USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

THE VALUE OF A NATIONAL EVALUATION SYSTEM IN PROMOTING DAIRY SUSTAINABILITY

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American Dairy Science Association Annual Meeting
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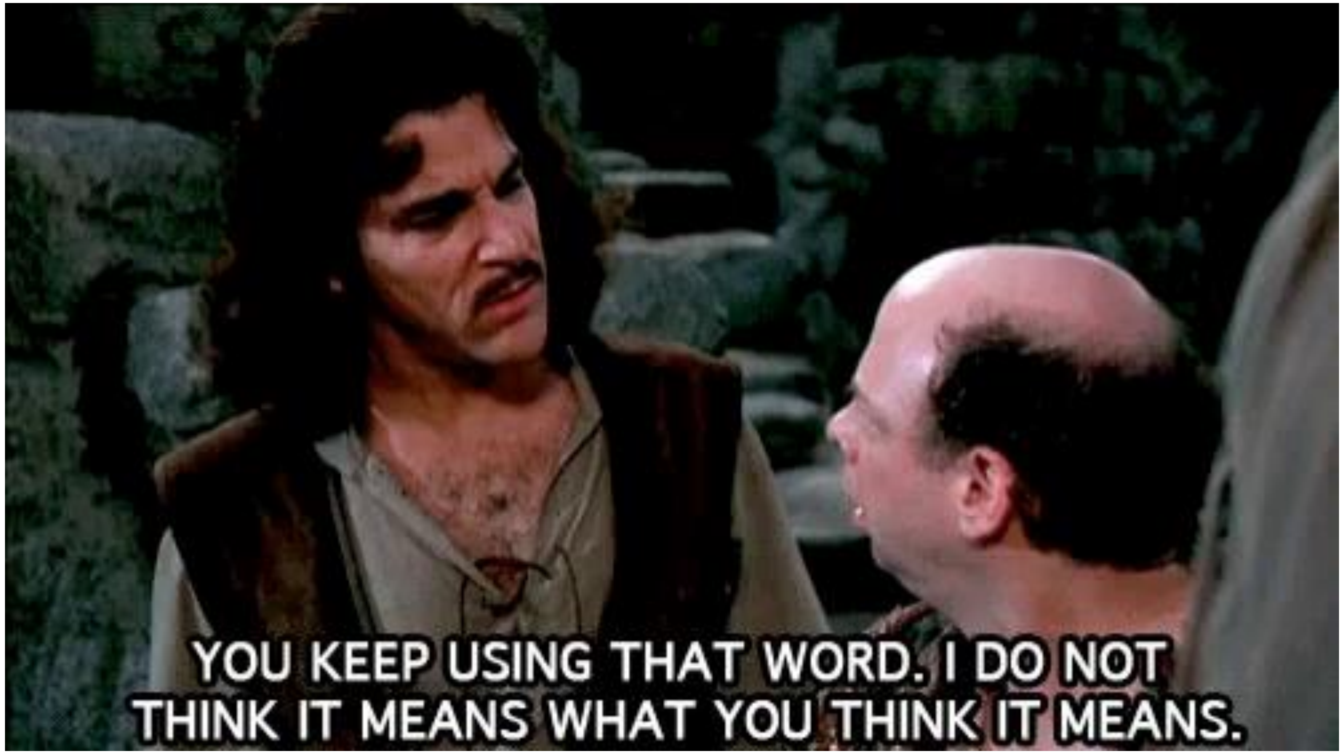
WHAT IS SUSTAINABILITY?

"the ability to be **maintained** at a certain rate or level"

-Oxford Languages



The Princess Bride (1987)

WHAT IS SUSTAINABILITY?

"the **balance** between the **environment**, **equity**, and **economy**"

-UCLA Sustainability Committee

"conditions under which **humans** and **nature** can exist in productive harmony to support present and future generations"

-US Environmental Protection Agency

"development that meets the needs of the present **without compromising** the ability of future generations to meet their own needs"

-UN World Commission on Environment and Development

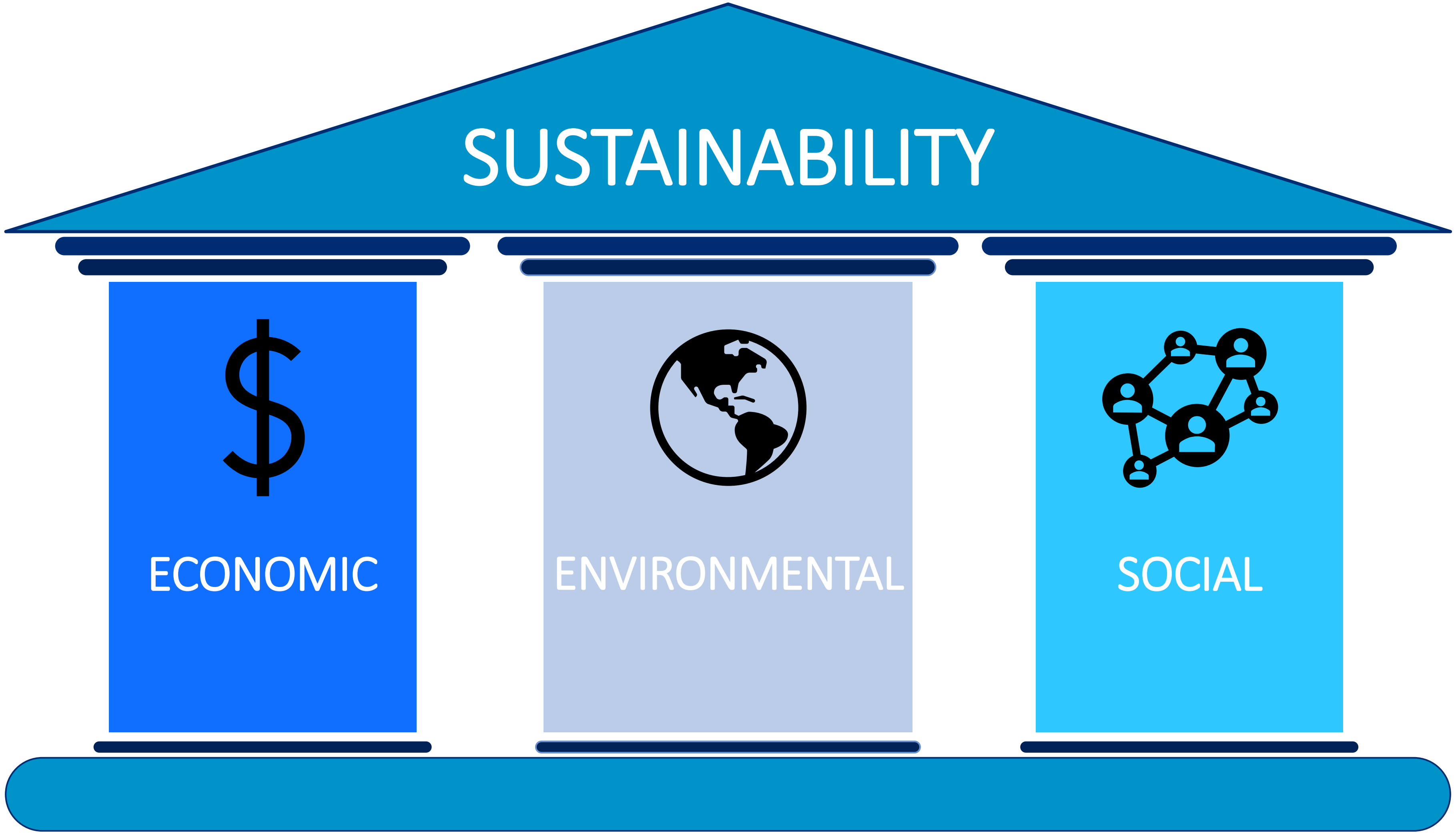
WHAT IS SUSTAINABILITY?

Farm Bill
[Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), Public Law 101-624, Title XVI, Subtitle A, Section 1603 (Government Printing Office, Washington, DC, 1990) NAL Call # KF1692.A31 1990]

"**sustainable agriculture** [is] an integrated system of plant and animal production practices… that will, over the **long term**:

- Satisfy **human** food and fiber needs;
- Enhance **environmental quality** and the **natural resource** base upon which the agricultural **economy** depends;
- Make the most efficient use of **nonrenewable resources** and on-farm resources and integrate, where appropriate, **natural biological cycles** and controls;
- Sustain the **economic viability** of farm operations; and
- Enhance the quality of life for **farmers** and **society** as a whole"

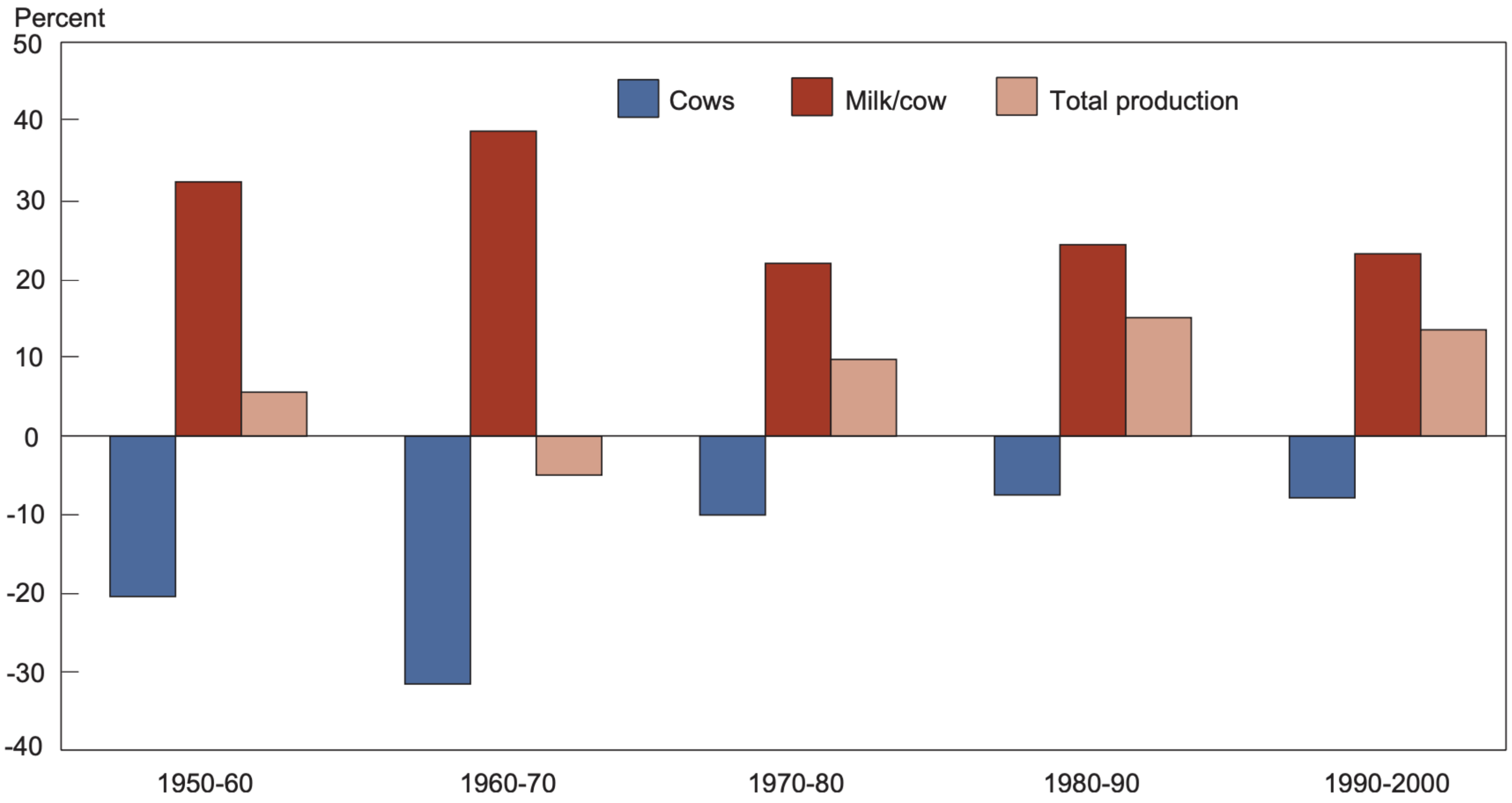
WHAT IS SUSTAINABILITY?



