



Resilience in Dairy Cattle - the Concluding Chapter

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March 4th, 2026**

Traditional test day (DHI) data

- Tester comes to the herd & takes a milk sample
- Sample is sent to the lab for processing
 - Milk components, SCC, pregnancy etc.
- Producer decides if they want it to be processed by DRPC (and on to CDCB)
- Data edits applied by CDCB – legacy ingestion system for quality control
- Typically, once per month or less frequent (12 records/cow/yr)
- CDCB receives data in formats 4,5,6,14 etc.



High frequency data

- What is high frequency data?
 - In our case, it is daily milk weights (i.e., parlor data) collected by either in line milk meters in “conventional” milking parlors
 - OR daily milk weight data coming from Automatic Milking Systems
 - In theory – cow on 3X could have up to 1,095 records/cow/yr



Using high frequency data

- Management purposes

- Making decisions on the day-to-day basis on how to manage cows efficiently
- How to group & feed cows
- Monitor cow health
- Increased parlor efficiency – labor allocation
- Culling decisions



- Genetic Selection

- Different quality control requirements
- Outlier detection
- Quality control procedures
- Merging data with DHI Test Day records to get official ID and calving information
- Currently, the herd must be on DHI Milk Recording to be useful for genetic improvement



Data

- Number of records:
 - 410 million individual daily milk weights
 - 82 million historical aggregated daily milk weights
 - 37.8 million test day records
 - 4.4 million health records
 - 5.5 million breeding records
- Number of herds: 312 herds in 37 states across the U.S.
- Number of cows: 702,861



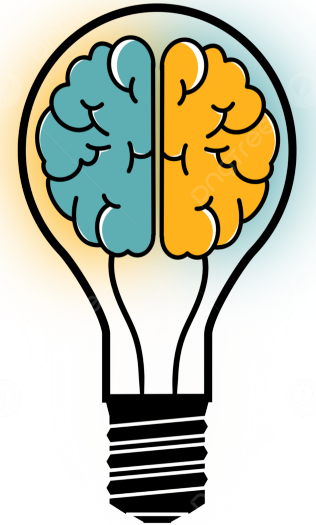
Project I: Genetic analysis of lactation consistency using daily milk weights for U.S. Holsteins

Consistency

“A level of performance that does not vary greatly in quality over time”

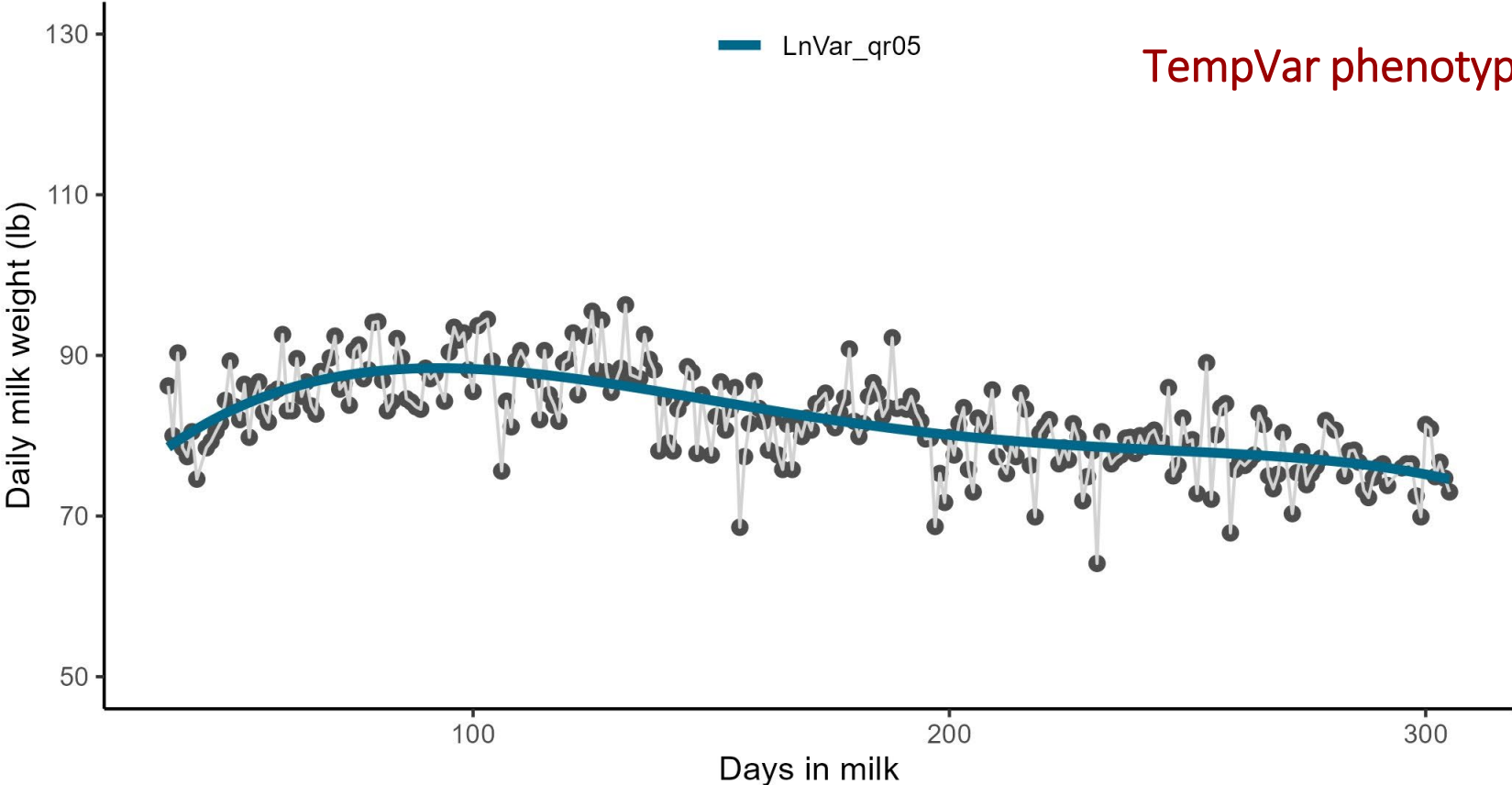
Our Goal

To achieve predictable performance in unpredictable conditions



Consistency

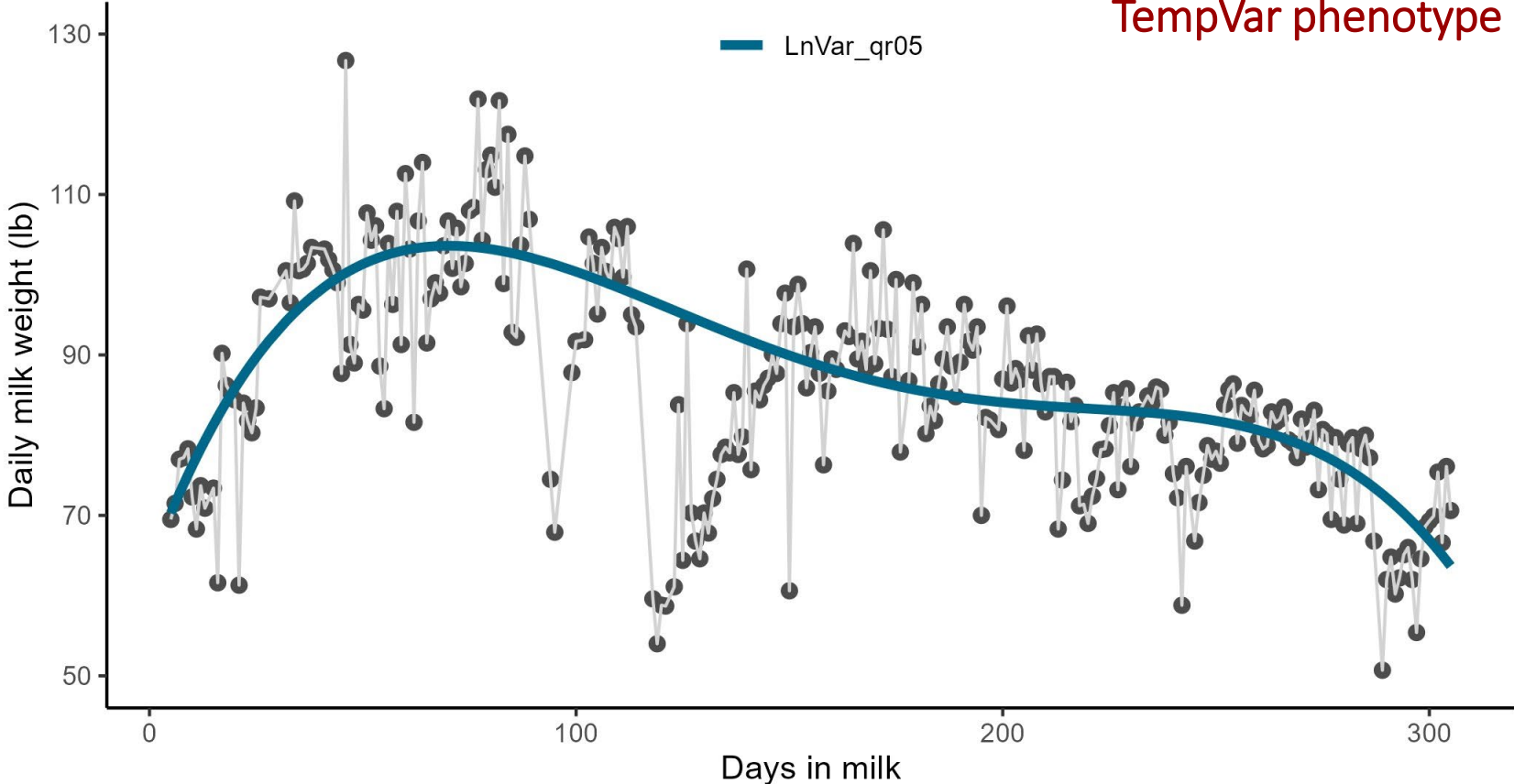
Consistent cow



TempVar phenotype → 2.86

Inconsistency

Inconsistent cow



TempVar phenotype → 4.68

Consistency = total variance over a lactation. Less variation = more consistency!

