p$ )	Cost of calf loss if DNA testing of yearling bulls not performed (US\$)	Breakeven cost DNA test if testing yearling bulls entering herd (US\$)	
		All bulls tested	Carrier bull
0.0001	<0.01	<0.01	213
0.0005	0.05	<0.01	216
0.001	0.20	0.01	219
0.005	5	0.37	247
0.01	20	1	281
0.02	79	6	350
0.03	178	13	419
0.04	317	23	488
0.05	495	37	557
0.06	713	53	626
0.07	971	72	695
0.08	1268	94	764
0.09	1605	119	833
0.1	1981	147	902
0.2	7924	586	1593
0.3	17828	1319	2283
0.4	31695	2344	2973
0.5	49523	3663	3663







# Cost of commercially-available DNA tests for US beef cattle

- Seedstock producers are using DNA information for pedigree verification, genetic defect testing, and genomic enhanced EBVs. Sometimes these analyses are sent to three different laboratories, and costs can be in excess of \$200 per animal.
- **At the current time the costs of DNA extraction and genomic analyses tend to exceed the value that is returned to any single sector.**



Type/Purpose of DNA Test	Species	Cost (\$US)
Microsatellite or SNP-based parentage test	Cattle	~\$ 10-25
Genetic Defects/Single gene tests	Cattle	~\$ 15-100
Illumina Bovine 3K (just genotypes - no prediction equation)/Research	Cattle	~\$ 38
Illumina Bovine 50K (just genotypes)/Research	Cattle	~\$ 80
Affymetrix Bovine 650K (just genotypes)/Research	Cattle	~\$200
Illumina Bovine 770K (HD) SNP Test (just genotypes)/Research	Cattle	~\$210
384 SNP Angus Profile (Igenity US/AGI)/Selection	Beef Cattle	~\$ 65
Illumina Bovine 50K (Pfizer Animal Genetics US/AGI)/Selection	Beef Cattle	~\$139



# Extracting DNA multiple times in different labs for different applications makes about as much sense as simultaneously paying to have access to all of the following communication devices





# New genotyping platforms and technologies will mean a single DNA sample can be assayed for multiple purposes

(Parentage, genetic defects, disease diagnostics, imputation to high density for predictions of genetic merit estimates, mate selection decisions to avoid inbreeding, and minimize matings between heterozygote “carriers” for deleterious recessive alleles, product traceback, differentiation, traceability).



## SEEKSIRE™ Parentage and Sire Identification Program for Cattle

SeekSire is created for ranchers, breeders and breed associations who need to manage their herd's pedigrees in a highly accurate and cost-effective manner. SeekSire can help maintain herd books, facilitate retrospective genetic improvement, and manage herd performance and quality. Additionally, when all sires and dams used in a herd are known and identified through DNA, it is possible to identify all progeny, thereby creating full traceability as well. GeneSeek's newest technology platforms make SeekSire very affordable!

## SEEKTRACE™ Traceability Program for Beef

SeekTrace can address traceability needs across the entire production to consumer pipeline. SeekTrace enables management of the origin, movement and identity of each animal through the entire supply, demand and consumption chain. A powerful set of DNA markers are used to identify a unique sample, and in conjunction with date of processing, facility or premise ID, any animal can be traced with the help of custom informatics solutions. While traceability has been a desirable solution for many years, high DNA testing costs have limited widespread adoption. But now, for the first time, new advances in DNA technology allow us to provide SeekTrace for a fraction of the end value of each animal.