TOPICS FOR DISCUSSION

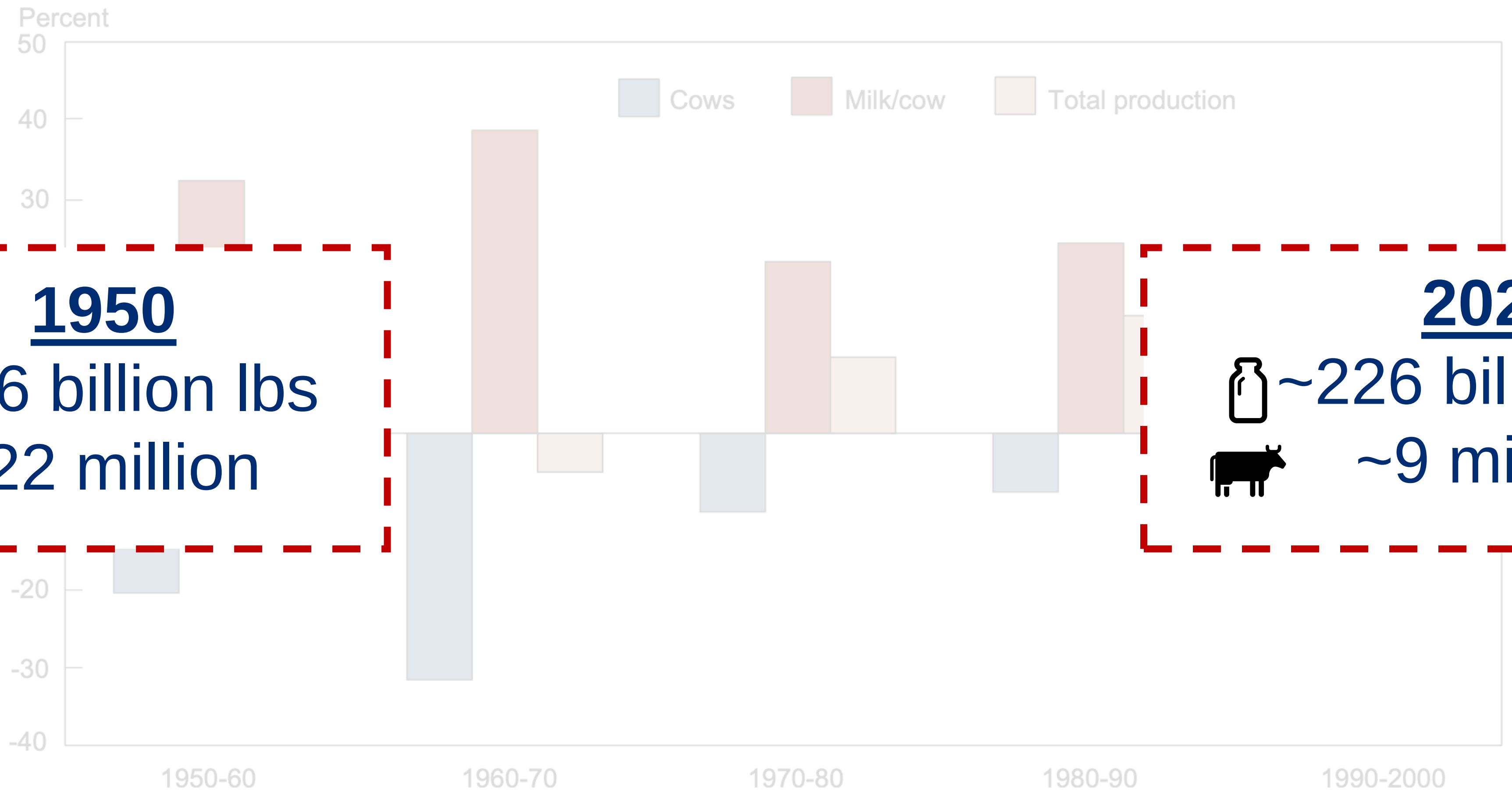
1. How have we been addressing sustainability in US dairy breeding?
2. What are the opportunities?
3. What are the lessons from the last 116 years of US dairy breeding programs?

EFFICIENCY AS SUSTAINABILITY



Blayney (2002) USDA Statistical Bulletin 978
Hoard's Dairymen (2022) Monthly Milk Production

EFFICIENCY AS SUSTAINABILITY



1950
~116 billion lbs
~22 million

2023
~226 billion lbs
~9 million

Blayney (2002) USDA Statistical Bulletin 978
National Agricultural Statistics Service, https://data.nass.usda.gov/dairy/milk-production/

FIRST, SOME HISTORY

1908 USDA Bureau of Animal Industry organized cow testing associations nationally

1915 Some bull associations calculated daughter-dam differences for their own bulls

1926 USDA calculated sire evaluations for 23 bulls and sent results directly to each bull's owner

Helmer Rabild, organizer of the first U. S. dairy herd-improvement association.

Newaygo County, MI
First U.S. DHI

https://aipl.arsusda.gov/aipl/history/hist_eval.htm

FIRST, SOME HISTORY

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Dairy Industry

Breed

Record of first 305 days of Lactation

Cow - Reg. No. | Date of Birth | Sire - Reg. No. | Dam - Reg. No.

Owner

P.O. Address | State

Calving date | Days in Milk | 3x 4x Days Milked | lbs. Milk | lbs. Fat

Remarks concerning record

BDIM- 960 | Signed

nearly $7,000 today!

U. S. Department of Agriculture
Agricultural Research Administration
Bureau of Dairy Industry
Washington, D. C.

Penalty for Private Use
to avoid payment of
Postage, $300

Official Business

BUREAU OF DAIRY INDUSTRY
U. S. Department of Agriculture
Agricultural Research Administration
Washington, D. C.

https://aipl.arsusda.gov/aipl/history/hist_eval.htm

FIRST, SOME HISTORY

1935 Milk records available for ~2% of dairy cows

https://aipl.arsusda.gov/aipl/history/hist_eval.htm

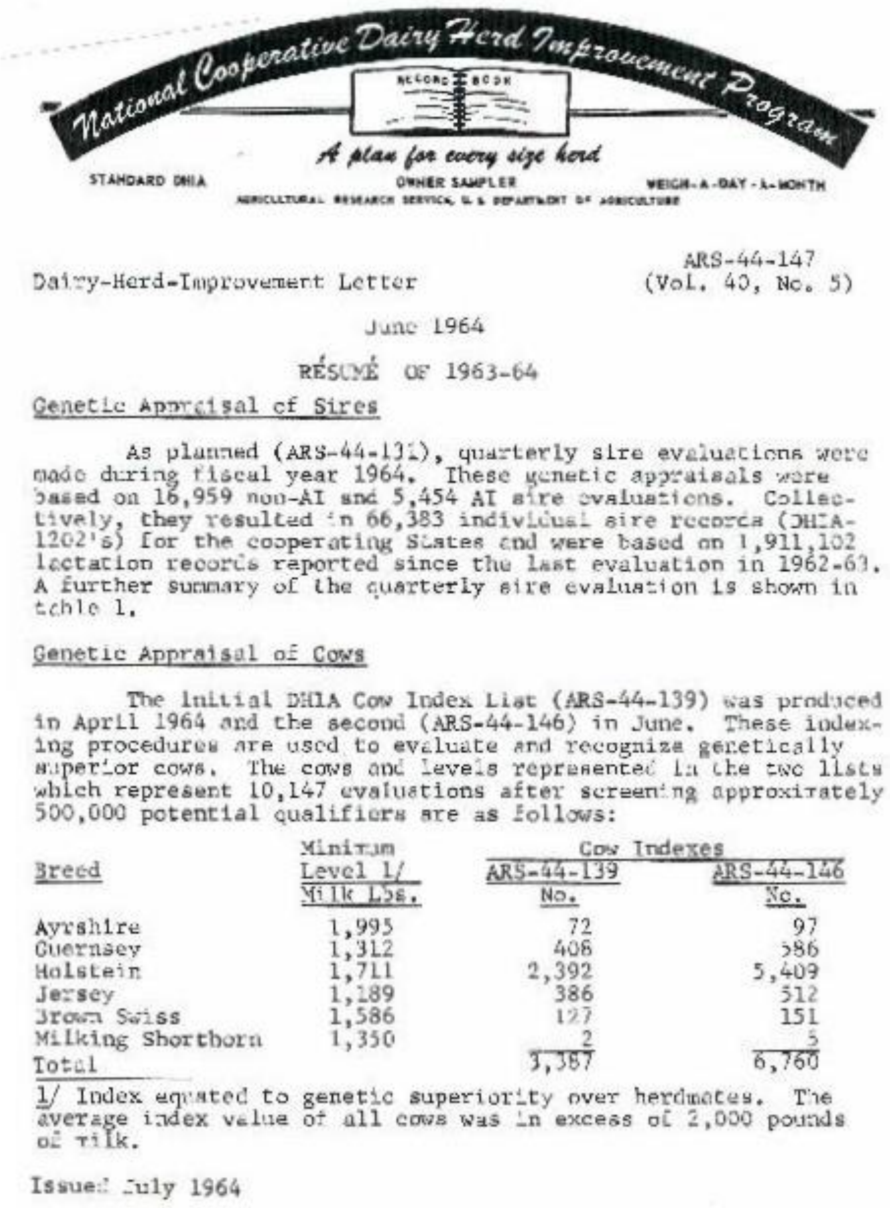
FIRST, SOME HISTORY

1964 National evaluations replaced regional processing center evaluations

1989 Animal model implemented considering relationships among all cows and bulls

2009 First official genomic evaluations

2013 Calculation and distribution of evaluations transferred to Council on Dairy Cattle Breeding



National Cooperative Dairy Herd Improvement Program

RECORD BOOK

A plan for every size herd

STANDARD DHIA — OWNER SAMPLER — WEIGH-A-DAY-A-MONTH

AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE

Dairy-Herd-Improvement Letter

ARS-44-147
(Vol. 40, No. 5)

June 1964

RÉSUMÉ OF 1963-64

Genetic Appraisal of Sires

As planned (ARS-44-131), quarterly sire evaluations were made during fiscal year 1964. These genetic appraisals were based on 16,959 non-AI and 5,454 AI sire evaluations. Collectively, they resulted in 66,383 individual sire records (DHIA-1202's) for the cooperating States and were based on 1,911,102 lactation records reported since the last evaluation in 1962-63. A further summary of the quarterly sire evaluation is shown in table 1.

Genetic Appraisal of Cows

The initial DHIA Cow Index List (ARS-44-139) was produced in April 1964 and the second (ARS-44-146) in June. These indexing procedures are used to evaluate and recognize genetically superior cows. The cows and levels represented in the two lists which represent 10,147 evaluations after screening approximately 500,000 potential qualifiers are as follows:

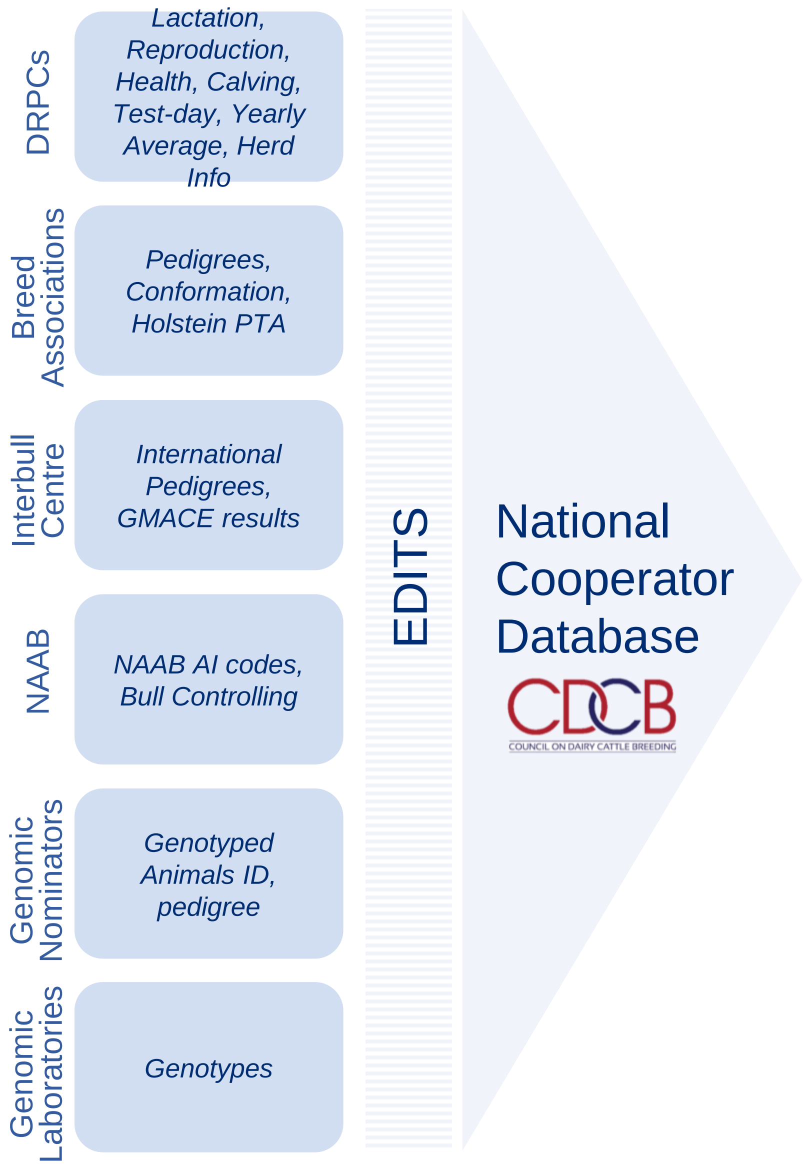
Breed	Minimum Level 1/ Milk Lbs.	Cow Indexes ARS-44-139 No.	Cow Indexes ARS-44-146 No.
Ayrshire	1,995	72	97
Guernsey	1,312	408	586
Holstein	1,711	2,392	5,409
Jersey	1,189	386	512
Brown Swiss	1,586	127	151
Milking Shorthorn	1,350	2	5
Total		3,387	6,760

1/ Index equated to genetic superiority over herdmates. The average index value of all cows was in excess of 2,000 pounds of milk.