Heritability

Univariate Model

$$y_{ijkl} = AFC_i + HYS_j + a_k + e_{ijkl}$$

Fixed effects

- Age at first calving (6 levels)
- Herd-year-season (2,347 levels)

Random effect

- Cow (102,216 levels)

TempVar is heritable!

$$h^2 = 0.24 (0.01)$$

Sire PTA Correlations with TempVar

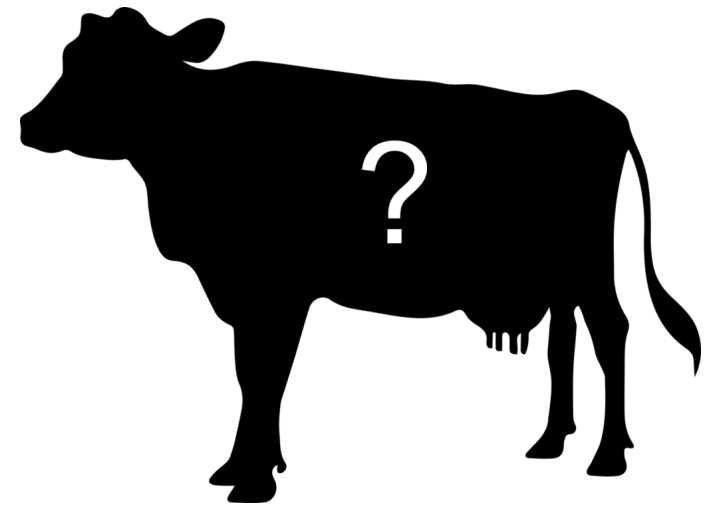
Trait	Correlation
Milk	0.57
Somatic Cell Score	0.26
Productive Life	-0.38
Livability	-0.48
Daughter Pregnancy Rate	-0.42

$$\hat{r}_{i,j} = \frac{\sqrt{\sum(Rel_i) \sum(Rel_j)}}{\sum(Rel_i Rel_j)} r_{i,j}$$

Correlations with early postpartum health traits ranged from -0.41 to -0.08
→ More consistent cows = fewer health problems

Take home messages

- Consistent performance is heritable $\rightarrow h^2 = 0.24$
- Consistent cows \rightarrow fewer health problems, increased longevity, more labor efficient
- Milk meter data \rightarrow Extracting value from data routinely generated on farm

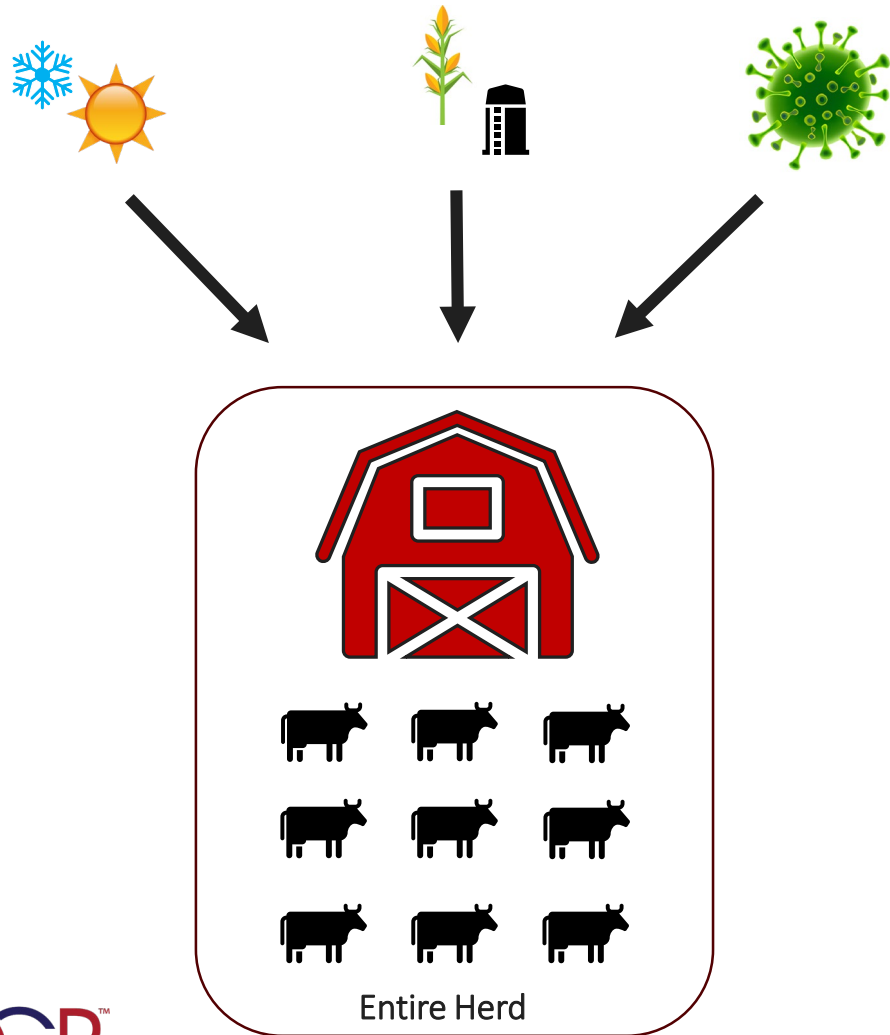


"Trouble free, anonymous cow"

Project II: Using daily milk weights to redefine contemporary groups for milk production traits