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## SNP Profiling and Illumina® Services

### Available Illumina Genotyping Assays

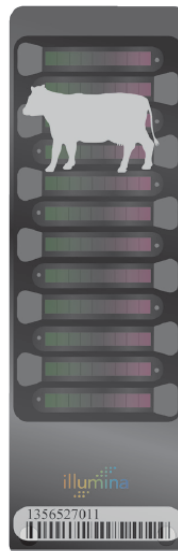
- **NEW** GeneSeek Genomic Profiler for dairy and beef - Custom low density bead chip featuring 10, 000 SNP markers
- Bovine SNP50 BeadChip – 54,609 informative SNP markers.
- BovineHD – High density genotyping with greater than 800,000 SNP markers

### SNP Genotyping Panels

- Sequenom® MassARRAY® spectrometry-based detection system for sensitive, accurate, and rapid genotyping
- 384 and 96-well options for high- and low-throughput applications
- Easy-to-use multiplexed assay design and optimization software saves research time and helps maximize efficiency
- Flexible SNP numbers allows for economical marker assisted selection

### BVDV Diagnostics

- PCR screening/ELISA confirmation
- Diagnostic testing can now be performed from hair follicle submissions
- BVDV and genomic testing all from the same sample
- International samples accepted



# All in one LD plus product from GeneSeek “Genomic Profiler” ~ US\$35-40 (+ recessive lethal royalty fees if assayed).

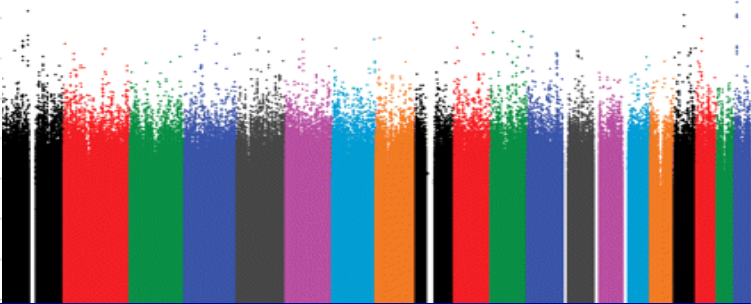
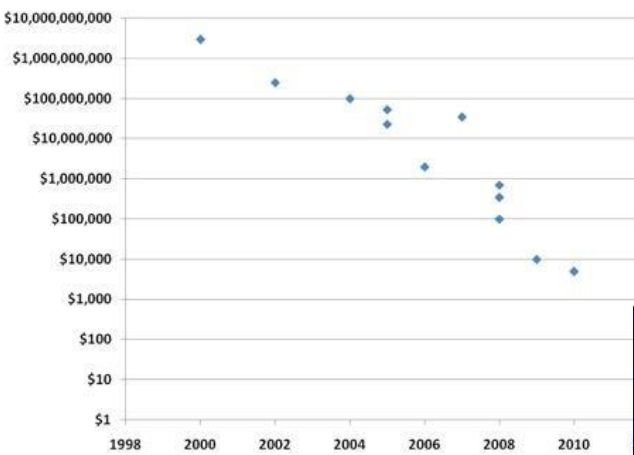


<http://biocomicals.blogspot.com>

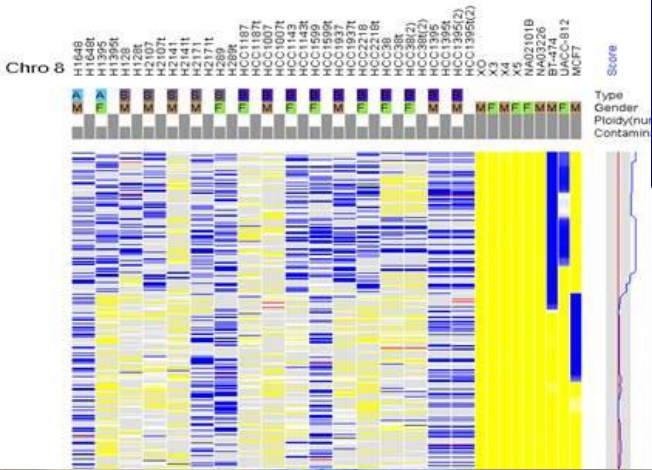
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# Cost of sequencing a genome



**What will happen when next generation sequencing meets next generation technology?  
 Next generation VALUE derived from DNA testing**



**Next Generation Electronic Cattle Ear Tags**



**Next generation thinker**







# TECHNOLOGICAL CHALLENGE: How do we collect phenotypes and DNA on all animals and make genotype information available to all sectors?