Issued July 1964

2024 NATIONAL EVALUATION SYSTEM

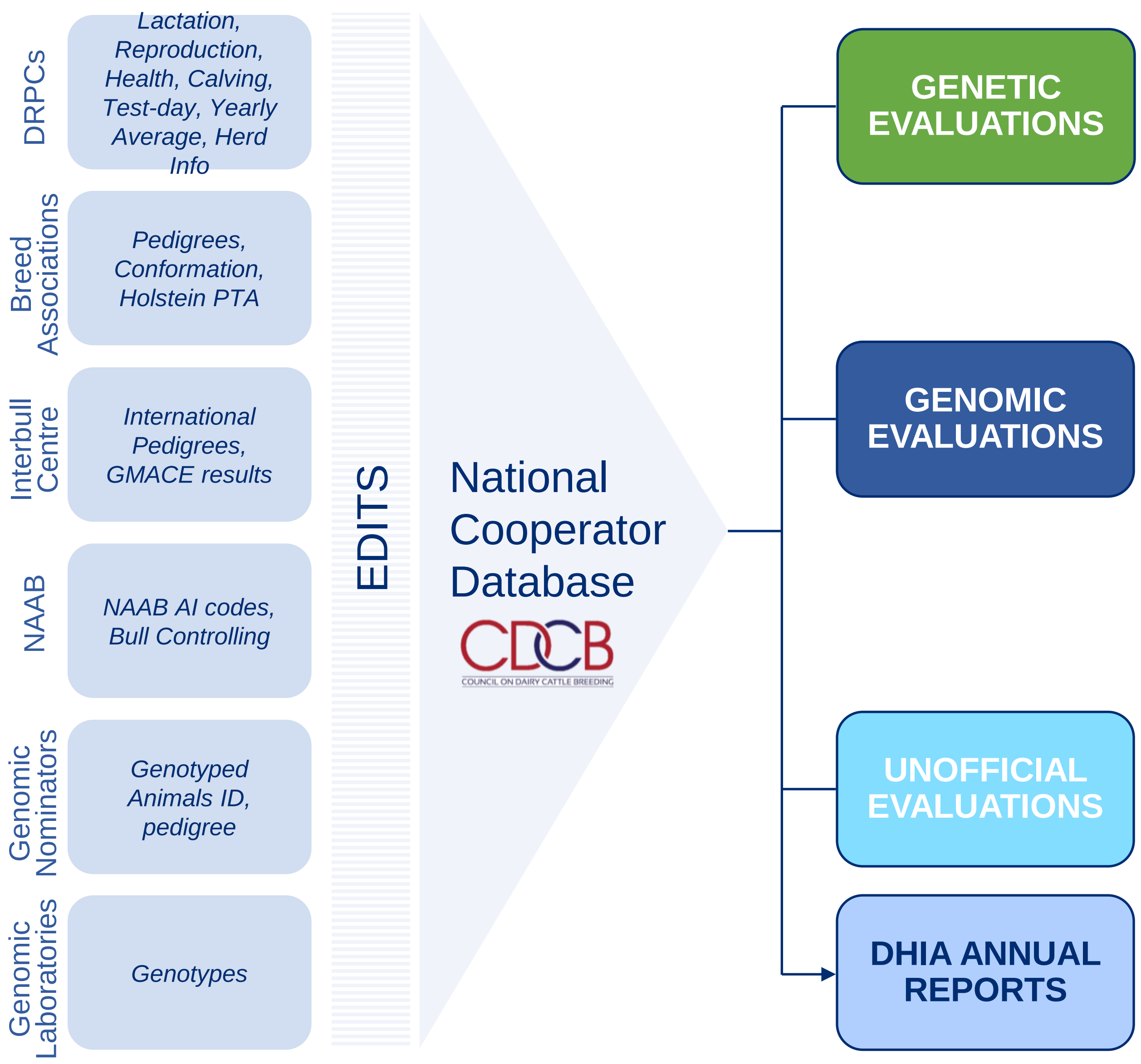
DRPCs	*Lactation, Reproduction, Health, Calving, Test-day, Yearly Average, Herd Info*
Breed Associations	*Pedigrees, Conformation, Holstein PTA*
Interbull Centre	*International Pedigrees, GMACE results*
NAAB	*NAAB AI codes, Bull Controlling*
Genomic Nominators	*Genotyped Animals ID, Pedigree*
Genomic Laboratories	*Genotypes*



> 100 million LACTATIONS

> 100 million PEDIGREES

> 8.5 million GENOTYPES


DRPCs
Lactation, Reproduction, Health, Calving, Test-day, Yearly Average, Herd Info
Breed Associations
Pedigrees, Conformation, Holstein PTA
Interbull Centre
International Pedigrees, GMACE results
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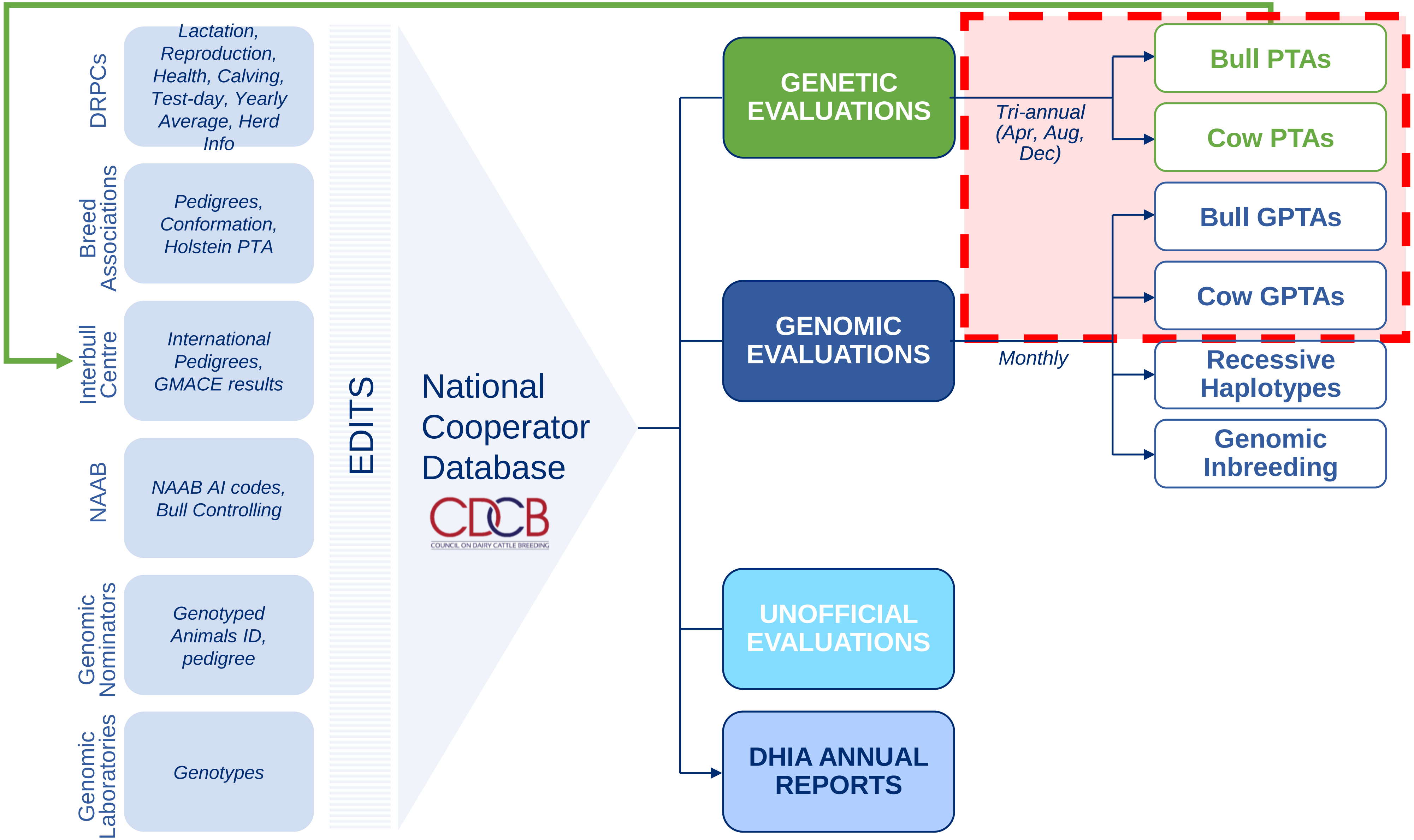
Genomic Laboratories
Genotypes
EDITS
National Cooperator Database
CDCB
COUNCIL ON DAIRY CATTLE BREEDING
GENETIC EVALUATIONS
GENOMIC EVALUATIONS
UNOFFICIAL EVALUATIONS
DHIA ANNUAL REPORTS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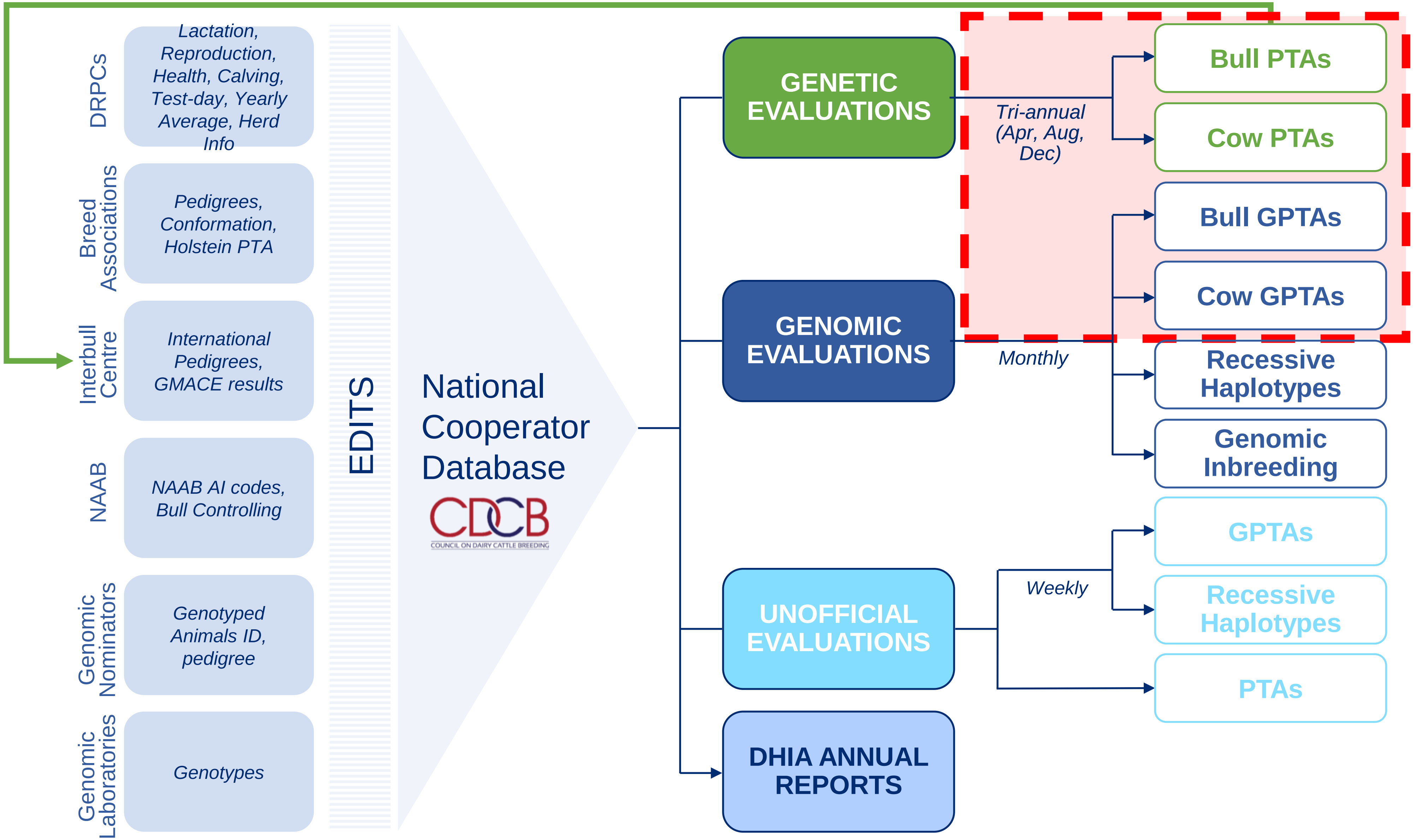
COUNCIL ON DAIRY CATTLE BREEDING
GENETIC EVALUATIONS
Tri-annual (Apr, Aug, Dec)
Bull PTAs
Cow PTAs
GENOMIC EVALUATIONS
Monthly
Bull GPTAs
Cow GPTAs
Recessive Haplotypes
Genomic Inbreeding
UNOFFICIAL EVALUATIONS
DHIA ANNUAL REPORTS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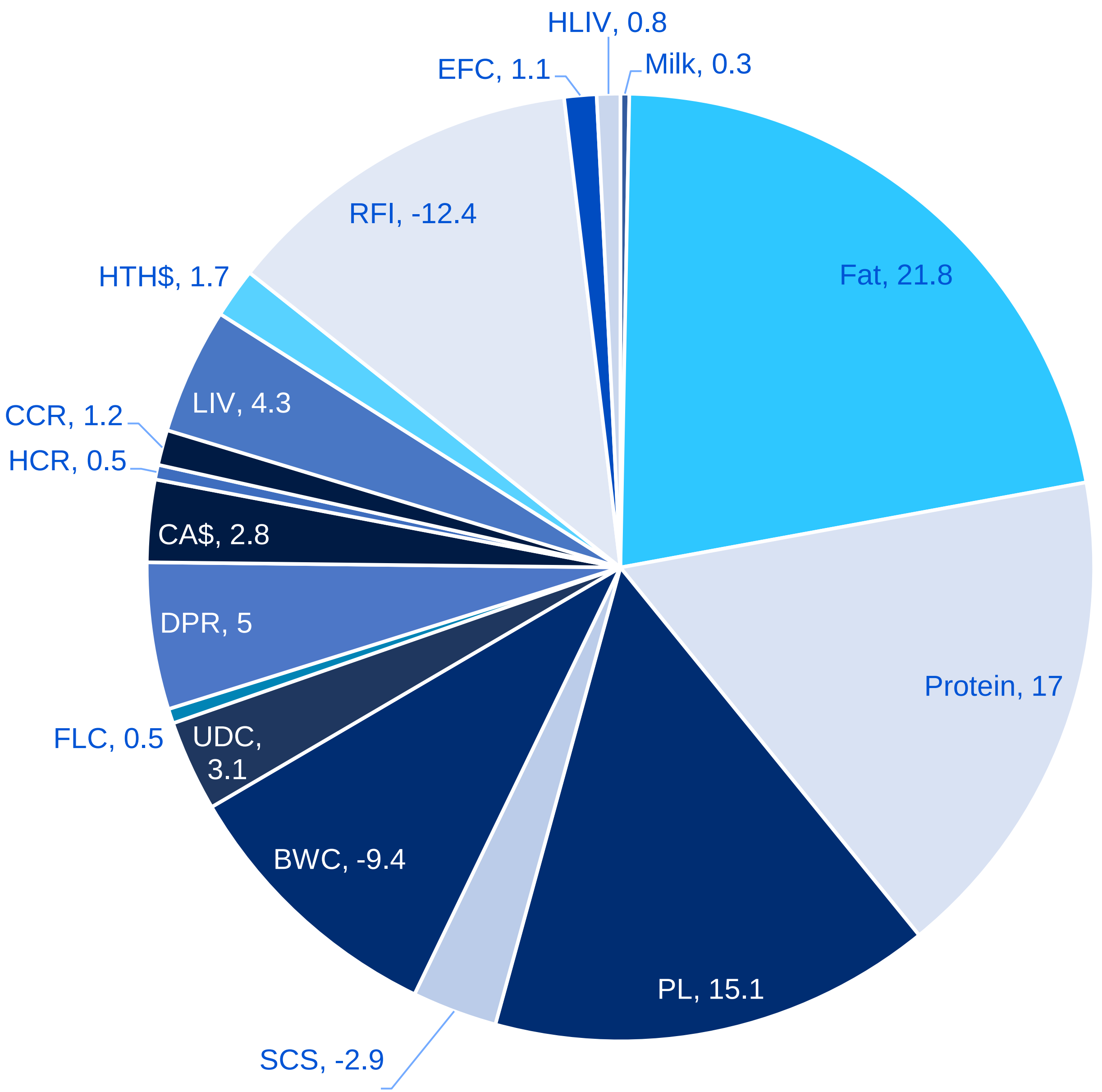
Recessive Haplotypes
PTAs
DHIA ANNUAL REPORTS