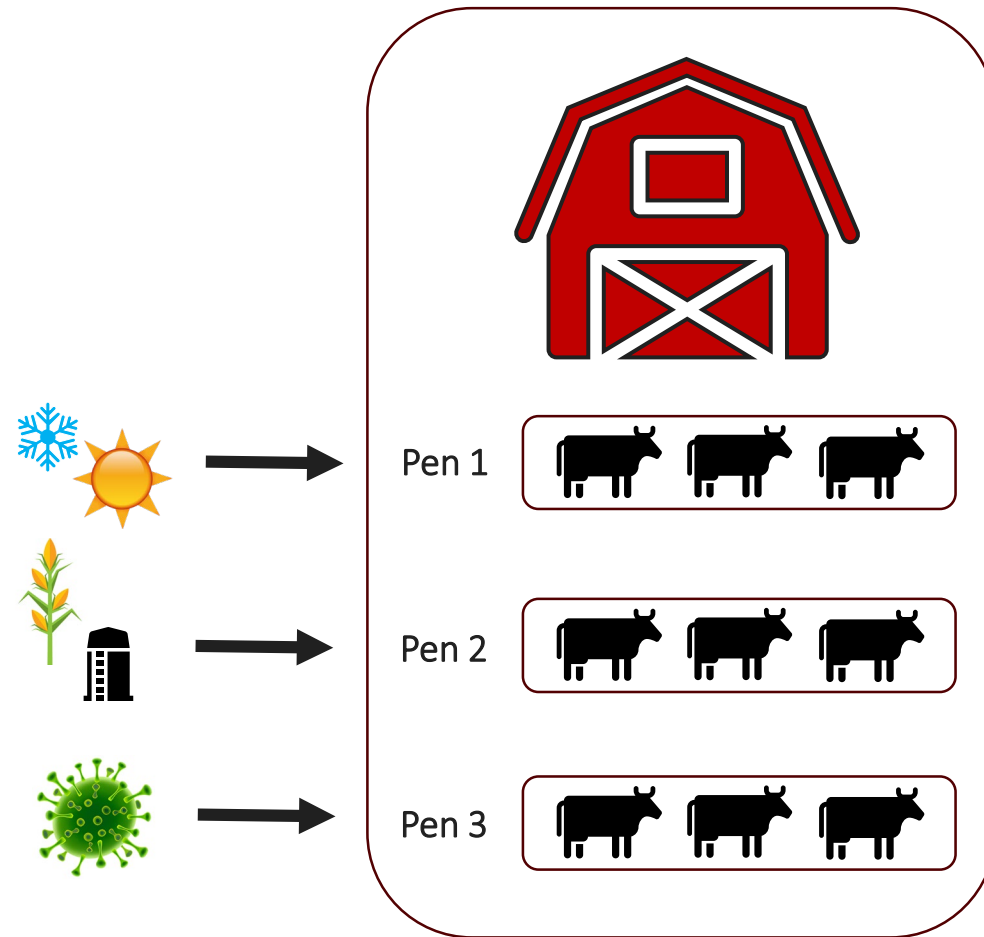
Current Approach

Grouping by Herd-Year-Season of Calving

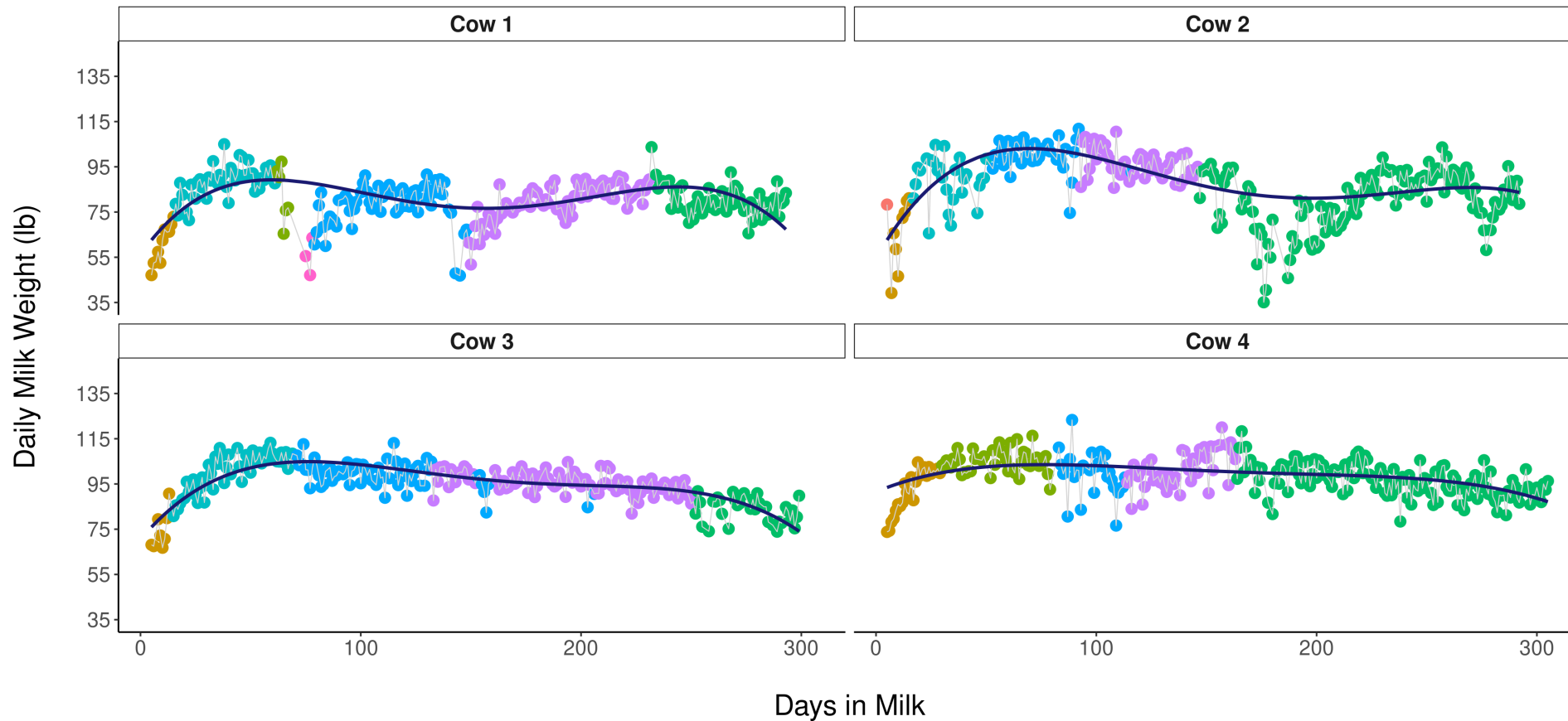


Our Approach

Grouping by Herd-Pen-Milking Date of Milking



Lactation curves for 4 random cows with pens identified



Cows are grouped into pens according to parity, lactation stage, reproductive status
→ Management is at the group/pen level

How do we incorporate this into genetic evaluation methodology?

Contemporary groups to estimate genetic parameters

Current Method

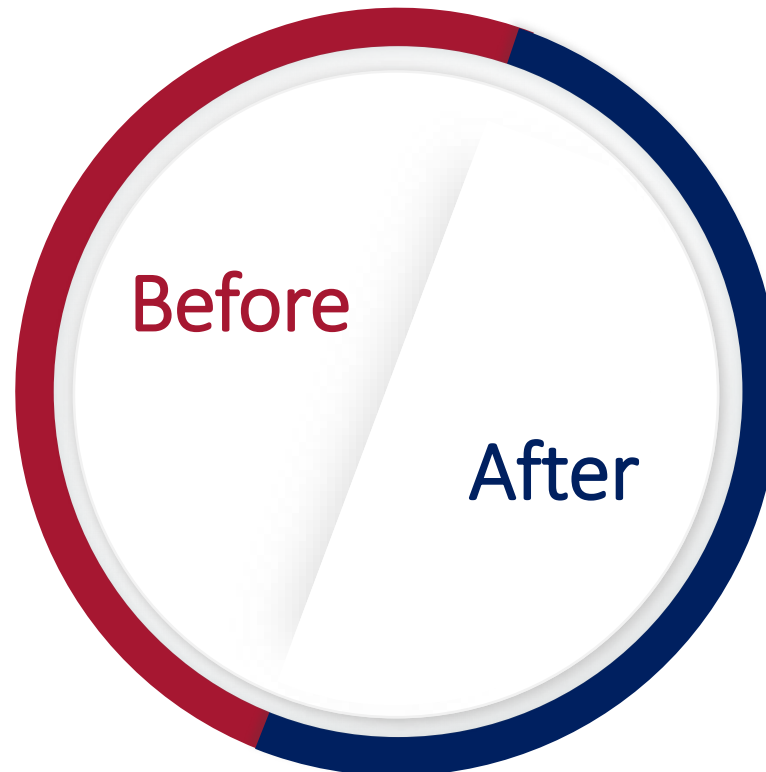
Phenotype

305-d Projected milk production

Contemporary Group

Herd-year-season

Each cow has 1 contemporary group



Proposed Method

Phenotype

Daily Milk Weights

Contemporary Group

Herd-pen-milking date

Each cow could have up to 300 contemporary groups if she changed pen every day of the lactation

Models

Model 1

$$305\text{-d Milk (kg)} = \text{AFC} + \mathbf{HYS} + \text{cow} + e$$

Model 2

$$\text{Daily Milk Weight (kg)} = \text{AFC} + \text{DIM} + \mathbf{HYS} + \text{cow} + \text{pe} + e$$

Model 3

$$\text{Daily Milk Weight (kg)} = \text{AFC} + \text{DIM} + \mathbf{HPM} + \text{cow} + \text{pe} + e$$

Model 4

$$\text{Daily Milk Weight (kg)} = \text{AFC} + \text{DIM} + \mathbf{HYS} + \mathbf{HPM} + \text{cow} + \text{pe} + e$$