## ONLY THESE SECTORS PRODUCE NEW ANIMALS



Use	Seedstock	Commercial	Feedlot	Processor
DNA-assisted selection	XXXX	X	XXXX	XXXX
Parentage	XX	X		
Recessive allele testing	XX	X		
Control of Inbreeding	XX	X		
Mate selection	XX	X		
DNA-assisted management/purchasing		X	XX	XX
Product differentiation				XXXX
Traceability				XX



# Ideally cattle would be genotyped ONCE early in life and genotypes shared with downstream production sectors to derive the maximum value from the fixed DNA collection and extraction costs



Cattle industry Sector	Mobile Device// Data Access Plan	Type of DNA product // DNA information access required	Cost? (US\$)
<b>Nucleus seedstock/AI bulls</b>	ipad	Full genome sequence	\$250
<b>Seedstock/bull multiplier</b>	iphone	HD 770 K genotype	\$50
<b>Registered females and stock bulls for commercial sector</b>	Talk and text smart phone	50K genotype + parentage + single gene traits/recessives	\$25
<b>Commercial cattle – Marker-assisted management (MAM), replacement heifer selection</b>	Prepaid cellular phone	Imputation LD chip + parentage + single gene traits/recessives	\$10
<b>Feedlot cattle purchasing, sorting and marker-assisted management (MAM)</b>	Pay as you go contract	Access genotypes from supplier (subset of LD imputation chip).	<\$1
<b>Traceability for voluntary labelling e.g. Angus beef</b>	Friends and family plan	Access genotypes from supplier (subset of LD imputation chip).	<\$1
<b>Traceability for disease outbreak/contaminated meat</b>	Emergency only phone (911 calls)	Access genotypes from supplier (subset of LD imputation chip).	<\$1




- + Create New Record
- 🔍 View Existing Records
- ⚙️ Manage Pastures
- 📊 BCS Score Descriptions
- ℹ️ Help

[www.Crystalyx.com](http://www.Crystalyx.com)

11:24 pm

Home Breed Average EPD Definit DNA Techno

## Beef Cattle EPDs Resource Guide



[beefcattleepdapp@live.com](mailto:beefcattleepdapp@live.com)

Give Feedback on this App!! [Click Here](#)

DNA Techno...

- ✖️ Igenity >
- ✖️ Pfizer >

PROXIMUS 4:30 PM

# SICK COW



ABOUT HOW SICK?

smartfarmapps

### PRO CATTLE BREEDING

COW MANAGER

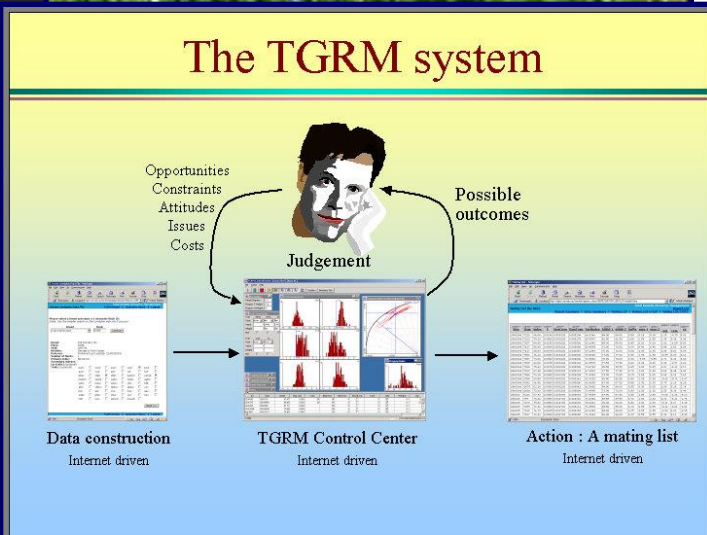
BREEDING MANAGER

BREEDING SUMMARY

21

01/08/2011 TO

SAVE







# STRUCTURAL CHALLENGE : Many cattle operations have fewer than 100 head, and most sell their cattle at auction prior to feedlot entry