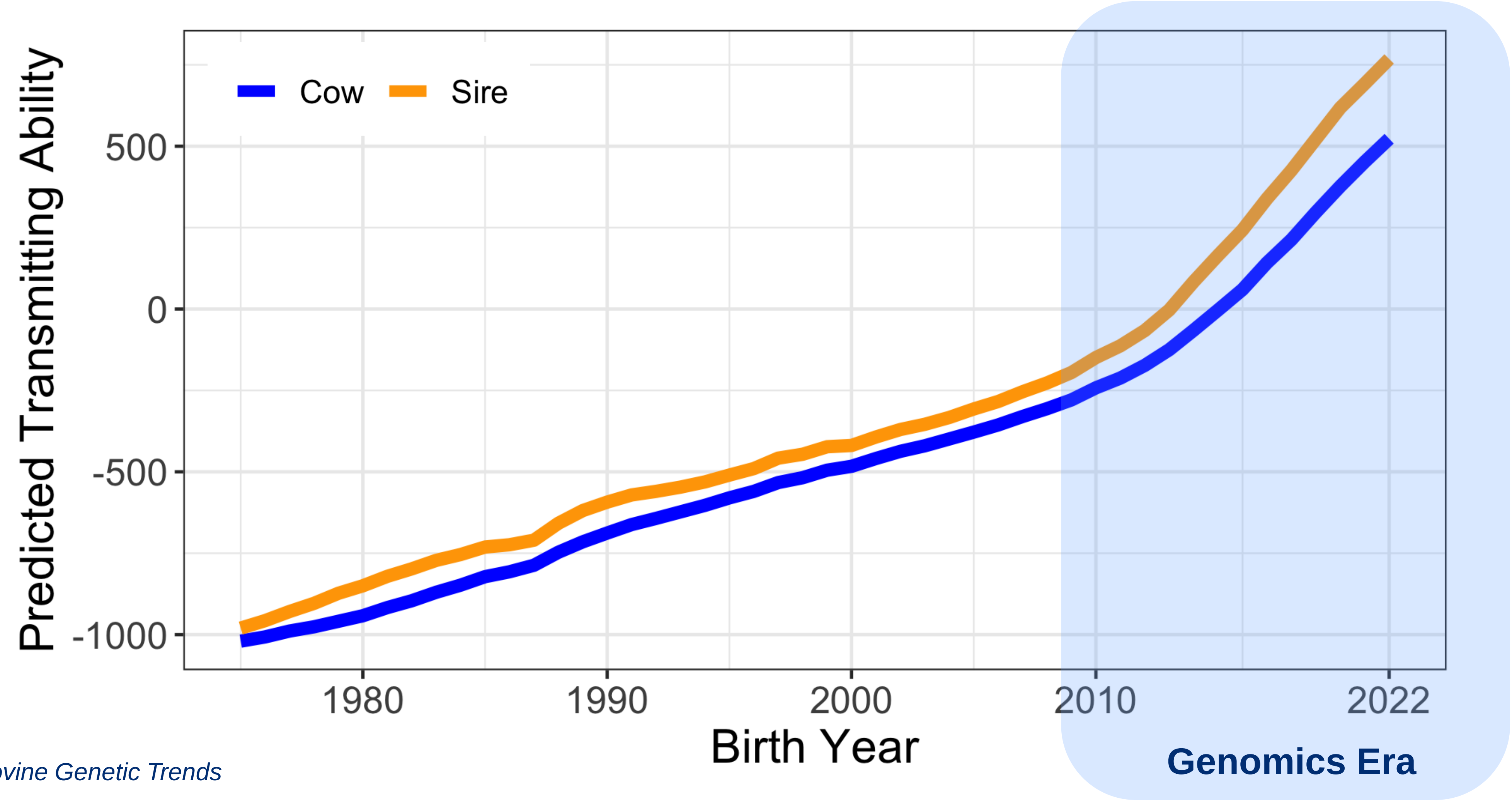
NET MERIT (NM$)

Relative values in 2021 NM$ for each:

Yield Traits
Productive Life
Somatic Cell Score
Body Weight Composite
Udder Composite
Feet/Legs Composite
Daughter Pregnancy Rate
Calving Ability
Heifer Conception Rate
Cow Conception Rate
Livability
Health Traits
Feed Saved
Early First Calving
Heifer Livability



NET MERIT (NM$)



Source: CDCB, Bovine Genetic Trends

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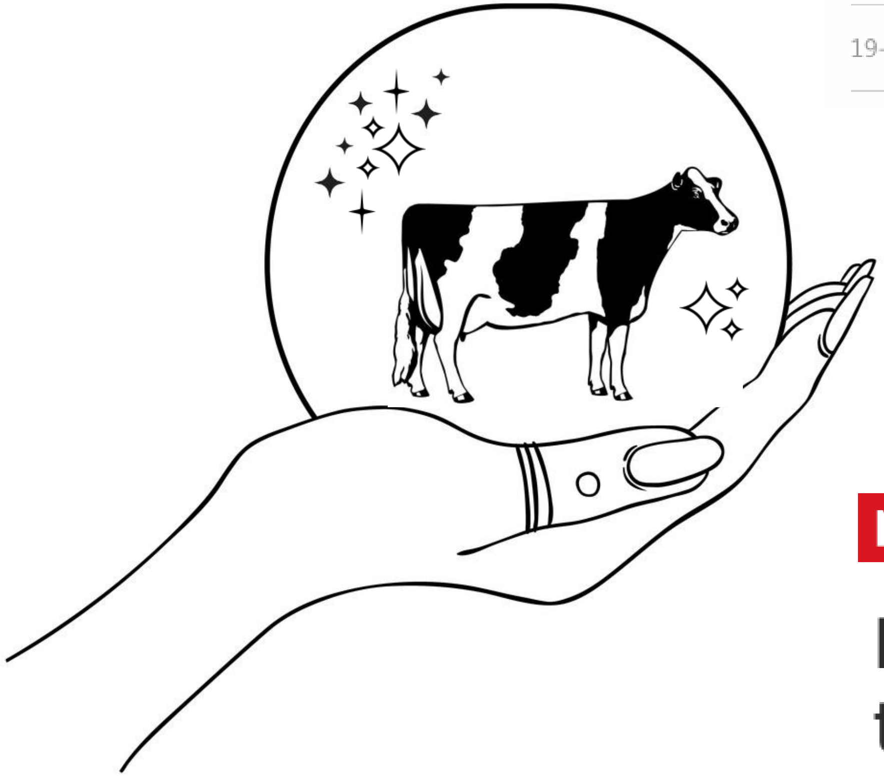
THE LONG GAME



DAIRY GLOBAL

Surviving high North American feed prices

19-08-2021 | Nutrition | Article

Rise of ethical milk: 'Mums ask when cows and their calves are separated'

The Guardian

npr

Days of intense heat have killed thousands of cattle in Kansas

June 16, 2022 · 12:39 PM ET

PRESERVING GENETIC DIVERSITY

HOARD'S DAIRYMAN

The truth about inbreeding in dairy cattle

There is no simple solution to inbreeding. It took years to get into this situation, and it's not going away tomorrow.

SCIENTIFIC AMERICAN.

From Two Bulls, Nine Million Dairy Cows

two Y chromosomes exist in a huge population of U.S. Holsteins; researchers want to know what traits have been lost

THE WALL STREET JOURNAL.

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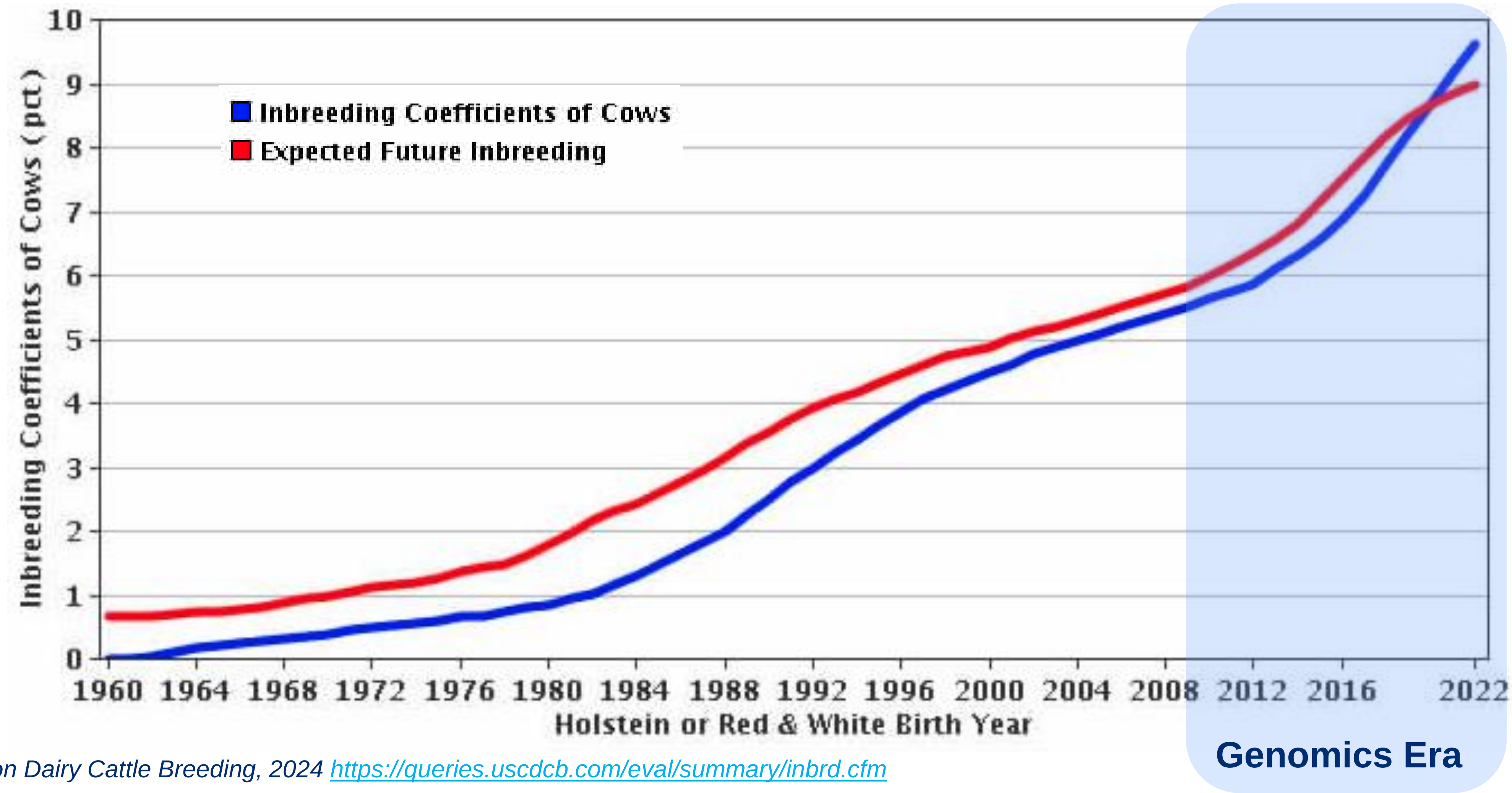
U.S. | THE NUMBERS

Most Dairy Cows Are Kissing Cousins, and Scientists Are Worried

Selective breeding helps Holsteins produce 94% of the nation's milk, but can also lead to the proliferation of diseases

INBREEDING TRENDS: HO/R&W



Source: Council on Dairy Cattle Breeding, 2024 https://queries.uscdcb.com/eval/summary/inbrd.cfm

WHY CARE ABOUT INBREEDING?