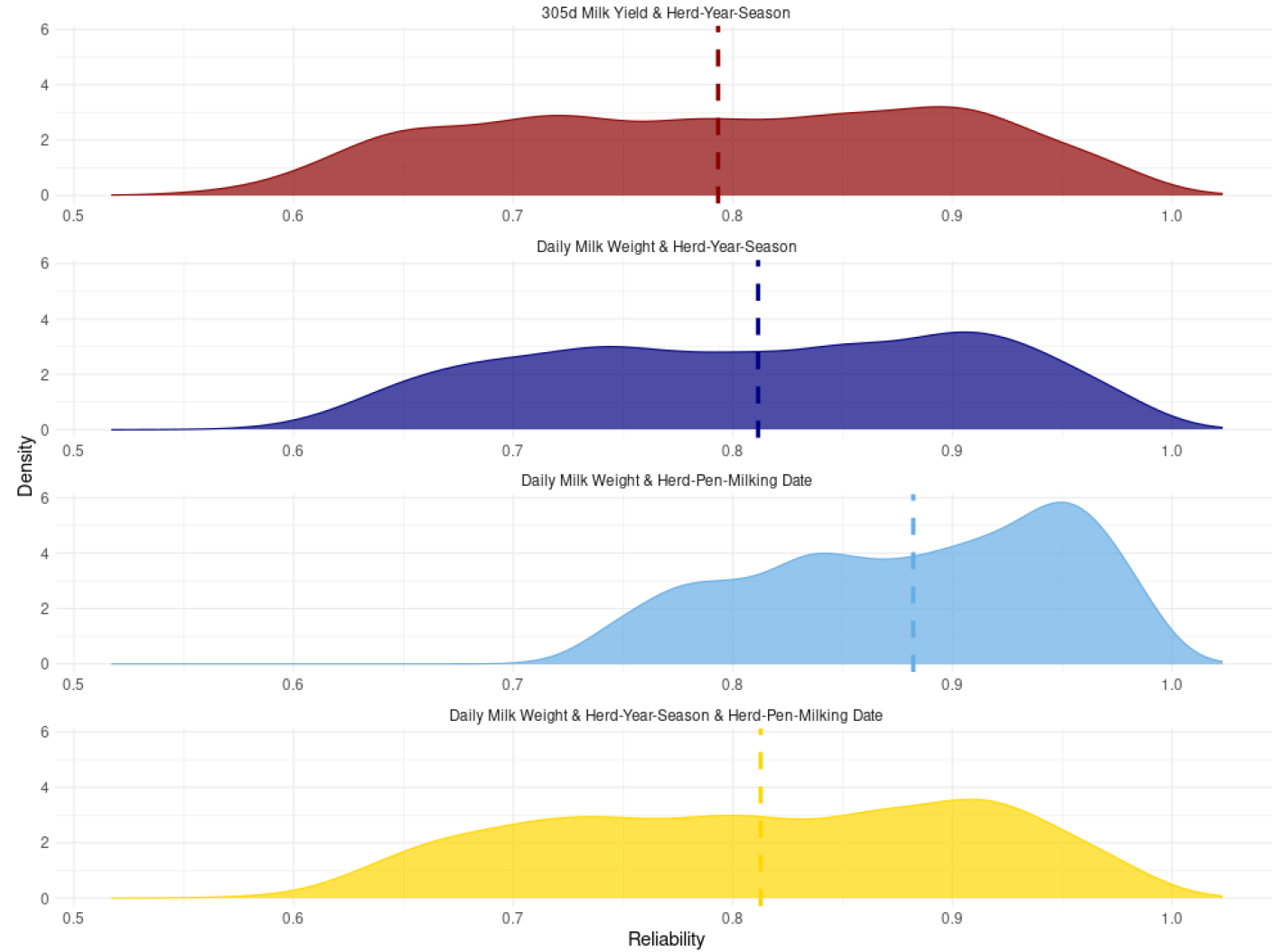
Sire PTA Reliabilities

Model 1

Model 2

Model 3

Model 4



Take home messages

- Utilizing high frequency data may require new definitions for contemporary groups
- We can increase sire PTA reliabilities utilizing daily milk weights
- Daily pen information more accurately captures the environment the cow is experiencing

Project III: Dairy cow resilience: data driven detection and quantification of perturbations using daily milk weights

Resilience

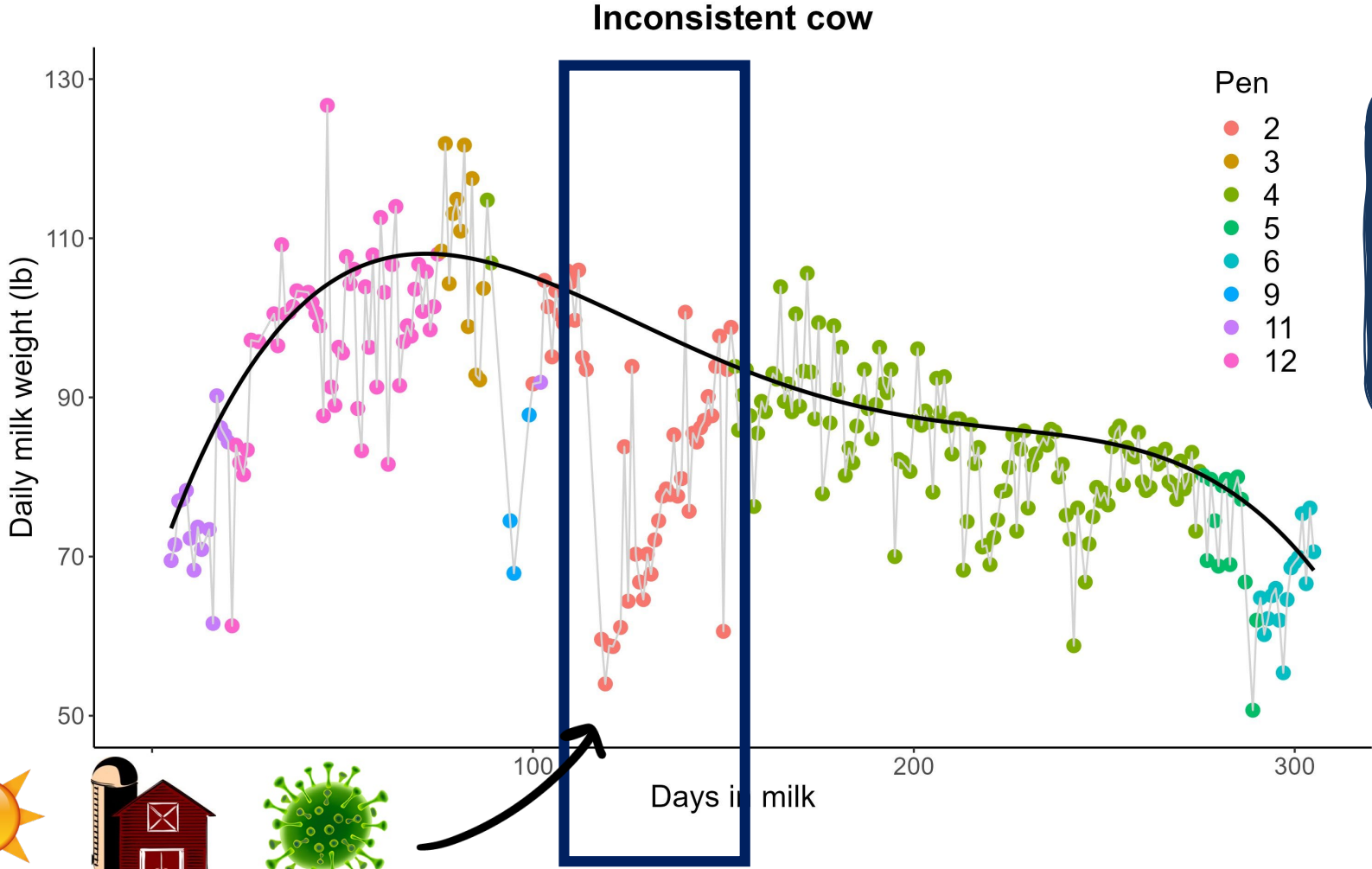
“The capacity to bounce back to normal functioning after a *perturbation* or maintain specific functions in the face of change or stress”

Our Goal

Scheffer et al., 2018

To first identify perturbations and then calculate individual cows' response at the pen level