## Whole industry selection indexes are developed to maximize the profitability of the whole supply chain

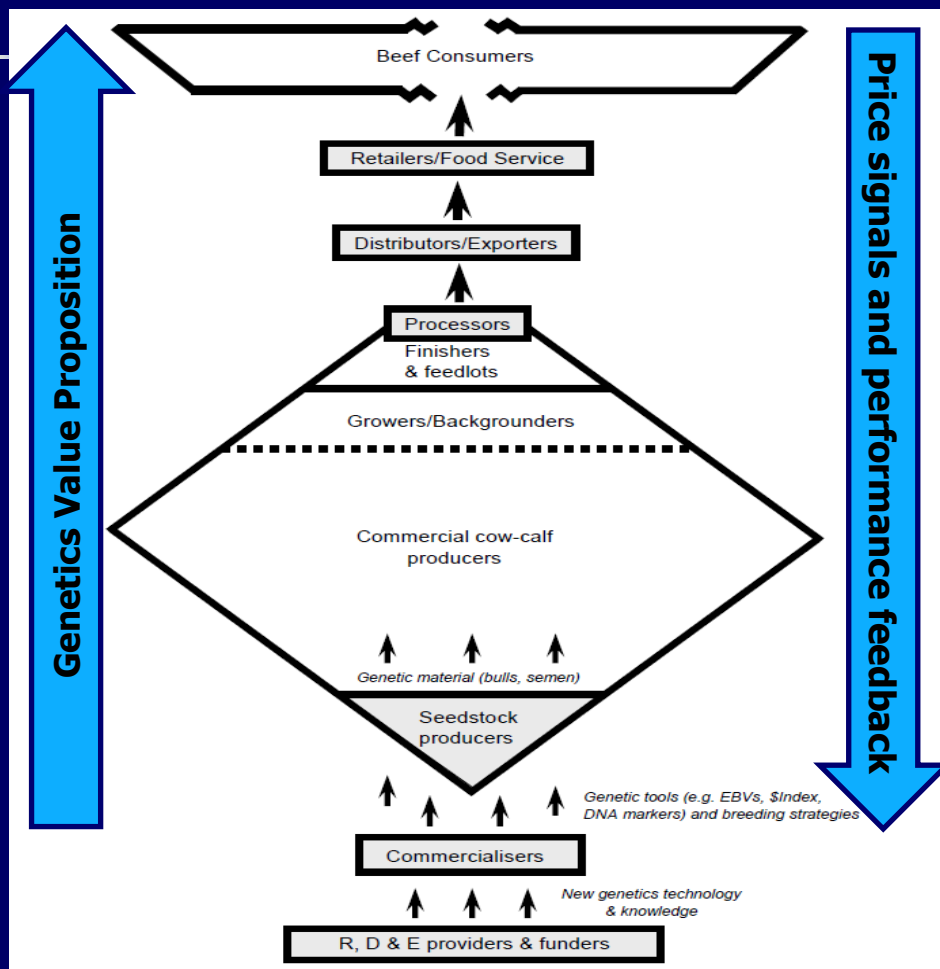
- In reality most producers' financial returns are tied very closely to the number of calves, a function of reproduction, and less if at all to feedlot performance (e.g. feed efficiency) and carcass traits, and even less to feedlot health (e.g. respiratory) and mortalities.
- To incentivize the inclusion of traits that provide value in downstream sectors in selection decisions, a mechanism to equitably share some of the value derived from improved feedlot performance and carcass quality is needed to compensate breeders and producers for collecting DNA and genomic information to improve these traits, and for including them in their breeding objectives with concomitant decreased selection pressure on production traits that return value directly to producers.