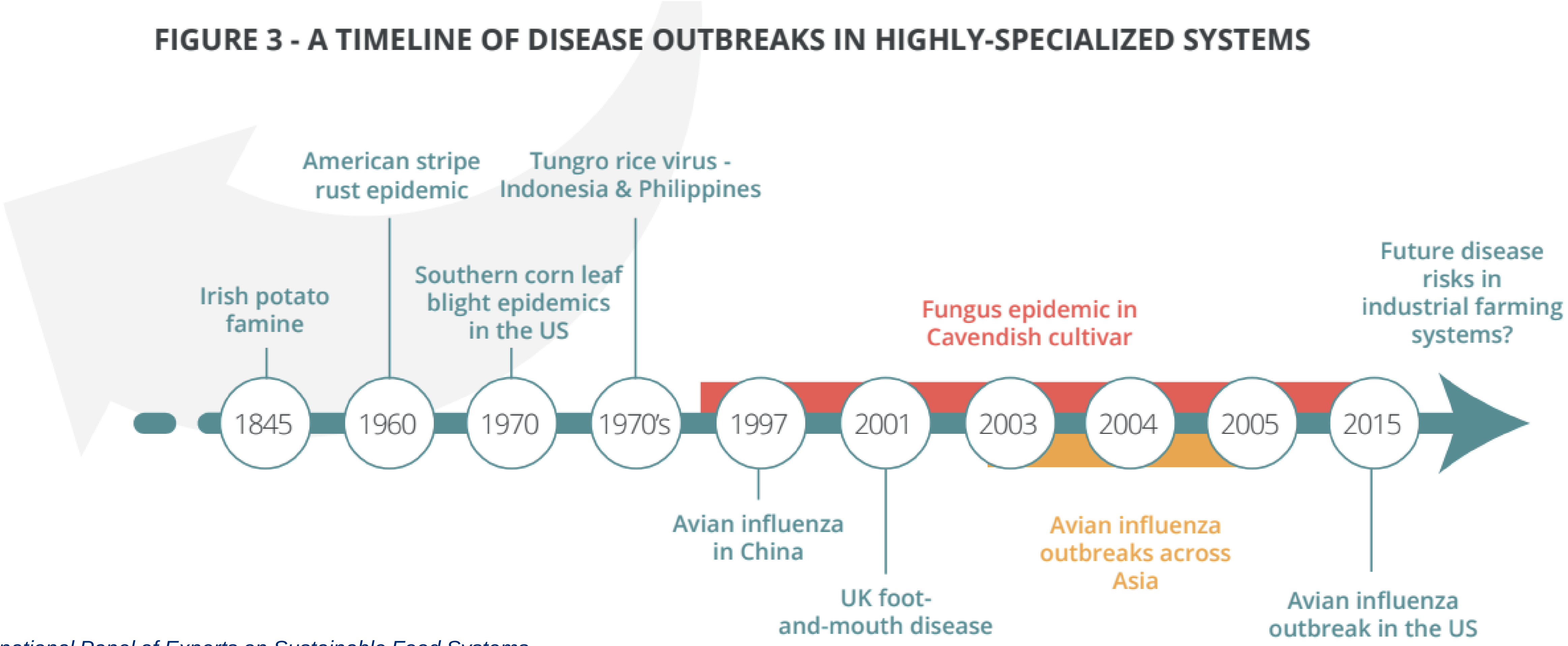
- **Inbreeding:** proportion of the genome that is identical due to shared ancestry
- **Inbreeding Depression:** decrease in fitness due to increased inbreeding
  - Harmful loci increase in frequency
  - Haplotypes like HH1

BREED	EFI
Ayrshire	7.0
Brown Swiss	7.1
Guernsey	7.9
Holstein	7.5
Jersey	7.9
Milking Shorthorn	4.5

Source: Council on Dairy Cattle Breeding, 2024
https://webconnect.uscdcb.com/#/summary-stats/breed-means-bases-heterosis-inbreeding-regressions

HOMOGENEITY = VULNERABILITY?

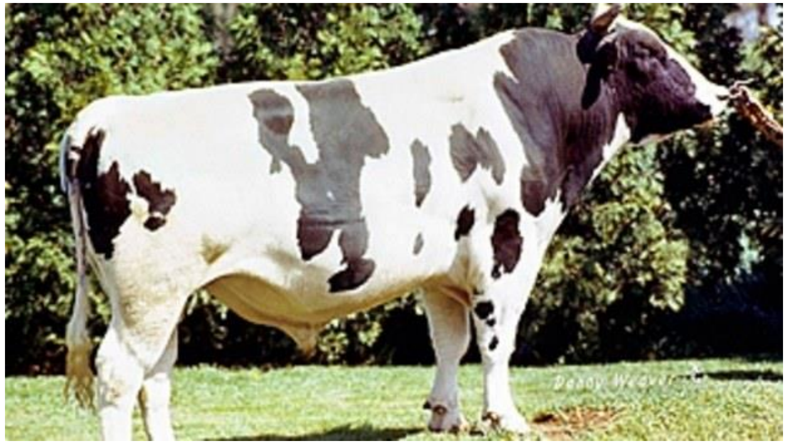
FIGURE 3 - A TIMELINE OF DISEASE OUTBREAKS IN HIGHLY-SPECIALIZED SYSTEMS



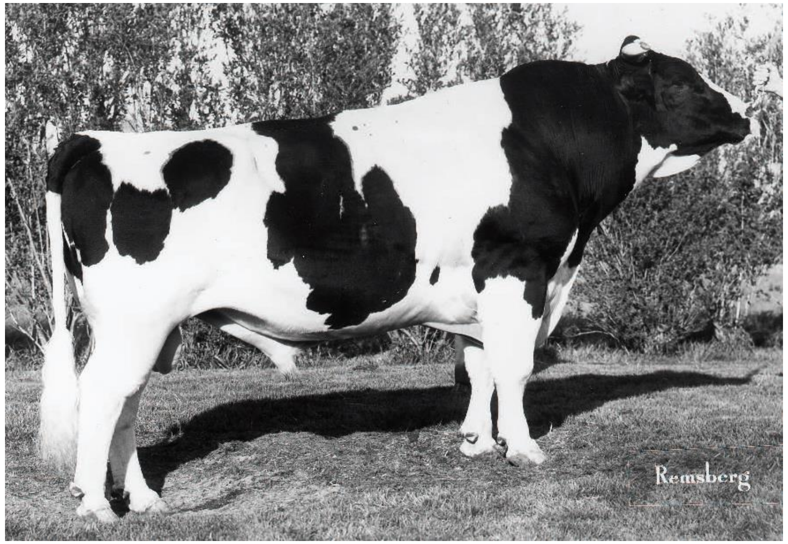
International Panel of Experts on Sustainable Food Systems
https://www.ipes-food.org/_img/upload/files/UniformityToDiversity_FULL.pdf

WHAT CAN WE DO?

- Inbreeding is unavoidable in a finite population, **but it can be managed!**
- Male genetic variation is very limited
- We must conserve female genetic diversity
    - Out-crossing
    - Cross-breeding



Pawnee Farm Arlinda Chief (above)



Round Oak Rag Apple Elevation (above)

PHENOTYPIC TOOLS

THE GLOBAL STANDARD FOR LIVESTOCK DATA

- Quantitative measures that directly relate to agriculture sustainability are preferable to qualitative measures
- ICAR has focused on information collected through milk recording as it relates to sustainability.
- Published a list of 43 key traits with standardized definitions for how they can be calculated.

https://www.icar.org/index.php/technical-bodies/task-forces/sustainability-task-force/

PROOF OF CONCEPT

Data Supplied from U.S. Records Processing Centers

DRMS DAIRY RECORDS MANAGEMENT SYSTEMS

amelicor

AgSource DAIRY

AgriTech Analytics
Your Choice for Exceptional Dairy Records

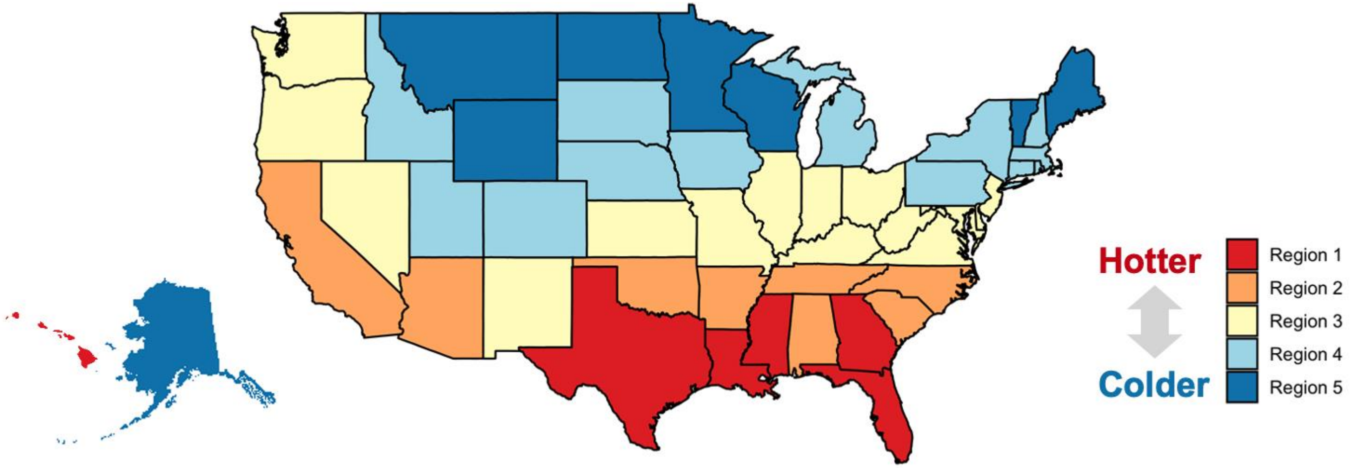
ICAR SUSTAINABILITY TASK FORCE TRAIT CATEGORIES

FEEDING & PRODUCTION	FERTILITY	HEALTH	LONGEVITY	YOUNG STOCK
AVG DIM	**AVG CALVING INTERVAL**	**AVG SCC**	**AVG CULLING AGE**	**AVG AGE FIRST CALVING**
N = 10,003	**N = 9,905**	**N = 9,830**	**N = 10,041**	**N = 10,095**

DEFINING PEER GROUPS

Three Strata Capture Varied U.S. Systems

REGION



MAJOR DAIRY BREEDS

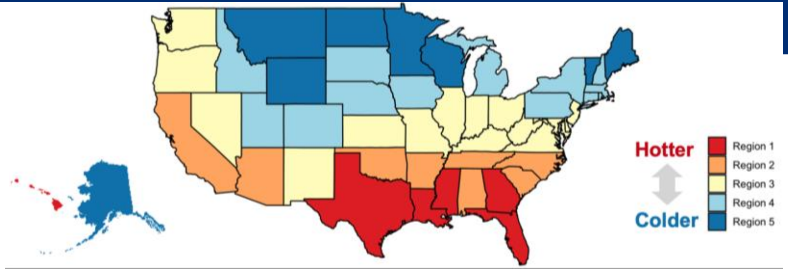
Holstein
Jersey
Brown Swiss
Ayrshire
Guernsey
Milking Shorthorn

SIZE

< 250 **> 1000**

HERD DEMOGRAPHICS

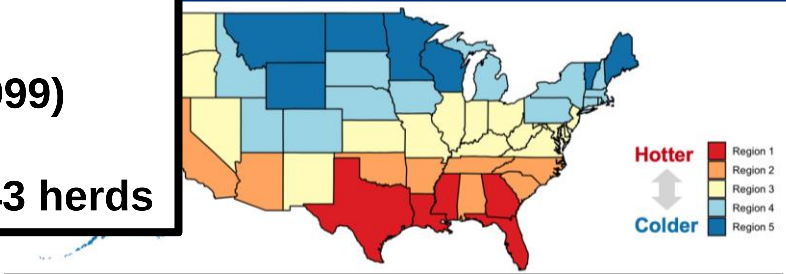
S < 250
M 250 – 999
L 1000+

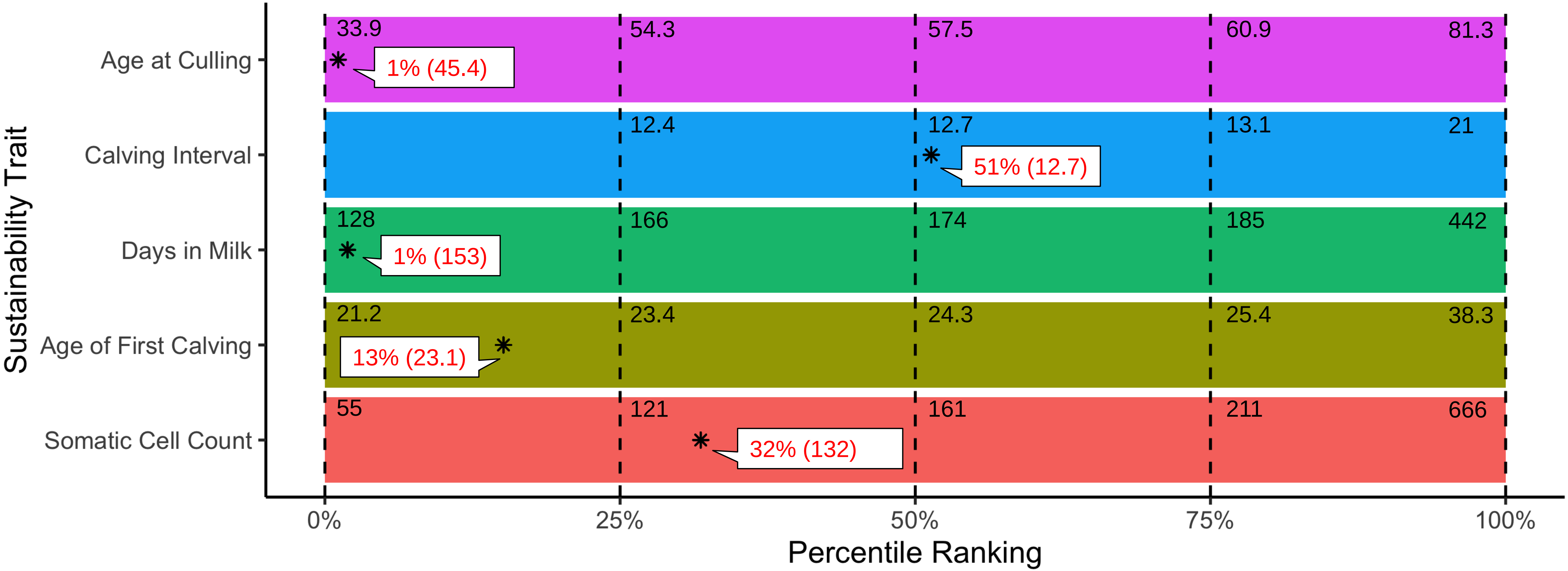


	R1			R2			R3			R4			R5		
	S	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**
AY							7			22			14		
BS				4			30			23	3		33	4	
DL										2					
FL													1	2	
GU	1						7			17	1		26	2	
HO	46	34	19	61	68	206	900	193	55	3248	**443**	213	1938	629	165
JE	6	2	3	28	18	34	108	18	3	131	18	7	105	15	4
MS				1			1			2			4		
WW													3		
XB							1								
XD						4				1			1		
XX	20	17	14	34	8	24	208	26	11	407	51	18	302	41	11