Perturbations

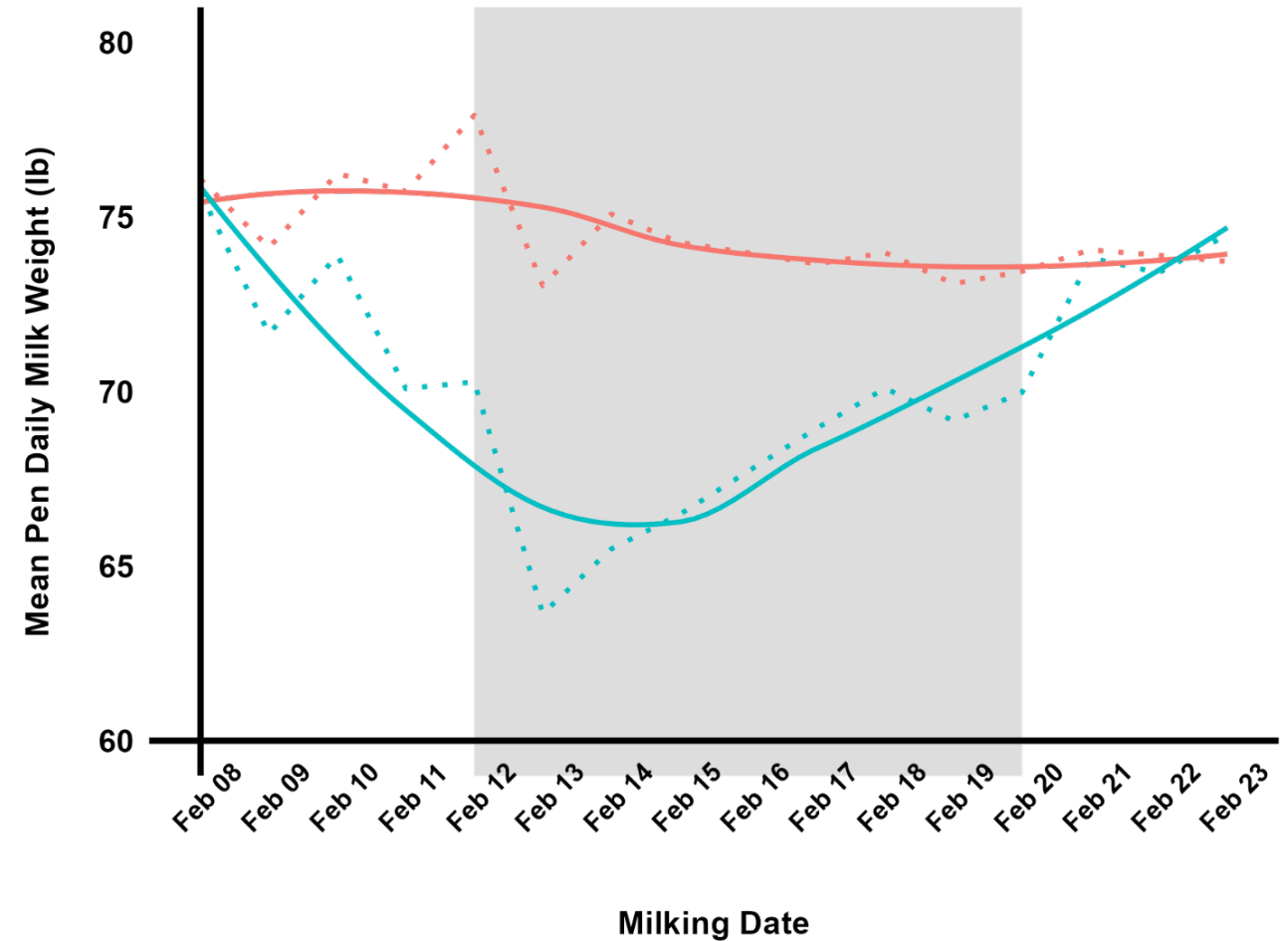


How do cows differ genetically in their ability to respond to pen level perturbations?

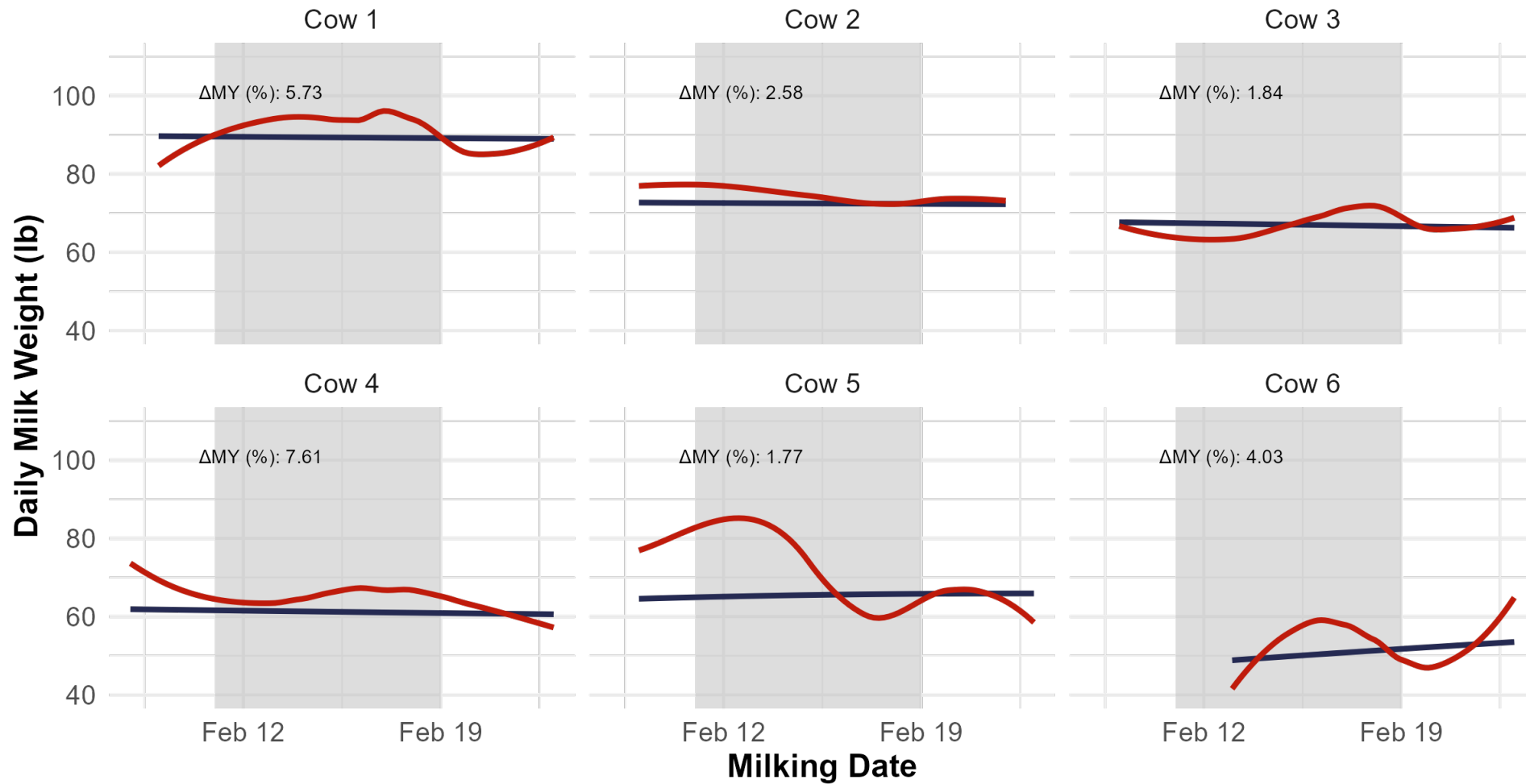


Step I – Identify when a perturbation occurs

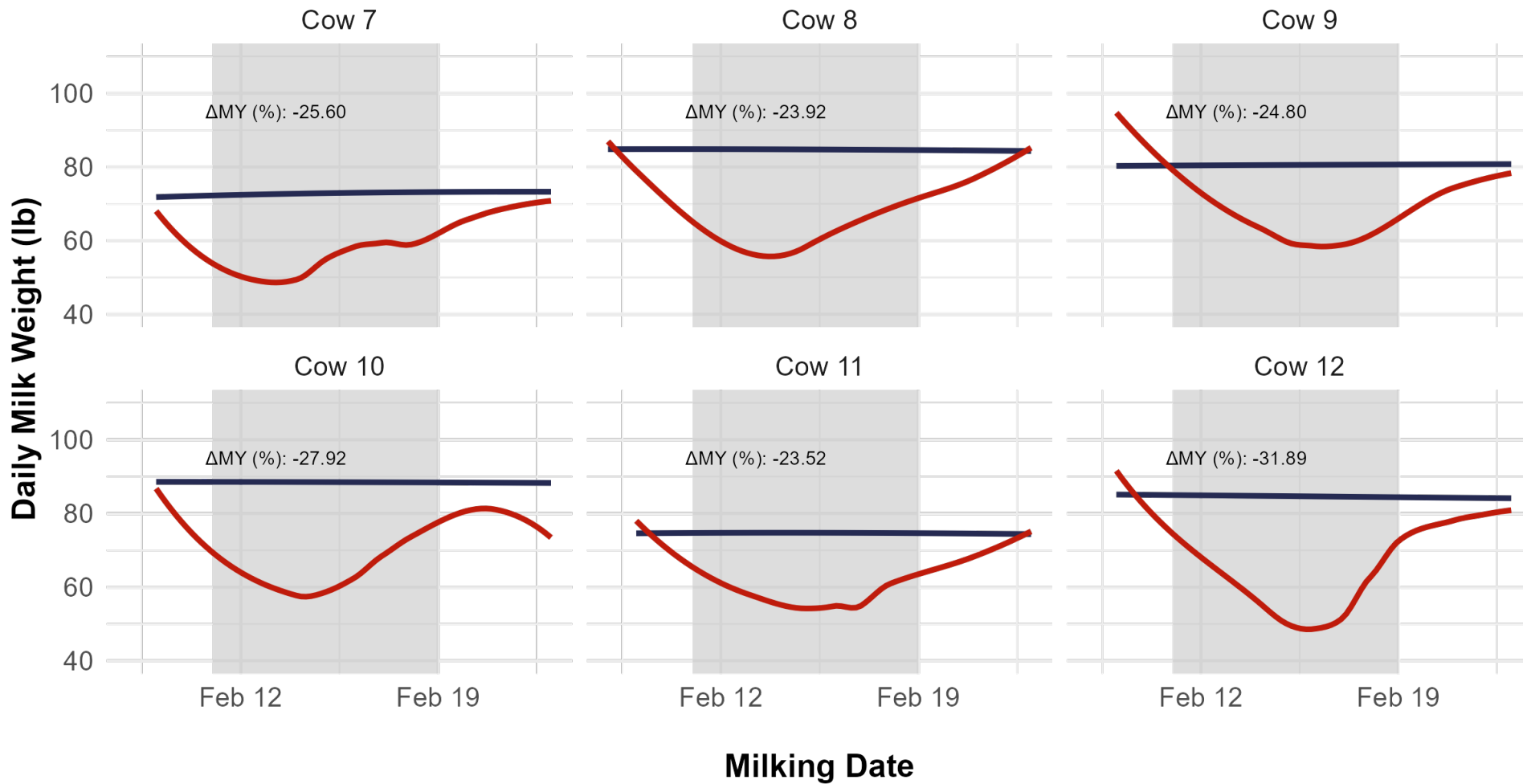
- Runs of homozygosity style coding to identify perturbations
- Difference between mean observed and expected milk production in a herd-pen-milking-date at pen level
- 40 combinations of severity and duration ranging from $\geq 3\%$ to $\geq 7\%$ milk yield loss in severity and ≥ 3 days to ≥ 10 days in duration
- Cows are required to have 50% of the records to be included