# Industry structure may evolve to enable the exchange of information and value between the different sectors.



For widespread technology adoption, breeders need to be adequately rewarded for making DNA investments and selection decisions for traits that benefit the different sectors of the beef industry.

Parnell, P.F. 2007. Effective value chain partnerships are essential for rapid adoption of beef genetics technology. Association for the Advancement of Animal Breeding and Genetics. 18. 167-174 .



# Concluding thought....

Breeds/groups that can organize themselves and **technologically** and **structurally** to seamlessly obtain and marry entire supply chain phenotypes and genotypes and take advantage of the rapidly-declining cost of genotyping to capture the cumulative value derived from using genomic information for multiple purposes (selection, parentage, genetic defects, marker-assisted management, product differentiation, traceability) will be ideally positioned to fully realize the nascent potential of genomic information.





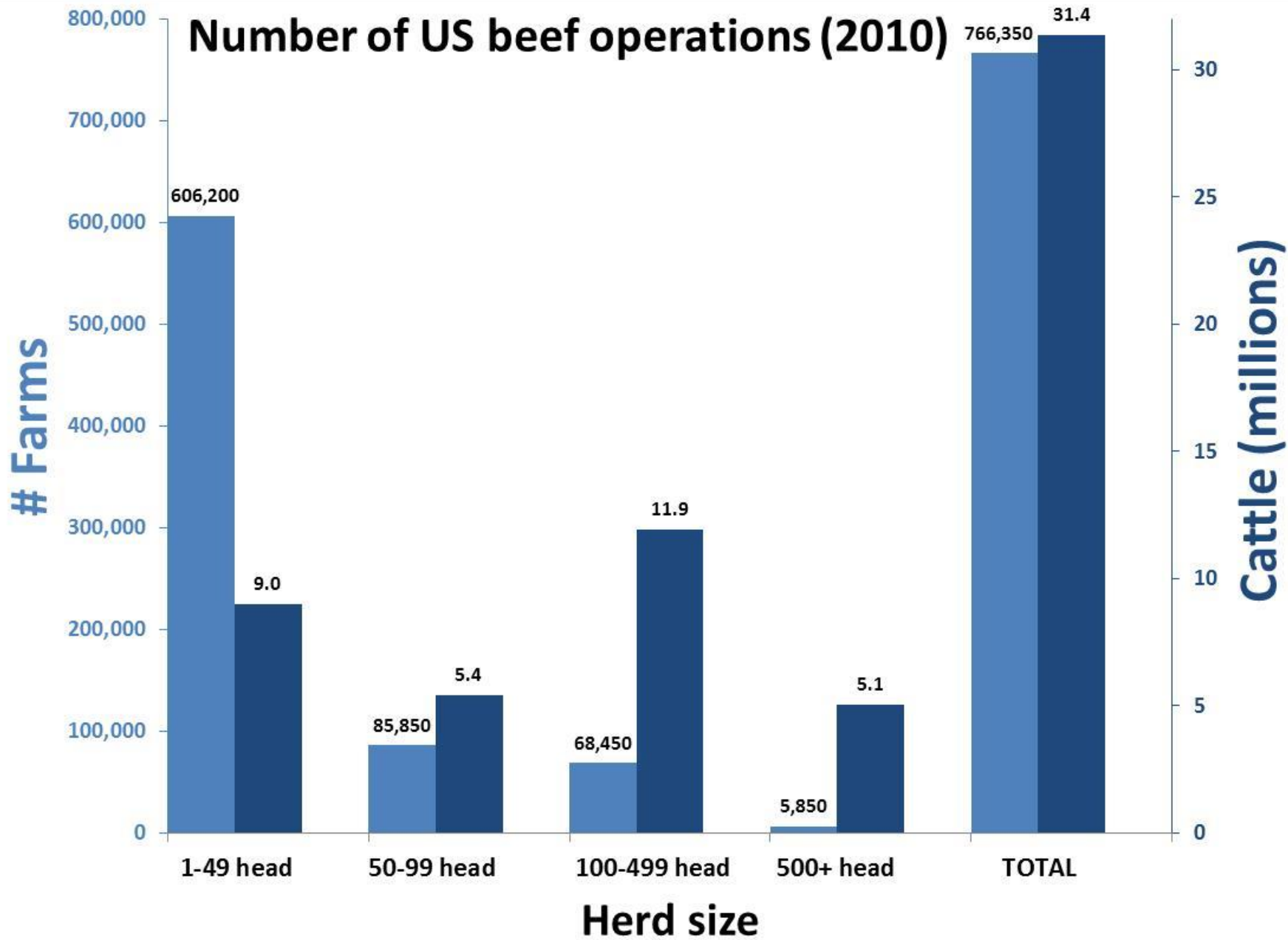
# Thanks for inviting me!