EXAMPLE: PERCENTILES

Example Herd:
Holstein
Medium (250 – 999)
Region 4
Peer Group = 443 herds





EXAMPLE: SCC

Curve Shaded by Percentiles

Example Herd:
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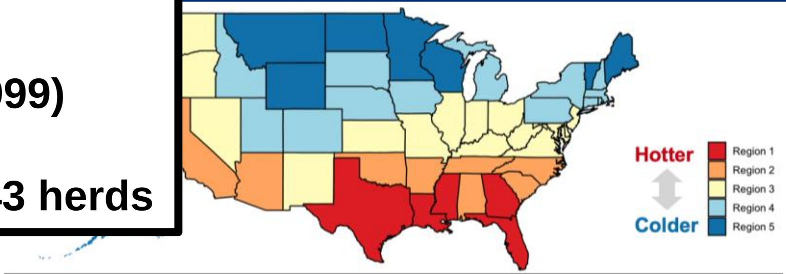
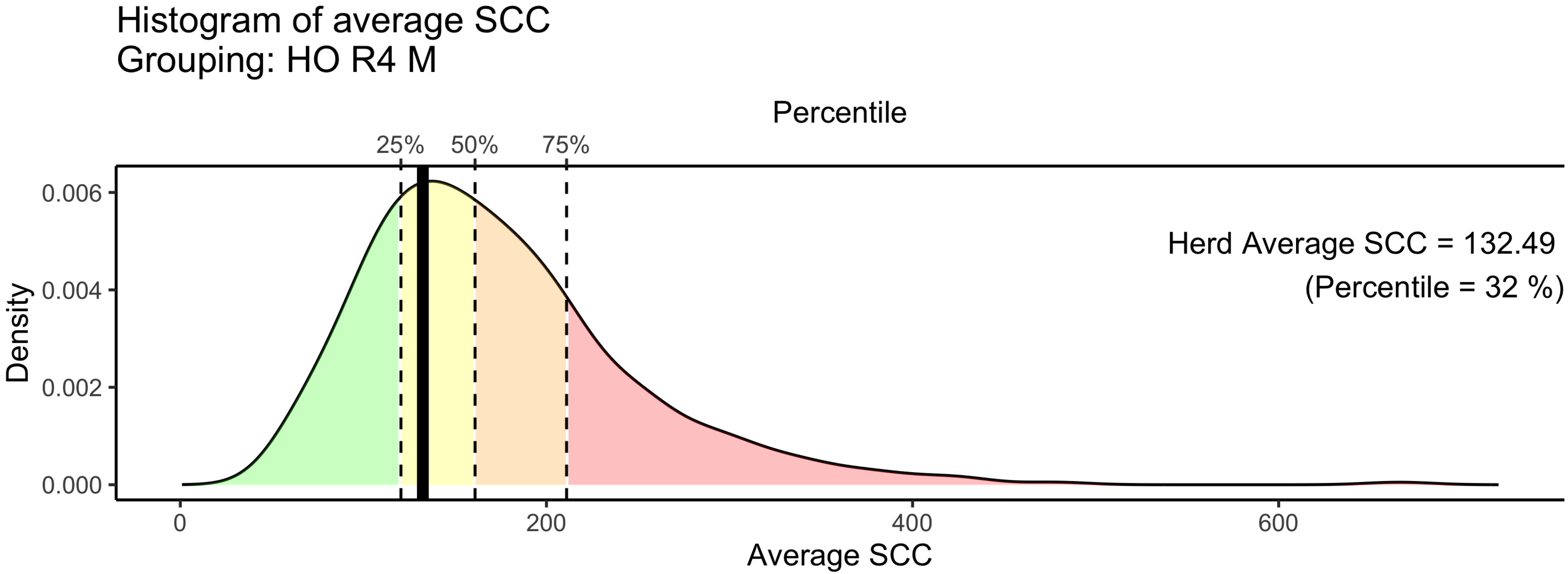
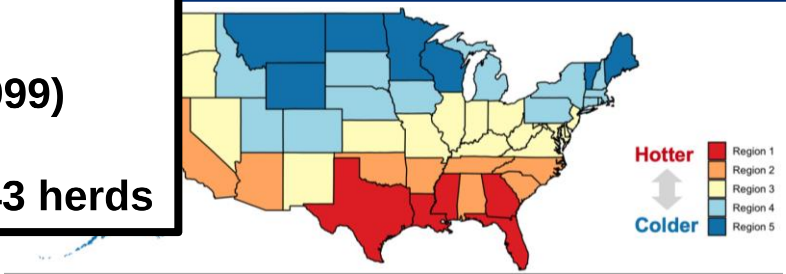


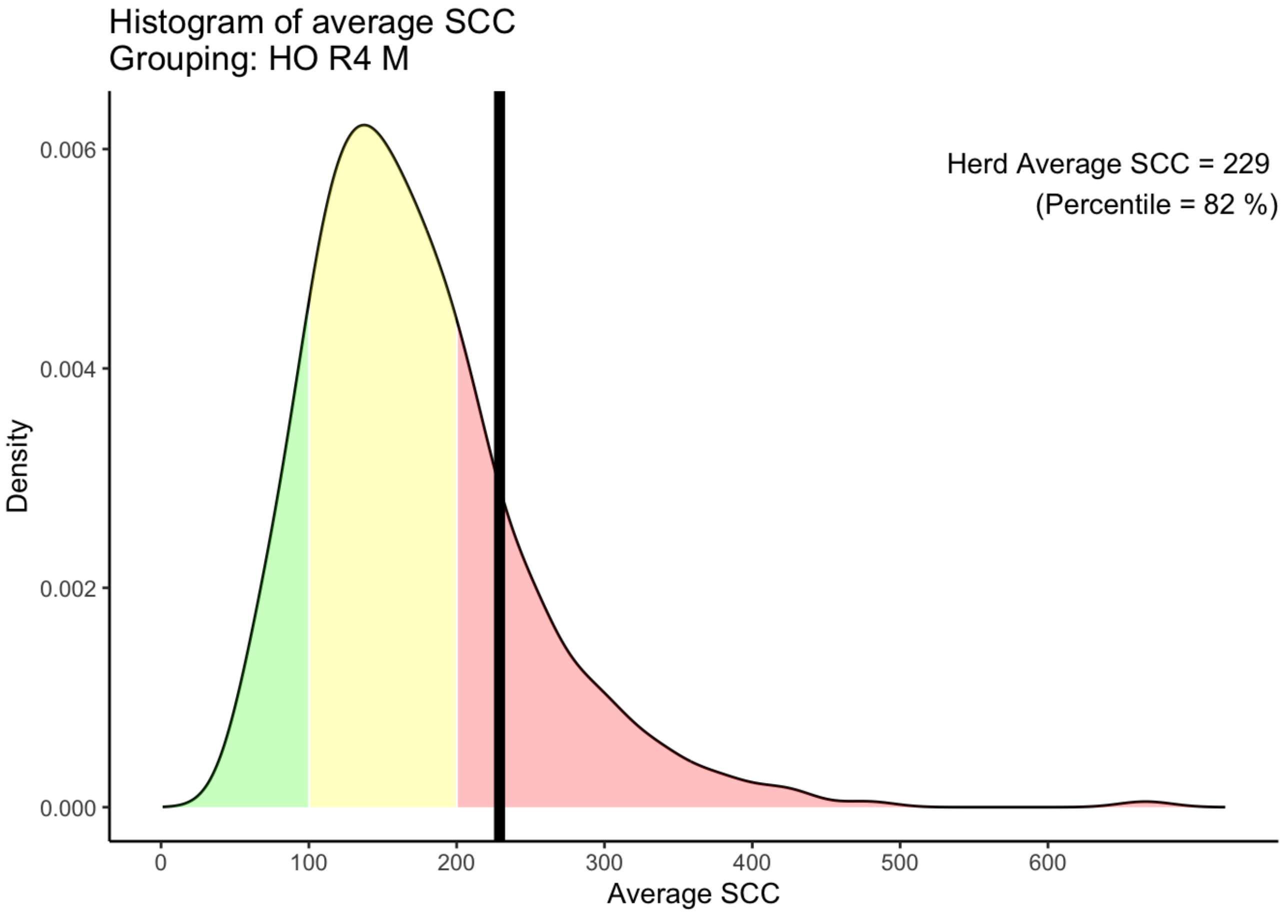


EXAMPLE: SCC

Curve Shaded by Ranges of Actual Values

Example Herd:
Holstein
Medium (250 – 999)
Region 4
Peer Group = 443 herds





Percentile rankings are limited because someone must be last – even if their actual value is perfectly acceptable!

EXAMPLE: CI

Curve Shaded by Ranges of Actual Values

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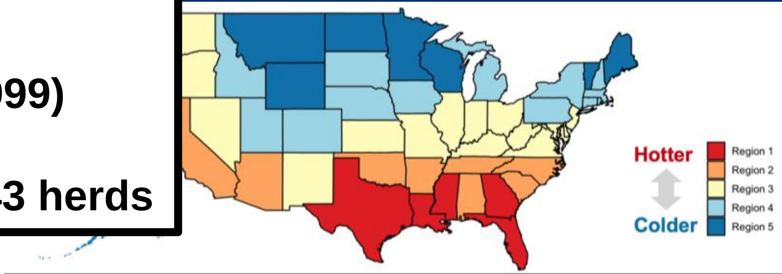
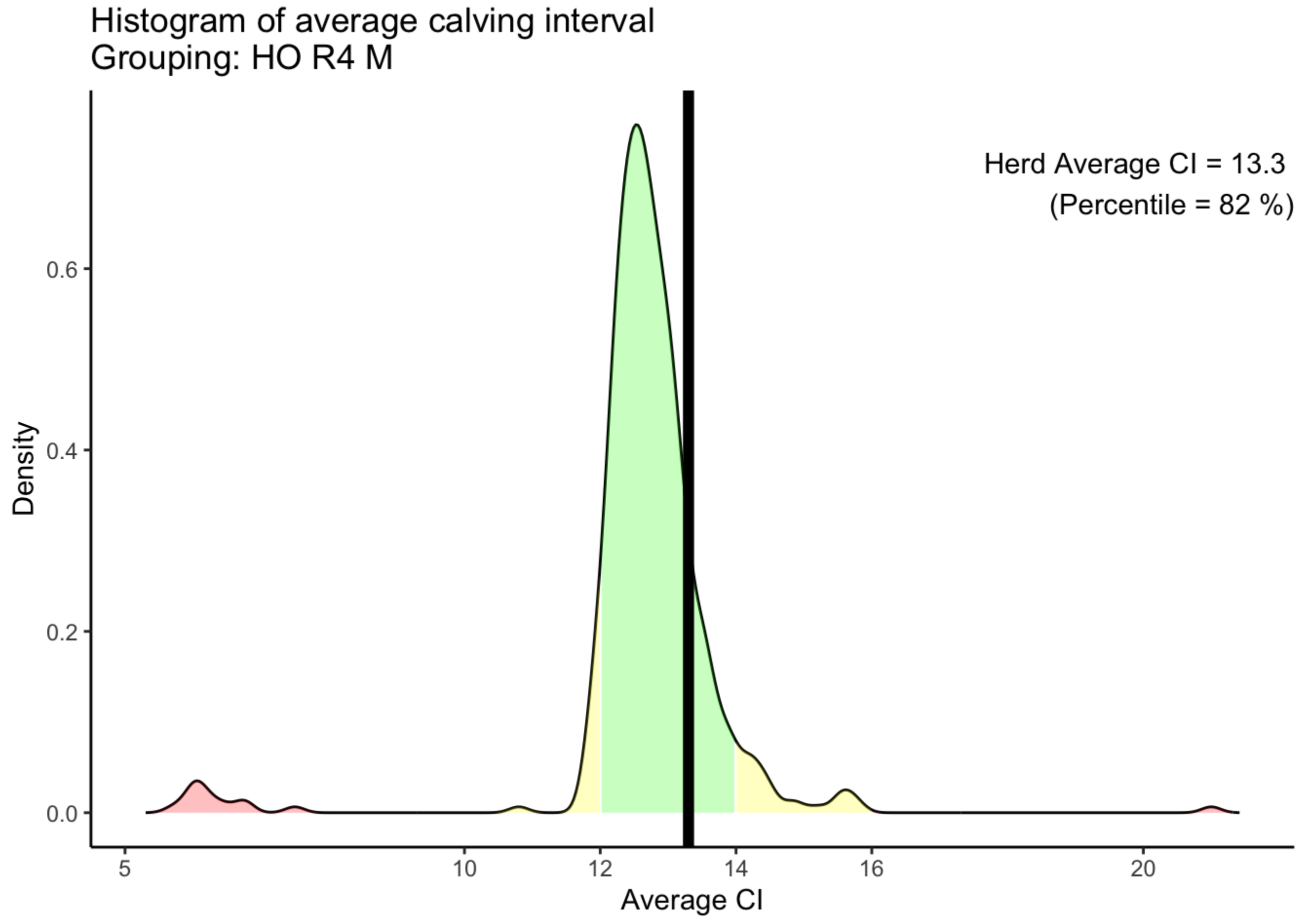
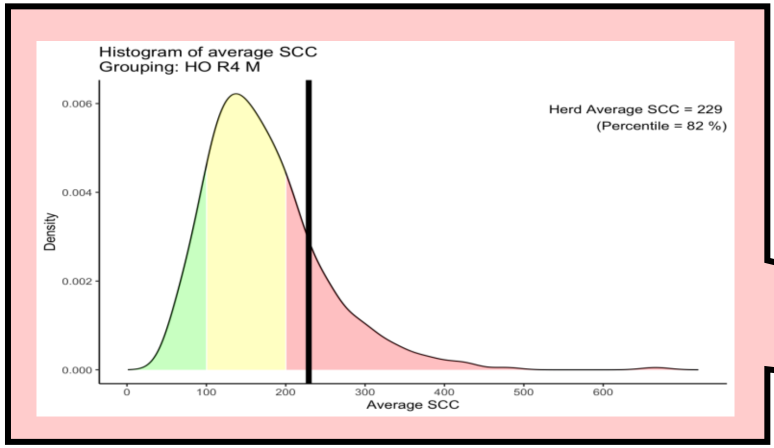