Step II – Resilience phenotype (Most resilient)



Step II – Resilience phenotype (Least resilient)



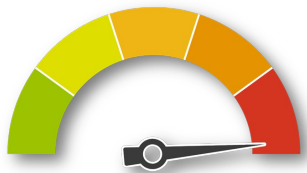
Heritabilities

- Phenotype: Δ Milk Yield
- Fixed effects
 - Calving age
 - Days in milk
 - Parity
 - Herd-year-season
- Random effects
 - Perturbation event
 - Cow
 - Permanent environmental
 - Residual

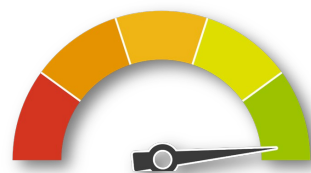
Duration	≥ 10 days	0.04 (0.008)	0.04 (0.010)	0.04 (0.020)	0.09 (0.040)	0.20 (0.080)
	≥ 9 days	0.03 (0.006)	0.04 (0.010)	0.06 (0.010)	0.08 (0.030)	0.15 (0.050)
	≥ 8 days	0.02 (0.004)	0.03 (0.007)	0.07 (0.010)	0.08 (0.020)	0.07 (0.030)
	≥ 7 days	0.02 (0.003)	0.03 (0.005)	0.05 (0.009)	0.06 (0.010)	0.06 (0.020)
	≥ 6 days	0.02 (0.002)	0.02 (0.004)	0.04 (0.006)	0.06 (0.010)	0.06 (0.010)
	≥ 5 days	0.01 (0.002)	0.02 (0.003)	0.04 (0.005)	0.05 (0.007)	0.05 (0.008)
	≥ 4 days	0.01 (0.001)	0.01 (0.002)	0.02 (0.003)	0.03 (0.004)	0.04 (0.006)
	≥ 3 days	0.01 (0.001)	0.01 (0.001)	0.02 (0.002)	0.02 (0.003)	0.03 (0.004)
		$\geq 3\%$	$\geq 4\%$	$\geq 5\%$	$\geq 6\%$	$\geq 7\%$
		Severity				

Take home messages

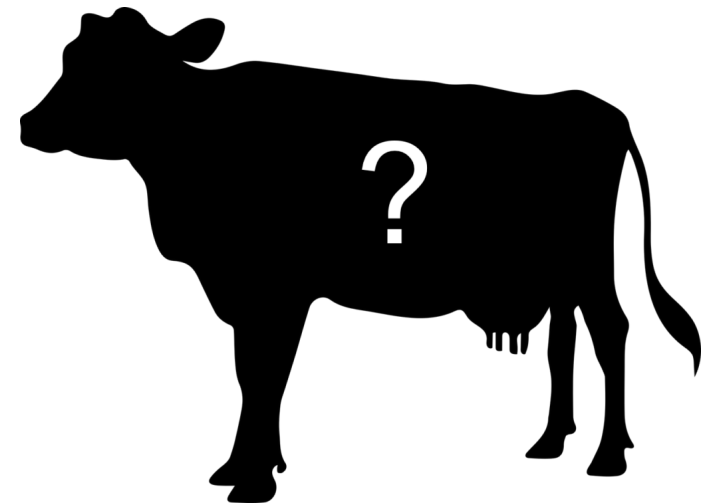
- Pen level perturbations can be identified using daily milk weights
- Cows respond differently to perturbations at the pen level
- Resilience is heritable (0.01 – 0.20)
- Resilience is expressed in challenging conditions



Challenge Level



Resilience Expressed

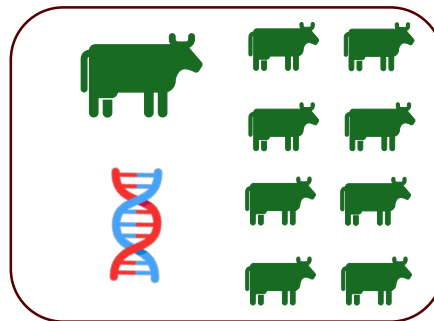
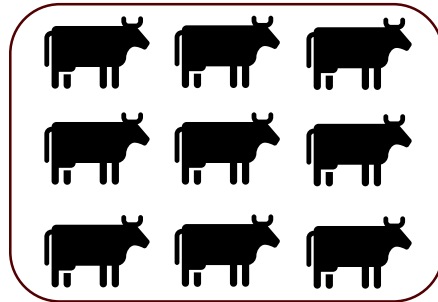
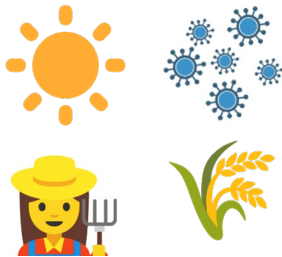
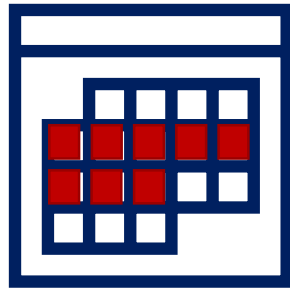


“Trouble free, anonymous cow”

Project IV: Assessing alternative resilience phenotypes in Holstein cows

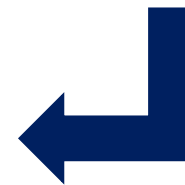
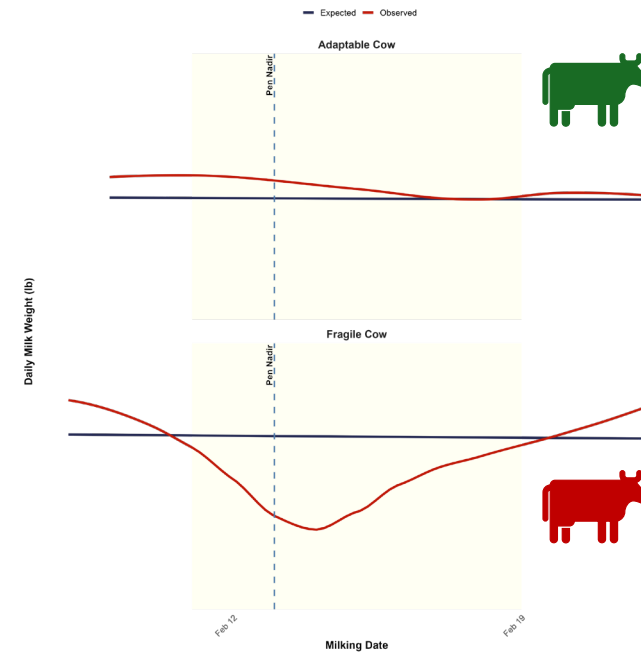
Objectives