Value proposition work supported by National Research Initiative competitive grant no. 2009-55205-05057 ("Integrating DNA information into beef cattle production systems") from the USDA National Institute of Food and Agriculture Animal Genome Program.











# There are 260 feedlots with a one time capacity of >16,000 cattle

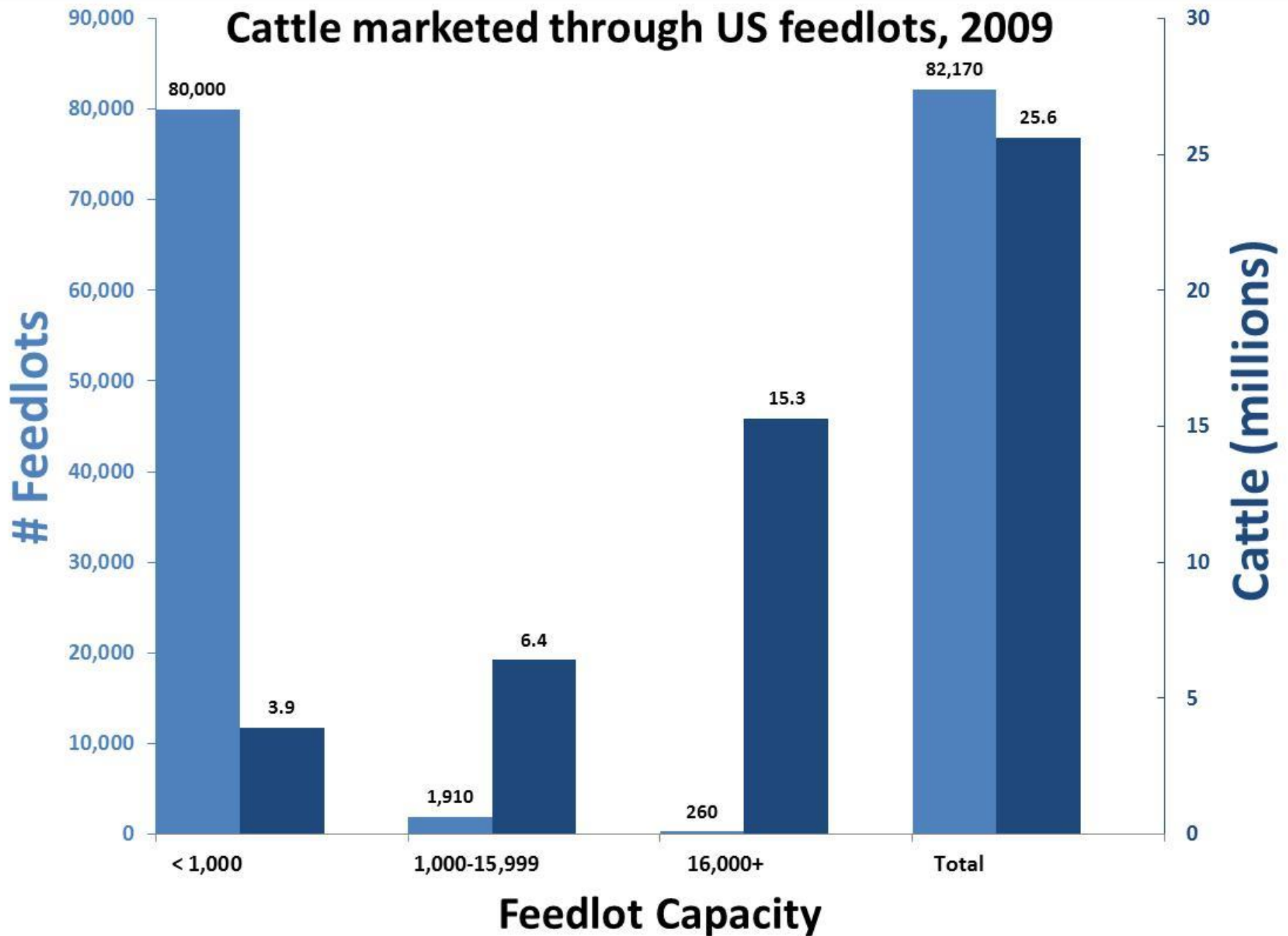
Capacity of large cattle feeding operations in the U.S. – 2009 (Source: web sites of the companies listed and personal communication)