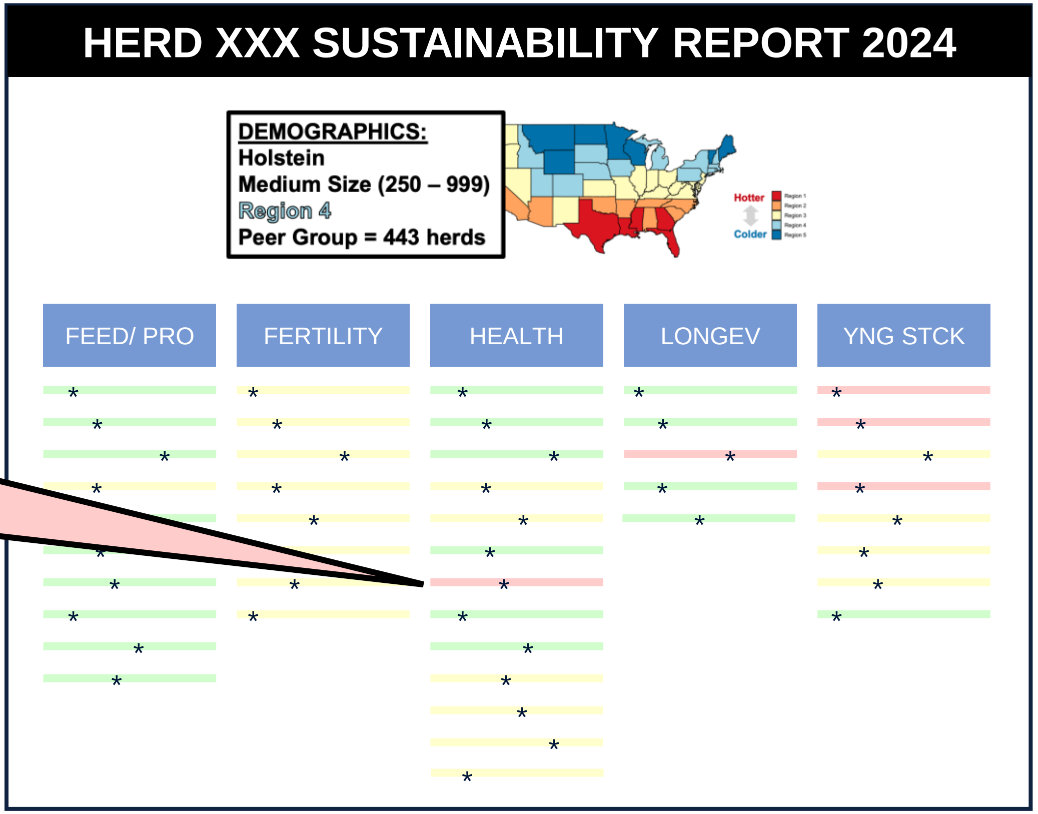
The next challenge is industry consensus on optimal values for each trait

WEB-BASED APPLICATION

Confidential analysis; accessed privately by owners

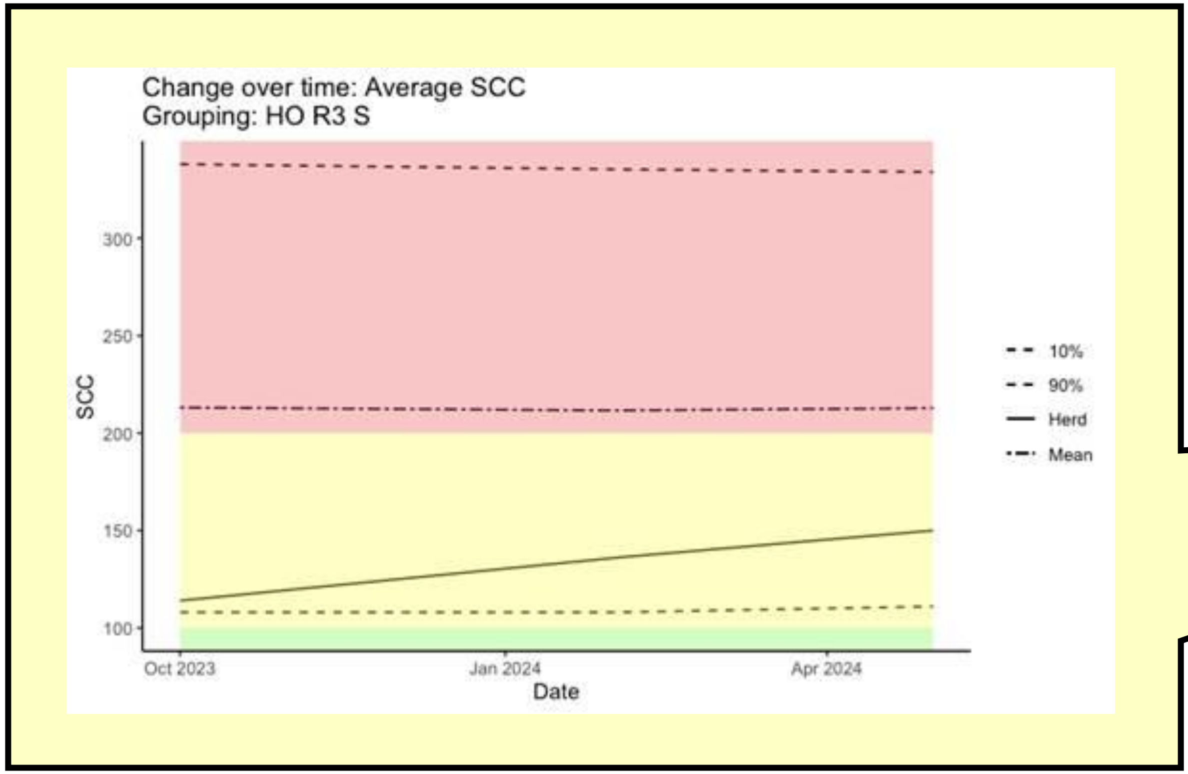


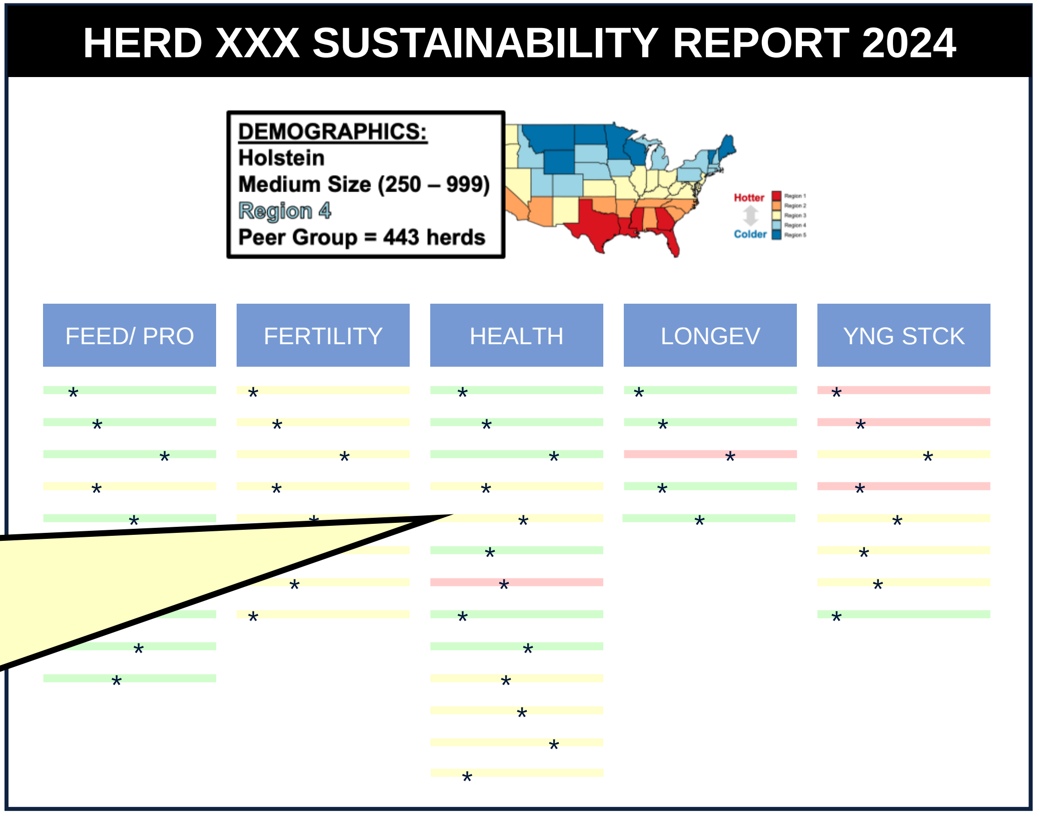
CLICK TO LEARN MORE!



WEB-BASED APPLICATION

Trend Tracking Over Time





EXPANDING TO OTHER TRAITS

Relative Ease of Implementation

MEDIUM

Milk Urea Nitrogen Rates	% Cows FPR >1.3/1.5 @ 1st Test Day
% Cows Culled (Reproductive)	% Cows with Lameness
% Cows Fertility Disorders	% Cows with Mastitis
Chronic Infection Rate	% Cows with Subclinical Metabolic
Dry Cow Cure Rate	Daily Production of Culled Animals
Fresh Cow Infection Rate	Lifetime Production of Culled Animals
% Cows Culled (Udder Health)	% Died at <60 DIM
% Cows Culled (Lameness)	% Female Young Stock Involuntary Culled
% Cows Culled (Other)	% Female Calves (Diarrhea)
% Cows FPR < 1 @ 1st Test Day	% Female Calves (Respiratory Disease)

EASY

Energy Corrected Milk
Days Open
1st Service Conception Rate
Lactation Number
Young Stock EBV Ranking
Young Stock Sire EBV Ranking
% Calves Born Dead

HARD

Apparent Pregnancy Loss Rate
Pregnancy Rate

NO DATA

Age at slaughter (beef), Body Weight, Daily Gain, Dry Matter Intake, Feed Efficiency, Methane Emissions, % Cows with Functional BCS, Non-return Rate 56 d, Selective Dry Cow Therapy Rate

COMMUNITY ENGAGEMENT

Angel VanRaden "milking" a "cow"

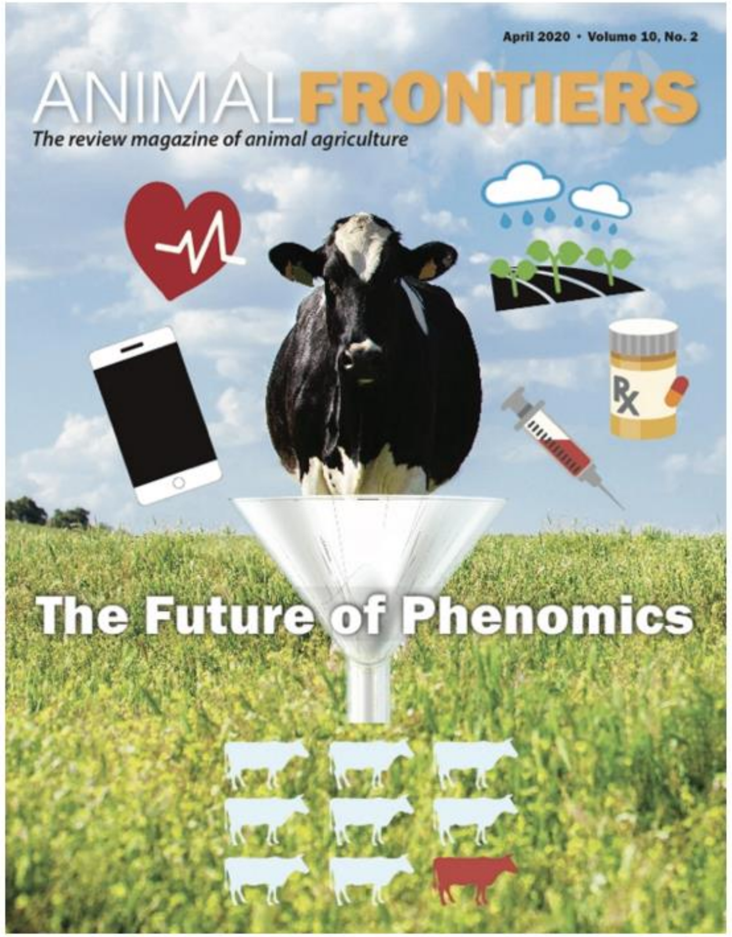
One of the last coal-powered sheep.
Most sheep are all electric now.