Step 1: Detect pen level perturbation



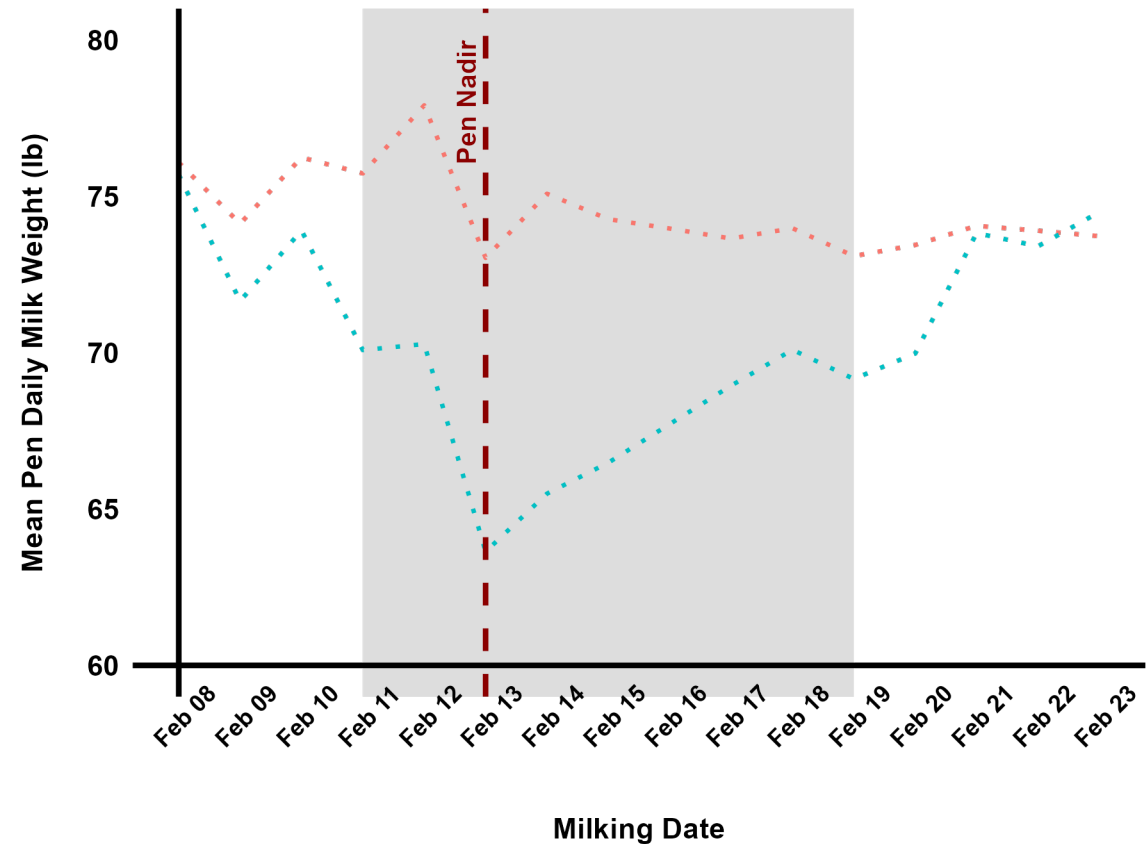
Step 3: Genetically select for resilient “adaptable” animals

Step 2: Quantify individual cow response using novel resilience phenotypes



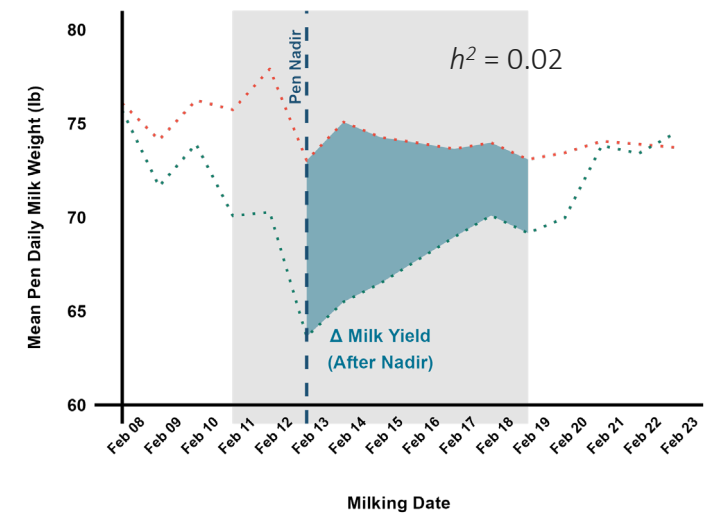
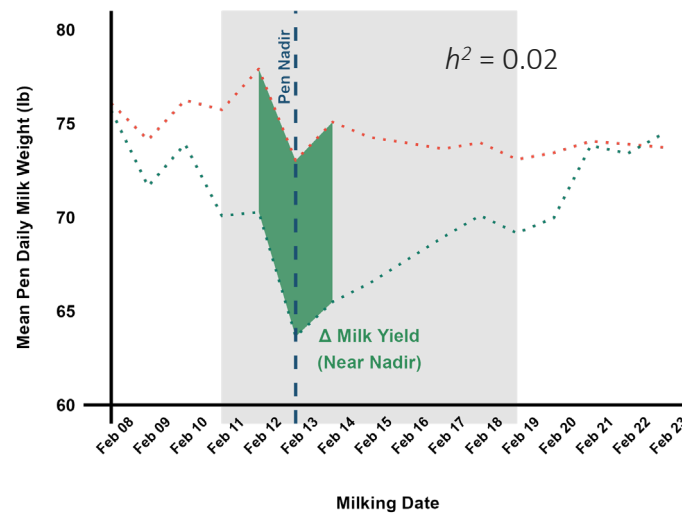
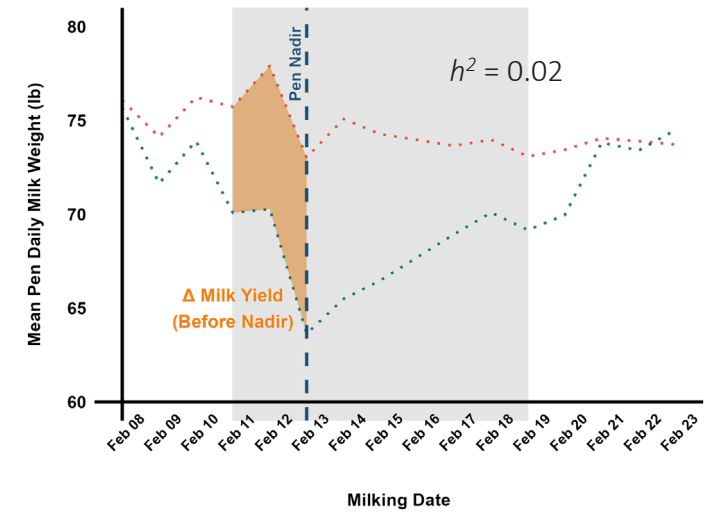
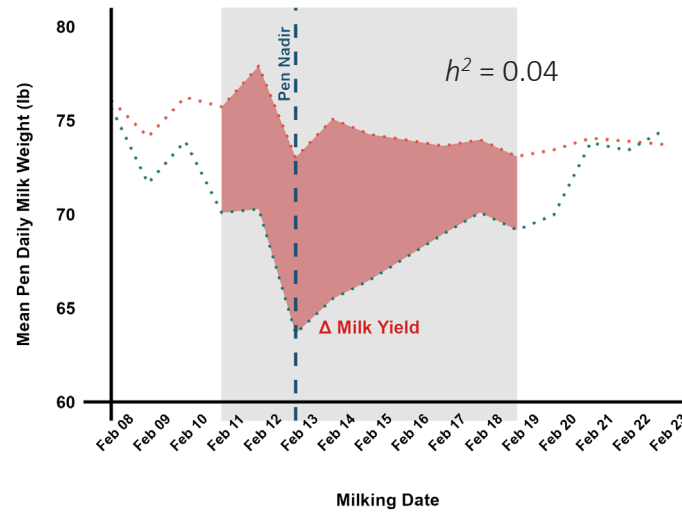
Identify the pen nadir date during the perturbation

- Identify the date where the mean observed milk production was lowest (nadir) during the perturbation
- In this example, it would be Feb 13th
- Calculate resilience indicators relative to the nadir identified at the group level
- Subset data ($\geq 5\%$ for ≥ 5 days)
 - Cow must have at least one record (1) before, (2) on and (3) after nadir
 - 34,044 cows with phenotypes
 - 7 different resilience phenotypes