Rank	Company	One-time capacity
1.	JBS Five Rivers Cattle Feeding LLC, Greeley, CO	839,000
2.	Cactus Feeders, Inc., Amarillo, TX	520,000
3.	Cargill Cattle Feeders LLC, Wichita, KS	335,000
4.	Frona Industries LP, Amarillo, TX	275,000
5.	AzTx Cattle Co., Hereford, TX	265,000
6.	J. R. Simplot Co., Grand View, ID	230,000
7.	Irisk and Doll, Cimarron, KS	200,000
8.	Four States Feedyards, Lamar, CO	195,000 <sup>1</sup>
9.	Agri Beef Co., Boise, ID	175,000
10.	Pinal Feeding Company, Maricopa, AZ	150,000 <sup>2</sup>

<sup>1</sup>Value for 2006 obtained from: <http://agr.wa.gov/fof/docs/feedlot.pdf>.

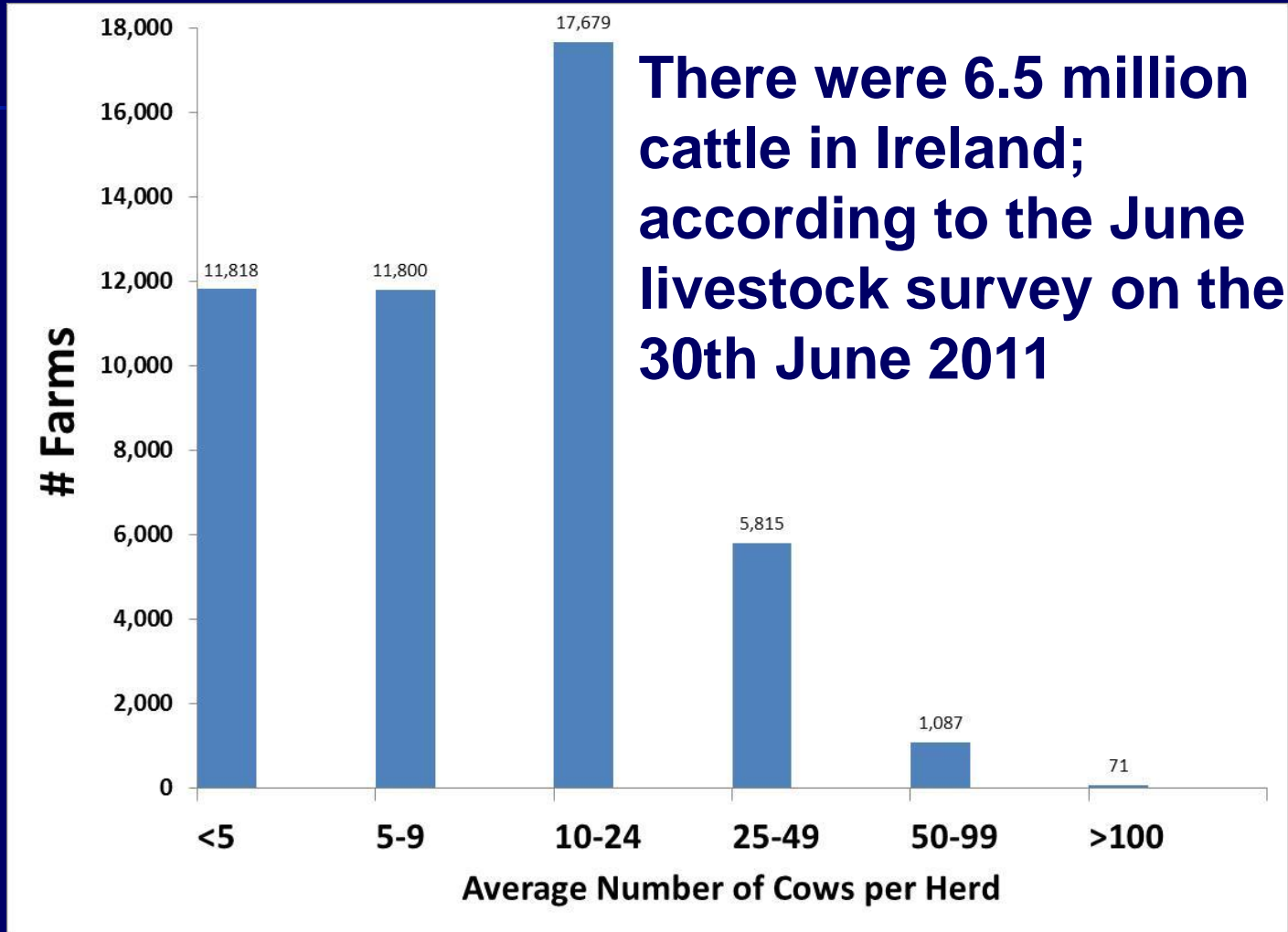
<sup>2</sup>Reported as “capacity for over 150,000 head of cattle” on the company web site.

# Cattle marketed through US feedlots, 2009





# Count of calving beef cows in various categories of cow size on the ICBF database and with at least one cow calving record in the period May 2007 to May 2008.



Evans et al. 2008. Developments in National and International beef evaluations; some experiences from Ireland. INTERBULL Meeting Niagara Falls, NY, June 16<sup>th</sup> -19<sup>th</sup>, 2008



# Different herd classifications based on type of beef cows calved for herds with at least one cow calving record in the period May 2007 to May 2008 in ICBF database.



Type of herd on ICBF database	Count of herds	Count of cows calved	Average number of cows per type of herd	
			Pedigree	Crossbred
Crossbred beef cows only	40,482	503,270	0	12
Pedigree beef & crossbred beef cows	5,905	126, 512	4	17
Pedigree beef, crossbred beef & dairy cows	967	17,712	4	14
Pedigree beef cows only	702	5,028	7	0
Pedigree beef and dairy cows	5	1,061	5	0
<b>TOTAL</b>	<b>48,061</b>	<b>527,071</b>	<b>5</b>	<b>10</b>

Evans et al. 2008. Developments in National and International beef evaluations; some experiences from Ireland. INTERBULL Meeting Niagara Falls, NY, June 16<sup>th</sup> -19<sup>th</sup>, 2008