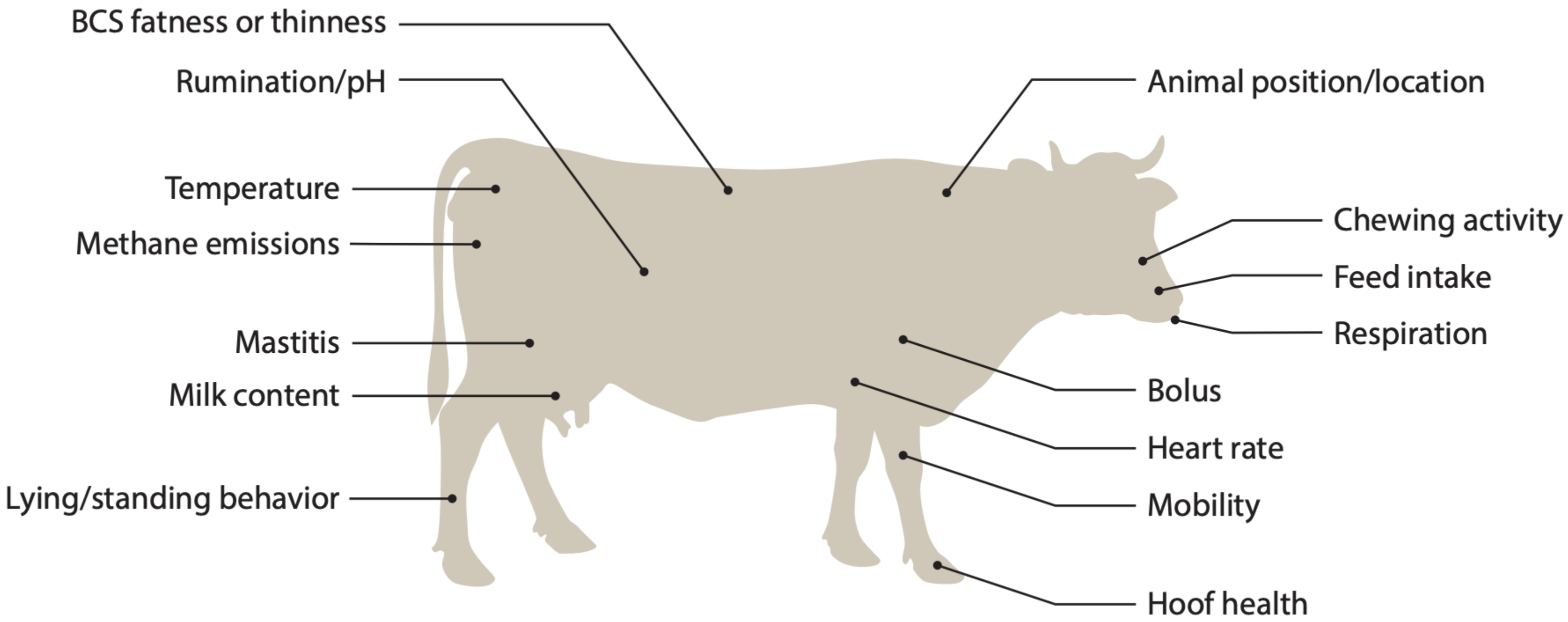
Are consumers willing to accept that we are being responsible in our stewardship?

NEW TRAITS & DATA STREAMS

- HEAT STRESS
- FEED EFFICIENCY
- METHANE EMISSIONS
- MICROBIOME
- ORGANIC SYSTEMS
- GRAZING SYSTEMS
- ROBOTIC SYSTEMS

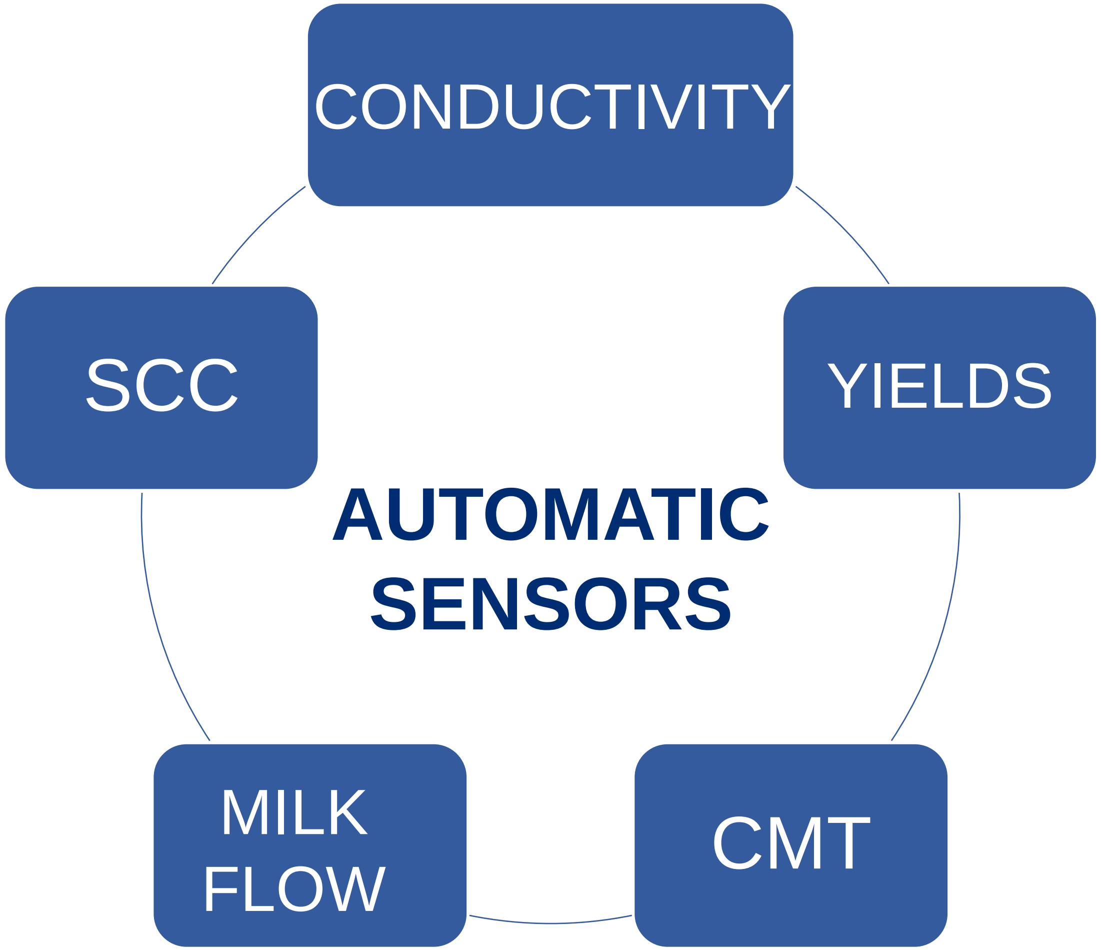
HIGH-THROUGHPUT PHENOTYPING





Halachmi et al 2019

EXAMPLE: AMS SYSTEMS



These are very useful for management decisions:

- Monitoring subclinical mastitis
- Managing bulk tank SCC
- Culling
- Selective dry therapy

DATA USABILITY CHALLENGES

- No standard data definitions or SOPs
- No standard validation, maintenance, or calibration protocols
- System bias and individual sensor bias
- Animal ID: phenotype mismatches
- Non-representative sampling
- Data storage, flow, quality control & assurance

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- Some companies plan to own sensor-generated data
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1. How can we standardize it?

2. Who can use it?

Businessweek | Feature

Farmers Fight John Deere Over Who Gets to Fix an $800,000 Tractor

The right-to-repair movement has come to the heartland, where some farmers are demanding access to the software that runs their equipment.

By Peter Waldman and Lydia Mulvany
March 5, 2020, 5:00 AM EST

THE DRIVE

THE WAR ZONE | REVIEWS | DONUT MEDIA | THE STORE | NEWSLETTER SIGNUP

Tesla's $16,000 Quote for a $700 Fix Is Why Right to Repair Matters

This is what people are fighting for.

BY ROB STUMPF JULY 12, 2021

NEWS

CNBC

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TECH

Apple's new fix-it policy is a drop in the bucket for 'right to repair'

PUBLISHED THU, DEC 30 2021•12:01 PM EST

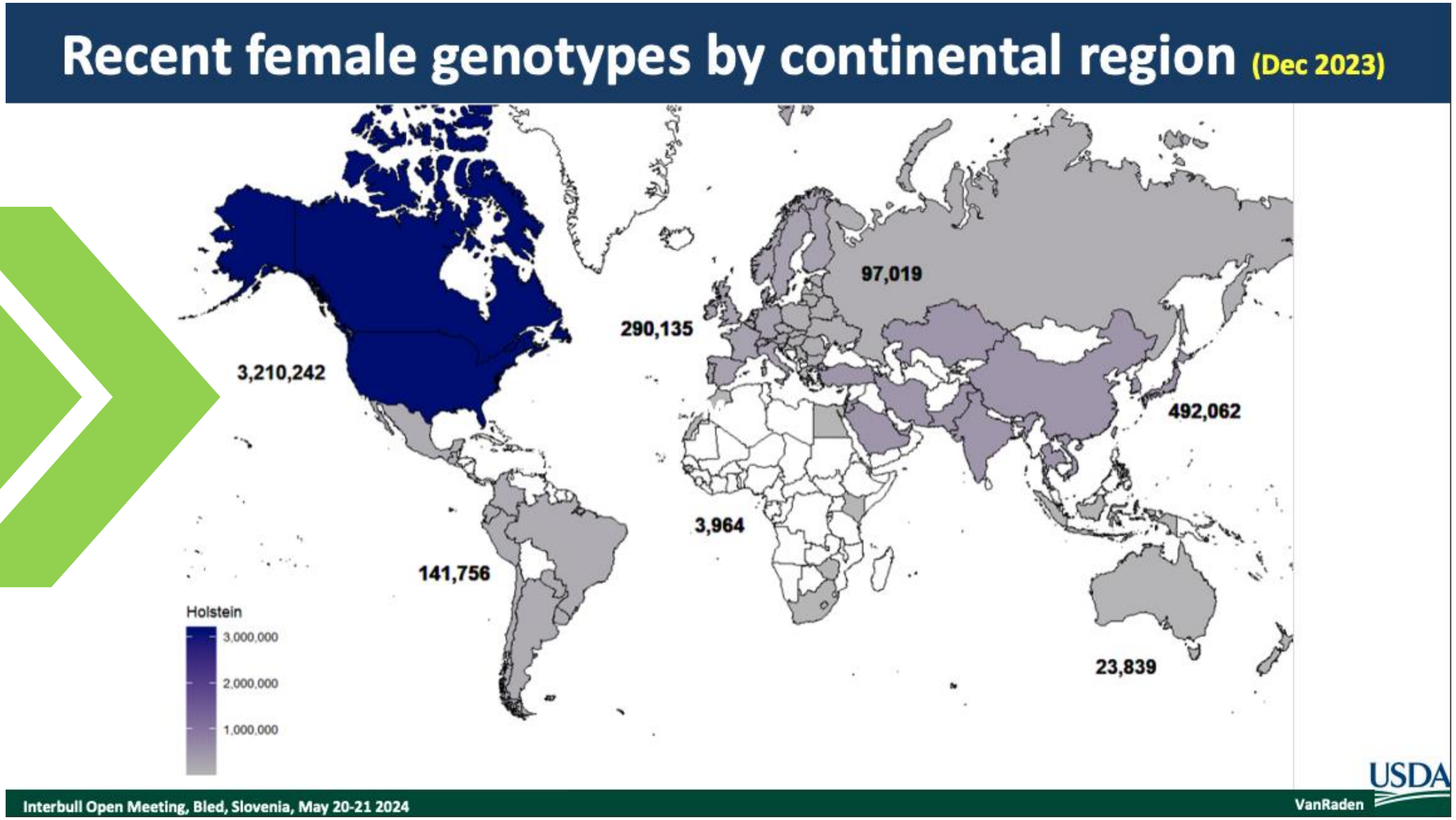
TOPICS FOR DISCUSSION

1. How have we been addressing sustainability in US dairy breeding?

2. What are the opportunities?

3. What are the lessons from the last 116 years of US dairy breeding programs?

WHAT HAS MADE US SUCCESSFUL?



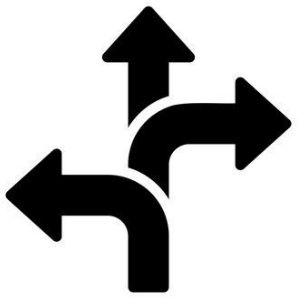
Source: VanRaden et al. 2024 Interbull Proceedings

WHAT HAS MADE US SUCCESSFUL?

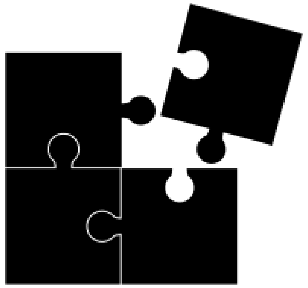
AGIL server stack, November 2022

WHAT HAS MADE US SUCCESSFUL?

Flexibility

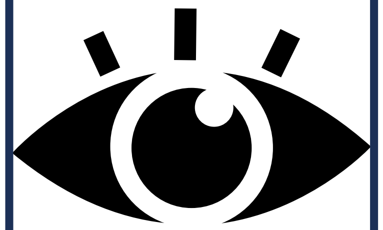


Adaptability

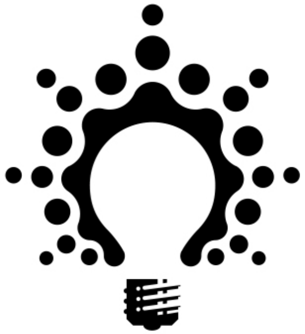


Cooperation

Realism



Evolution



WE HAVE ALWAYS EVOLVED TO MEET CHANGE.

WE WILL CONTINUE TO DO SO.

THANK YOU. QUESTIONS?

Data were available to the authors from CDCB under USDA Agricultural Research Service Material Transfer Research Agreement #58-8042-8-007. While CDCB offers data stewardship, sole ownership and rights pertaining thereto remain with the producer and we thank U.S. dairy producers for sharing their data for research use.

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