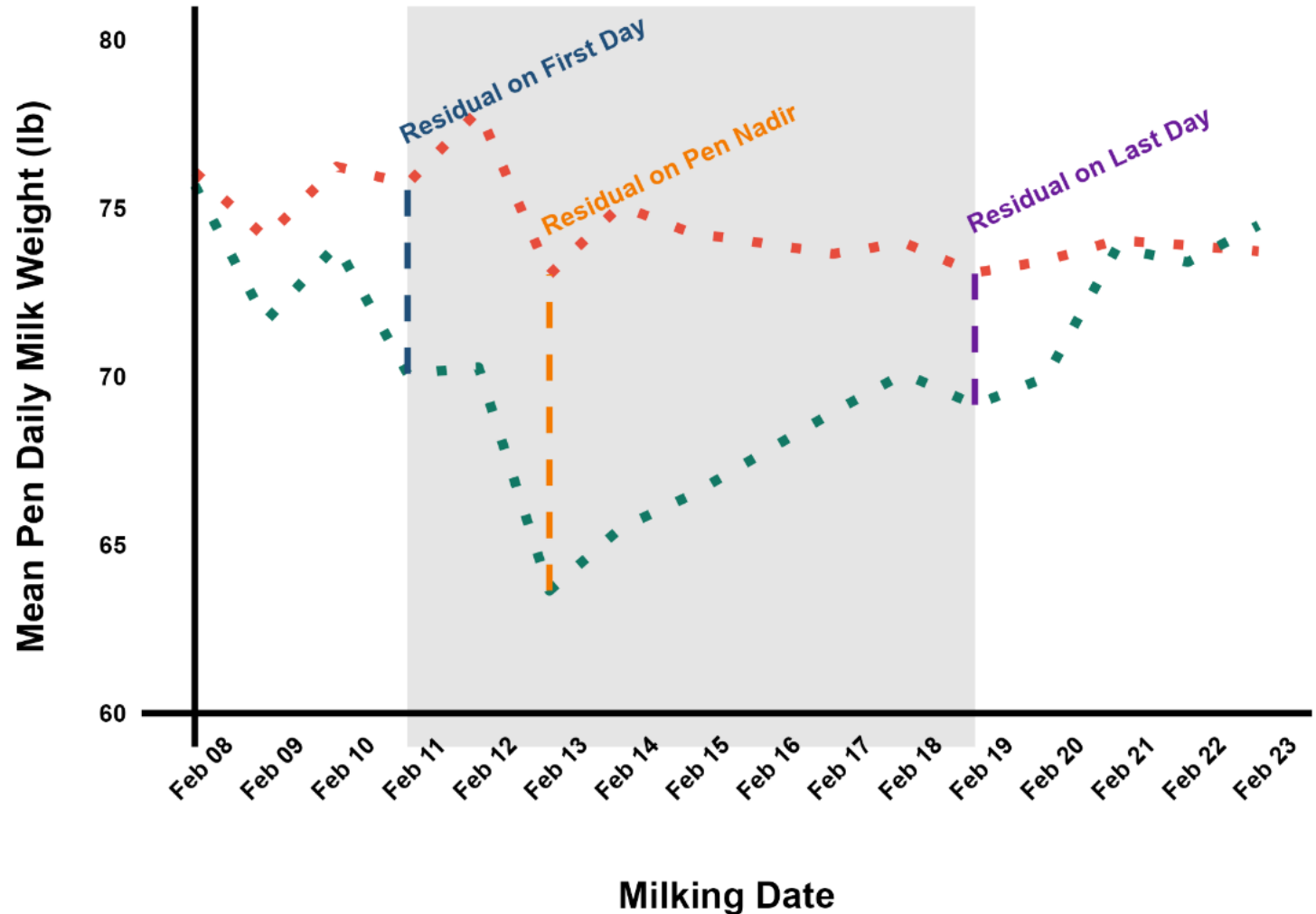
Alternative resilience phenotypes

- Heritabilities ranged from 0.02 (0.006) – 0.04 (0.0009)
- Heritabilities decreased as the duration decreased
 - less data, more noise



Alternative resilience phenotypes

- Heritabilities ranged from 0.004 (0.004) – 0.02 (0.007)
- Single day estimation
 - Greater standard errors
 - Less informative about resilience



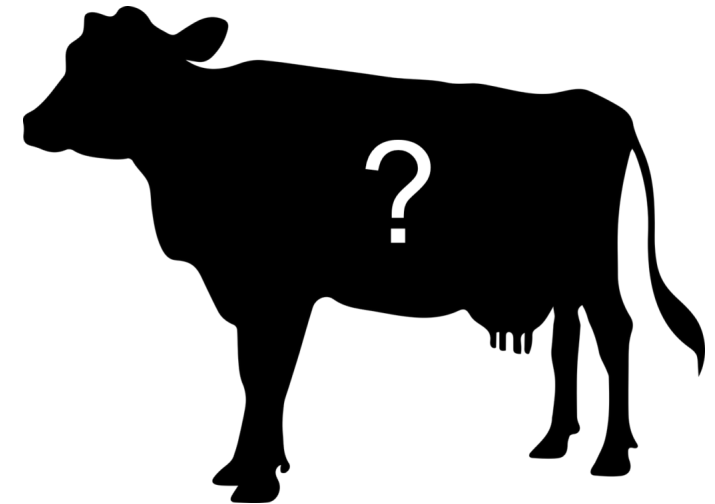
Genetic Correlations

Resilience phenotype	305-d milk (kg)
Δ Milk Yield Overall (%)	-0.13 (0.09)
Δ Milk Yield Before Nadir (%)	-0.22 (0.11)
Δ Milk Yield Near Nadir (%)	-0.20 (0.11)
Δ Milk Yield After Nadir (%)	-0.07 (0.12)
Residual on First Day (kg)	-0.30 (0.38)
Residual on Nadir (kg)	-0.06 (0.12)
Residual on Last Day (kg)	-0.02 (0.45)



Take home messages

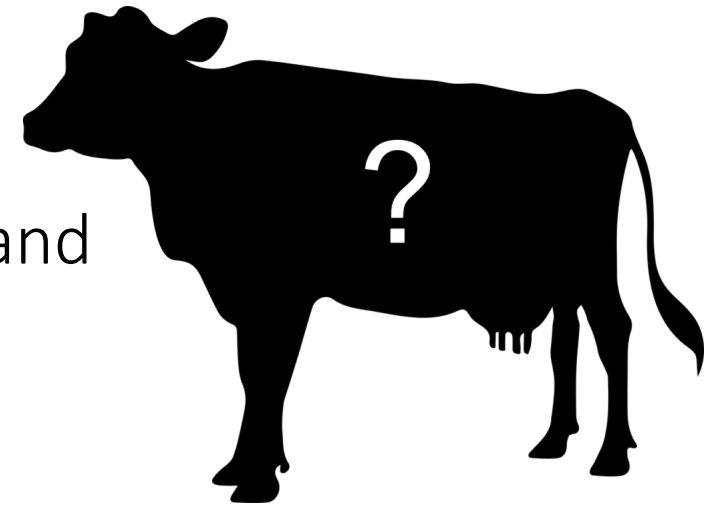
- Phenotypes derived from single measurements (residuals) have lower heritabilities
- We can select for resilience and milk yield simultaneously
- ΔMY is a more useful way to measure resilience



“Trouble free, anonymous cow”

Overall Conclusions

- High-frequency phenotypes enable novel trait development
- Genetic evaluations can be improved through precision data
- Consistency and resilience traits are heritable and biologically meaningful
- Future/Implementation: Combination of consistency and resilience phenotypes in resilience index or sub-index



“Trouble free, anonymous cow”



Beyond the Dissertation: What now?

Resilience

- ▶ WCGALP presentation
 - Genetics of dairy cow resilience in US Holsteins
- ▶ Lactation persistency?
 - What's the relationship between consistency and persistency?
 - Bivariate model to investigate this
 - UW Madison continuing research



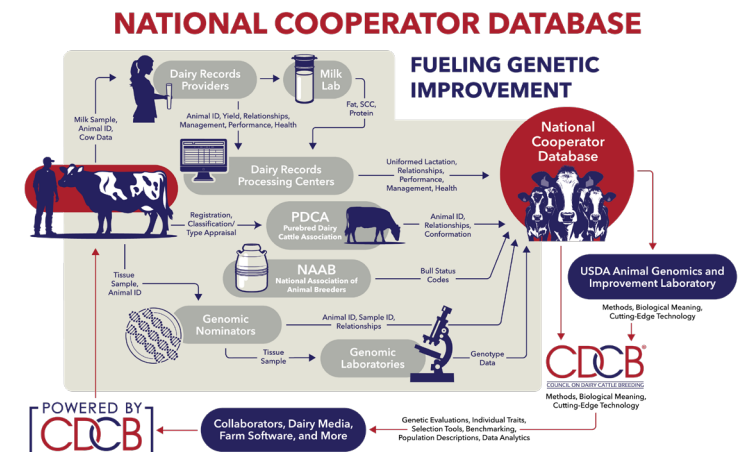
Livestock Data Analytics Expert

- ▶ Started August 2025
- ▶ Based in Madison, WI (Remote)
- ▶ Subject matter expert on CDCB's phenotypic data ingestion system
- ▶ Develop and enhance functionalities that improve data efficiency, quality control and accessibility for data providers
- ▶ Integrating novel data types into CDCB's portfolio
- ▶ R & D projects that enhance the value of on-farm data analytics



Priorities

- ▶ Understanding data flow from farm to NCD
- ▶ Improving phenotypic data flow into National Cooperator Database at CDCB
- ▶ Current system → Milk recording data, daily milk weights: updating phenotypic editing system to reflect advances in genetic improvement and management
- ▶ Future potential of phenotypic data → Sensors (for cows and environment) etc.
- ▶ Communication with DRPCs



What's CDCB doing to improve errors?

- ▶ Investigate and summarize error codes generated by CDCB EDITS system
- ▶ Prioritize error codes based on occurrence/ability to fix
 - High/Medium/Low
 - Improve description of return codes
 - Develop documentation on steps required for fix
- ▶ Meeting with DRPCs
- ▶ Provide actionable insights to DRPCs on how to fix error codes



National Performance Metrics



▶ CDCB CowCast March episode

▶ WebConnect

▶ National Performance Metrics:

- Updates
- Data that flows to National Cooperator Database
- How to access the tables/graphs
- Interesting trends over time



Queries Special Section Top Animal Listing Summary Stats National Performance Metrics Login

NATIONAL PERFORMANCE METRICS





CDCCBTM

COUNCIL ON DAIRY CATTLE BREEDING

Thank you!